



Is there a benefit to additional neuroaxial anesthesia in open nephrectomy? A prospective NSQIP propensity score analysis

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Received: 30 April 2019 / Accepted: 13 June 2019 / Published online: 20 June 2019
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Abstract

Introduction Neuroaxial (i.e., spinal, regional, epidural) anesthesia has been shown to be associated with reduced readmission rate, decreased hospital stay, and decreased overall complication rate in orthopedic and gynecologic surgery. Our aim was to identify differences in intra- and postoperative complications, length of stay and readmission rates in open nephrectomy patients managed with neuroaxial anesthesia.

Materials and methods Utilizing National Surgical Quality Inpatient Program (NSQIP) database, we identified patients who have undergone an open nephrectomy between 2014 and 2017. Patients were further subdivided based on anesthesia modality. We used the propensity score-matching (PSM) method to adjust for baseline differences among patients who received general anesthesia alone and those with additional neuroaxial anesthesia. Using step-wise multivariable logistic regression, we identified preoperative and intraoperative predictors associated with 30-day procedure-related readmission, complications, and postoperative length of stay.

Results Out of 3,633 patients identified, 2346 patients met our inclusion and exclusion criteria. There was no difference in baseline characteristics after propensity score matching between general and additional neuroaxial anesthesia. Postoperative outcomes including: procedure-related readmission, rate of reoperation, operative time, all complications were similar between the groups. Adjuvant neuroaxial anesthesia group did experience a prolonged postoperative hospital stay that was statistically significant as compared to patients with general anesthesia alone [5.3 (3.5) days vs 4.8 (2.9) days, $p=0.007$]. Compared to GA alone after multivariable logistic regression, neuroaxial anesthesia was not statistically significant for readmission ($p=0.909$), any complication ($p=0.505$), but did showed increased odds ratio of prolonged postoperative stay [aOR 1.107, 95% CI 1.042–1.176, $p=0.001$] after adjusting for multiple factors.

Conclusion Using 2014–2017 NSQIP database, we were able to demonstrate no additional reduction in complication or readmission rate in patients with neuroaxial anesthesia as compared to general anesthesia alone. Furthermore, patients who did receive neuroaxial anesthesia experienced a longer postoperative course.

Keywords Renal cell · Kidney cancer · Neuroaxial anesthesia

Abbreviations

ERAS	Enhanced recovery after surgery
NICE	National Institute of Health and Care Excellence
aOR	Adjusted odds ratio
RB	Regional block

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s11255-019-02208-z>) contains supplementary material, which is available to authorized users.

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ASA	American Society of Anesthesiology
DVT	Deep-vein thrombosis
VTE	Venous thromboembolism
NA	Neuroaxial anesthesia
CPT	Current procedural terminology
NSQIP	National Surgical Quality Improvement Program

Introduction

Optimal anesthesia is an essential component of enhanced recovery pathway after surgery (ERAS) as it has the potential to facilitate earlier mobilization, and expedite the return of bowel function. This leads to a shorter length of stay, and accelerated convalescence [1]. Neuroaxial (i.e., spinal, regional, epidural) anesthesia has been associated with a fewer 30-day readmission rate, decreased hospital stay. Furthermore, a reduction in hospital mortality has also been reported, in particular due to decreased deep venous thromboembolism (DVT) [2, 3]. Studies evaluating neuroaxial (NA) anesthesia in non-urologic realms have described spinal anesthesia (SA), in combination with general anesthesia (GA), as a better-tolerated technique. It provides a more predictable effect, lesser hemodynamic and respiratory repercussion as evidenced by excellent outcomes in patients undergoing cardiac, vascular, orthopedic, pelvic and abdominal surgery [2–5]. Neuroaxial anesthesia is a well-established option to minimize perioperative side-effects [5], including surgical stress (hypertension and tachycardia), reduce pulmonary compromise (atelectasis, pneumonia, and prolonged ventilating), while still allowing for superior postoperative pain control with a reduction in perioperative opioid consumption [5–7].

Local anesthetic interferes with blood clotting and hypercoagulability, which can reduce incidence of postoperative DVT [8–10]. Based on the above-mentioned considerations, the National Institute of Health and Care Excellence (NICE) in the United Kingdom recommends including neuroaxial anesthesia as part of venous thromboembolism (VTE) prevention in patients undergoing non-cardiac surgery [11].

Radical nephrectomy is a commonly performed urologic surgery in the United States [12, 13]. Given the unique benefits provided by neuroaxial anesthesia in orthopedic and cardiac literature [14–17], we aimed to evaluate the benefits of adjunct anesthesia in the open nephrectomy cohort. Specifically, the objective of the present study was to identify differences in intra- and postoperative complications, length of stay and readmission rates between patients managed with general anesthesia alone as compared to general + neuroaxial (spinal, regional and epidural) anesthesia.

Methods

The NSQIP database includes over 150 perioperative data elements, which were collected from over 600 hospitals. Current Procedural Terminology (CPT™) was utilized to determine the associated procedures. Patients were included in the study if they were 18 years or older at the time of surgery between 2014 and 2017. For the purpose of the study, CPT codes were used to identify patients who have undergone an open nephrectomy (50545, 50220, 50230). Patients were further subdivided based on additional anesthesia modality general anesthesia alone (GA) vs general in combination with neuroaxial anesthesia (regional block, epidural or spinal anesthesia).

Patients were excluded if they had preoperative ascites, disseminated cancer or sepsis, or if they were on ventilator at the time of surgery. Patients who underwent open nephrectomy for reasons other than cancer [ICD 9 (189.x), ICD 10(C64.x)] were excluded from the analysis. Patients with missing values (preoperative hematocrit, height, weight, and those with unknown or unassigned ASA status, and unknown dependent status), older than 90 years, and emergent procedures were excluded. Patients with any additional concurrent general surgery procedures (i.e., cholecystectomy, appendectomy, colectomy, etc.) were also excluded.

Data elements that were collected included age, race/ethnicity, body mass index (BMI), smoking, diabetes mellitus (DM), hypertension (HTN) on medications, dyspnea, chronic obstructive pulmonary disease (COPD), bleeding disorders, steroid use, greater than 10% weight loss within 6 months before surgery, preoperative hematocrit, American Society of Anesthesiology (ASA) physical status, blood transfusion within 72 h prior to surgery, congestive heart failure, and functional status. Functional status was defined as dependent (partial or total) versus independent.

Intraoperative variables that were evaluated in the analysis included procedure type, total operating time, and wound classification. Wound classification was defined using the National Healthcare Safety Network.

Postoperative variables included postoperative length of hospital stay, total length of stay, complications, readmission, procedure-related readmissions and reoperation rates.

Statistical analysis

The primary outcome was the association between additional anesthesia and procedure-related readmission. Secondary outcomes evaluated anesthesia technique, complications, and postoperative length of stay.

We used the propensity score-matching (PSM) method to adjust for baseline differences between patients who received general anesthesia alone and those who received

both general and neuroaxial anesthesia using 1:1 caliper width of 0.15 for the propensity score through the nearest neighbor matching for [age, race, BMI, sex, smoking, diabetes mellitus, hypertension on medications, history of COPD, dyspnea, history congestive heart failure, bleeding disorders, steroid use, greater than 10% weight loss within 6 months before surgery, preoperative hematocrit, and American Society of Anesthesiology (ASA) physical status \geq class 3, and preoperative transfusion in 72 h prior to surgery, preop acute renal failure, and dialysis].

Step-wise backward elimination was performed with forcing the additional anesthesia variable on the model. The variables, that have been evaluated, included age, race, gender, BMI, smoking status, diabetes, dyspnea, COPD, medically treated hypertension, chronic steroid use, bleeding disorders, congestive heart failure, preoperative transfusion, weight loss, preoperative hematocrit, preoperative serum creatinine, ASA status, renal failure, dialysis, operative time and wound classification. The model with the lowest Akaike Information Criterion (AIC) was selected for multivariable regression analysis (MVR).

Multivariable logistic regression analysis was utilized to model for 30-day any complications and procedure-related readmissions, while negative binomial regression was used to model for postoperative stay. Descriptive statistics are reported as means with standard deviations for continuous variables and as counts and percentages for categorical variables. Chi-square and Student's *t* test were used to compare categorical and continuous variables, respectively. All statistical analyses were performed using R 3.5.2. *p* values < 0.05 were considered clinically significant.

ACS NSQIP or the participating hospitals have not verified and are not responsible for the statistical validity of the study analysis or the conclusions derived by the authors. Studies from the NSQIP database are considered exempt by the institutional review board.

Results

Out of 3633 patients identified, 2346 patients met our inclusion and exclusion criteria and were eligible for propensity score matching (Fig. 1). Prior to PSM, patients in general anesthesia were unevenly matched for BMI [31.2 (7.2) vs. 30.4 (7.5), $p = 0.031$], race [1306 (74.2) vs 290 (49.4), $p < 0.001$], and hypertension [1163 (66.1) vs 359 (61.2), $p = 0.033$], general vs neuroaxial anesthesia, respectively. After 1:1 PSM, there were 1090 patients total, with even distribution of 545 patients in each category, with no demographic differences between the two groups (Supplementary Fig. 1). Out of 545 patients, approximately 52.6% of all patients were Caucasians and 68% were males. Mean age

was 62.2 ± 12.2 years with mean BMI 30.6 ± 7.4 kg/m². The most common comorbidity was hypertension on medication (61.3%) followed by diabetes (23.9%) (Table 1).

The differences previously seen prior to PSM, including BMI, race, and hypertension rate were no longer significant. The remainder of the descriptive statistics was equally distributed among the groups (Table 1).

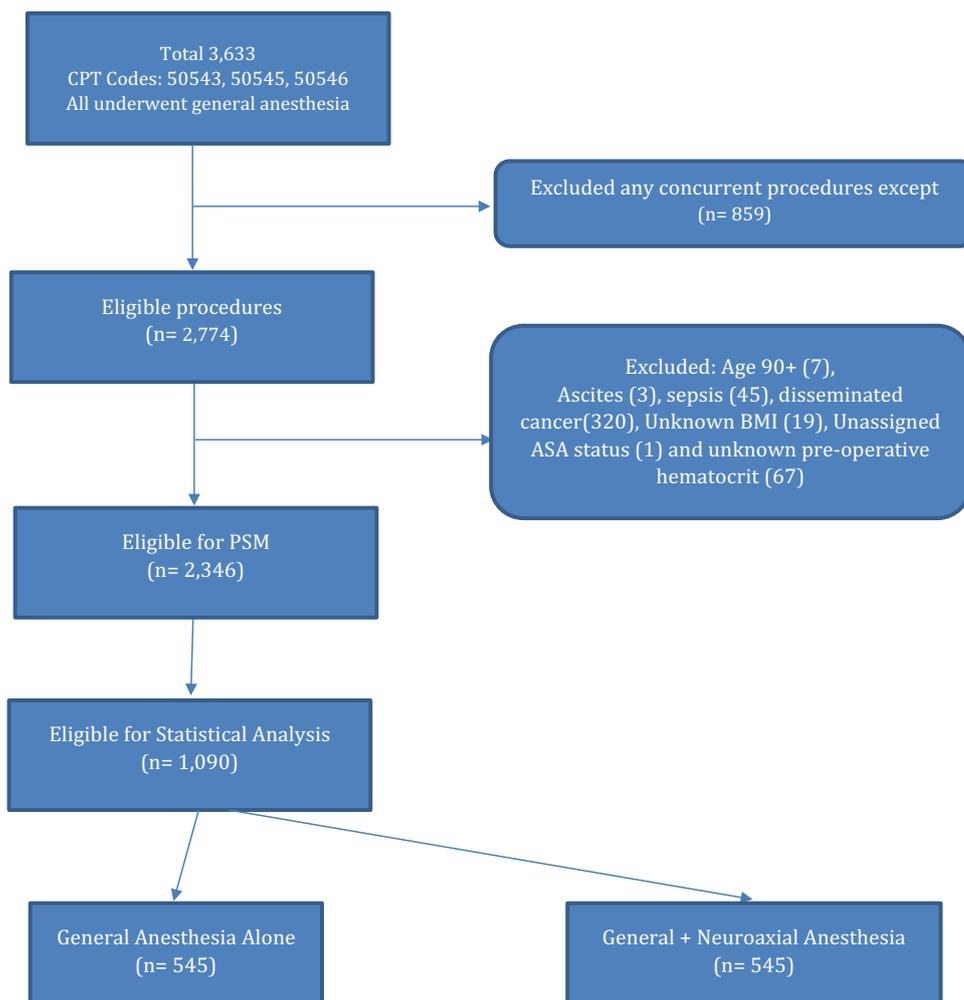
Intraoperative and postoperative outcomes are shown in Table 2. Prior to PSM, general anesthesia group demonstrated a longer operative time (min) [166.6 (92.4) vs 154.7 (77.1), $p = 0.005$], as well as shorter postoperative length of stay (days) [4.8 (3.6) vs 5.3 (3.4), $p = 0.004$]. Despite propensity score matching, adjuvant neuroaxial anesthesia group continued to show a longer postoperative length of stay as compared to general anesthesia alone [5.3 (3.5) vs 4.8 (2.9), $p = 0.007$] days (Table 2).

Overall, the complication rate was 23.9%, with no differences in complications between GA alone vs adjuvant neuroaxial anesthesia group, $p = 0.434$. The most common complication after open nephrectomy in the general anesthesia alone cohort was a urinary tract infection seen in 11 (2%) patients, while pneumonia was more common in the neuroaxial anesthesia group 15 (2.8%), although the difference among GA and NA were not significant. Both groups experienced a high rate of intra- and postoperative transfusion requirements 101 (18.5%) and 94 (17.2%), $p = 0.635$, as well as all-readmissions 25 (4.6%) vs 24 (4.4%), $p = 0.096$, albeit the differences again were not significant in either of the postoperative outcomes (Table 2).

Variables selected for multivariable regression were based on step-wise backward elimination, with model with lower AIC selected for MVR. Compared to GA alone after multivariable logistic regression, adjuvant neuroaxial anesthesia showed increased odds ratio of prolonged postoperative stay [aOR 1.107, 95% CI 1.042–1.176, $p = 0.001$] (Table 3) after adjusting for age, dyspnea, CHF, COPD, ASA status, ARF, dialysis, operative time, and preoperative hematocrit value. The addition of neuroaxial anesthesia was not associated with decreased procedure-related readmission rate (aOR 0.966, 0.537–1.736, $p = 0.909$), or a decrease in the complication rate (aOR 0.9, 0.659–1.227, $p = 0.505$) when compared to general anesthesia alone (Tables 4, 5).

Discussion

NSQIP program provides a large, validated dataset covering over 600 institutions in the United States. This allows multi-center investigations without relying on inaccurate administrative data [18, 19]. NSQIP has been utilized previously for extensive urologic research; however, the program has been underutilized to evaluate enhanced recovery pathways and modes of anesthesia in the urologic domain. The purpose of

Fig. 1 Flow diagram: inclusion/exclusion

the present study was to determine the effect of anesthetic choice on readmission rate, length of stay, and complications in patients following partial/radical nephrectomy.

Our study did not show a reduction in procedure-related readmissions and complication rate in patients who underwent additional neuroaxial anesthesia as compared to general anesthesia alone. While studies within orthopedic and gynecologic domain often show benefits of neuroaxial anesthesia (i.e., spinal, epidural, and regional block) [14, 20], our study did not show this within urologic domain. The results of our study are in line with a prospective study published by Wongyingsinn et al., which focused on the effects of combined general and spinal anesthesia in patients undergoing colectomy, that found to change in postoperative complication rates [17]. The above-mentioned study, however, did note a decreased time of hospitalization in patients with neuroaxial anesthesia, a result not replicated in our study. In fact, our analysis demonstrated a prolonged hospitalization time in patients in the adjunct neuroaxial group.

Similarly, in contrast to previously published literature in vascular [21], and orthopedic surgery [22] that have revealed a lower odds ratio of respiratory complications in patients with neuroaxial anesthesia, our study after adjusting for multiple comorbidities and baseline demographic factors, did not find this to be true. The difference in both outcomes might be accounted by dissimilar population and surgical procedure as well as strict inclusion/exclusion guidelines with strict PSM matching. In addition, unlike previously published literature, our study did not demonstrate reduction in lower extremity DVT with neuroaxial anesthesia; however, this is likely due to small number [22 (0.9)] of patients within our cohort who developed a DVT.

Neuroaxial anesthesia is a frequently utilized strategy for pain control in patients undergoing open nephrectomy. One disadvantage of continuous epidural anesthesia and regional blocks is the need for a catheter and infusion pump, as well as urinary catheterization, further impeding early mobilization [23]. In our study, neuroaxial anesthesia was associated with increased length of stay, possibly due to the prohibitive

Table 1 Preoperative characteristics

	Before PSM			<i>p</i>	After PSM			<i>p</i>
	Overall	General anesthesia	Additional anesthesia		Overall	General anesthesia	Additional anesthesia	
<i>n</i>	2346	1759	587		1090	545	545	
Age: mean (SD)	61.9 (11.9)	61.8 (11.8)	62.1 (12.2)	0.653	62.2 (12.2)	61.9 (12.2)	62.4 (12.2)	0.528
BMI: mean (SD)	31 (7.3)	31.2 (7.2)	30.4 (7.5)	0.031	30.6 (7.4)	30.9 (7.2)	30.3 (7.5)	0.167
Race (%)				< 0.001				0.892
White	1596 (68.0)	1306 (74.2)	290 (49.4)		573 (52.6)	283 (51.9)	290 (53.2)	
Black or African American	202 (8.6)	171 (9.7)	31 (5.3)		68 (6.2)	37 (6.8)	31 (5.7)	
Other	90 (3.8)	67 (3.8)	23 (3.9)		46 (4.2)	23 (4.2)	23 (4.2)	
Unknown/not reported	458 (19.5)	215 (12.2)	243 (41.4)		403 (37.0)	202 (37.1)	201 (36.9)	
Male (%)	1515 (64.6)	1123 (63.8)	392 (66.8)	0.216	741 (68.0)	366 (67.2)	375 (68.8)	0.603
Diabetes (%)	582 (24.8)	450 (25.6)	132 (22.5)	0.147	261 (23.9)	141 (25.9)	120 (22.0)	0.156
Smoke (%)	429 (18.3)	319 (18.1)	110 (18.7)	0.79	208 (19.1)	103 (18.9)	105 (19.3)	0.939
Dyspnea (%)	171 (7.3)	127 (7.2)	44 (7.5)	0.896	91 (8.3)	49 (9.0)	42 (7.7)	0.511
Hx. COPD (%)	120 (5.1)	93 (5.3)	27 (4.6)	0.585	54 (5.0)	27 (5.0)	27 (5.0)	1
Hx. CHF ^a (%)	32 (1.4)	21 (1.2)	11 (1.9)	0.306	19 (1.7)	8 (1.5)	11 (2.0)	0.643
Hypertension on medications (%)	1522 (64.9)	1163 (66.1)	359 (61.2)	0.033	668 (61.3)	332 (60.9)	336 (61.7)	0.852
Acute renal failure (%)	20 (0.9)	17 (1.0)	3 (0.5)	0.435	5 (0.5)	2 (0.4)	3 (0.6)	1
On dialysis (%)	103 (4.4)	80 (4.5)	23 (3.9)	0.597	44 (4.0)	21 (3.9)	23 (4.2)	0.878
Chronic steroids use (%)	84 (3.6)	70 (4.0)	14 (2.4)	0.095	29 (2.7)	16 (2.9)	13 (2.4)	0.707
Weight loss ^b (%)	59 (2.5)	42 (2.4)	17 (2.9)	0.597	28 (2.6)	11 (2.0)	17 (3.1)	0.338
Bleeding disorder (%)	61 (2.6)	49 (2.8)	12 (2.0)	0.408	26 (2.4)	14 (2.6)	12 (2.2)	0.843
Preoperative transfusion ^c (%)	27 (1.2)	22 (1.3)	5 (0.9)	0.575	9 (0.8)	4 (0.7)	5 (0.9)	1
ASA ≥ 3 (%)	1670 (71.2)	1258 (71.5)	412 (70.2)	0.573	786 (72.1)	390 (71.6)	396 (72.7)	0.736
Functional status (%)				0.187				0.131
Independent	2301 (98.1)	1723 (98.0)	578 (98.5)		1069 (98.1)	533 (97.8)	536 (98.3)	
Dependent	35 (1.5)	30 (1.7)	5 (0.9)		16 (1.5)	11 (2.0)	5 (0.9)	
Unknown	10 (0.4)	6 (0.3)	4 (0.7)		5 (0.5)	1 (0.2)	4 (0.7)	
Preop hematocrit: mean (SD)	39.2 (6)	39.09 (6)	39.6 (5.8)	0.06	39.6 (5.7)	39.6 (5.6)	39.7 (5.8)	0.729

Bold values represent statistical significance ($p < 0.05$)

^aCongestive heart failure (CHF) in 30 days before surgery

^b> 10% loss body weight in last 6 months

^cPreop transfusion of ≥ 1 unit of whole/packed RBCs in 72 h prior to surgery

nature of the epidural catheter itself, and the complexity in co-management with the anesthesiology team. While the overall difference in length of stay between the general and the adjuvant neuroaxial anesthesia was only 0.5 days, at our institution, the direct costs associated with 0.5 day stay were \$1404 without the cost of neuroaxial anesthesia itself ranging from \$9267 for a regional block to \$13,071 for an epidural [24]. Thus, the addition of neuroaxial anesthesia in

open nephrectomy cohort does not provide clear 30-day differences in outcomes; quite on the contrary, it is associated with increased length of stay. With US healthcare expenditure now accounting for almost 18% of the country's gross domestic product, prevention of superfluous care is vital [25].

In the present study, CHF, ASA class, chronic dialysis, operative time, and preoperative hematocrit levels were all independent risk factors for any complication. In addition,

Table 2 Intra/postoperative outcomes

	Before PSM			<i>p</i>	After PSM			<i>p</i>
	Overall	General anesthesia	Additional anesthesia		Overall	General anesthesia	Additional anesthesia	
<i>n</i>	2346	1759	587		1090	545	545	
Any complication (%)	605 (25.8)	472 (26.8)	133 (22.7)	0.051	260 (23.9)	136 (25.0)	124 (22.8)	0.434
Postoperative infection								
Superficial incisional SSI (%)	32 (1.4)	25 (1.4)	7 (1.2)	0.835	14 (1.3)	9 (1.7)	5 (0.9)	0.42
Deep incisional SSI (%)	6 (0.3)	5 (0.3)	1 (0.2)	0.999	3 (0.3)	3 (0.6)	0 (0.0)	0.248
Organ/space SSI (%)	11 (0.5)	10 (0.6)	1 (0.2)	0.382	3 (0.3)	2 (0.4)	1 (0.2)	1
Urinary tract infection (%)	42 (1.8)	32 (1.8)	10 (1.7)	0.997	20 (1.8)	11 (2.0)	9 (1.7)	0.821
Sepsis (%)	11 (0.5)	9 (0.5)	2 (0.3)	0.86	4 (0.4)	2 (0.4)	2 (0.4)	1
Septic shock (%)	6 (0.3)	5 (0.3)	1 (0.2)	0.999	2 (0.2)	1 (0.2)	1 (0.2)	1
Wound disruption (%)	7 (0.3)	7 (0.4)	0 (0.0)	0.274	1 (0.1)	1 (0.2)	0 (0.0)	1
Respiratory complications								
Pneumonia (%)	47 (2.0)	32 (1.8)	15 (2.6)	0.351	23 (2.1)	8 (1.5)	15 (2.8)	0.206
Unplanned intubation (%)	30 (1.3)	22 (1.3)	8 (1.4)	1	14 (1.3)	6 (1.1)	8 (1.5)	0.788
Pulmonary embolism (%)	18 (0.8)	10 (0.6)	8 (1.4)	0.102	10 (0.9)	3 (0.6)	7 (1.3)	0.341
On ventilator greater than 48 h (%)	22 (0.9)	18 (1.0)	4 (0.7)	0.619	10 (0.9)	6 (1.1)	4 (0.7)	0.751
Renal complications								
Progressive renal insufficiency (%)	30 (1.3)	23 (1.3)	7 (1.2)	0.998	17 (1.6)	10 (1.8)	7 (1.3)	0.625
Acute renal failure (%)	28 (1.2)	25 (1.4)	3 (0.5)	0.124	10 (0.9)	7 (1.3)	3 (0.6)	0.341
Cardiovascular complications								
Stroke/CVA (%)	4 (0.2)	3 (0.2)	1 (0.2)	1	2 (0.2)	1 (0.2)	1 (0.2)	1
Cardiac arrest requiring CPR (%)	17 (0.7)	14 (0.8)	3 (0.5)	0.672	5 (0.5)	2 (0.4)	3 (0.6)	1
Myocardial infarction (%)	23 (1.0)	19 (1.1)	4 (0.7)	0.544	11 (1.0)	7 (1.3)	4 (0.7)	0.544
DVT (%)	22 (0.9)	20 (1.1)	2 (0.3)	0.137	6 (0.6)	4 (0.7)	2 (0.4)	0.682
Transfusions (intra- or post-operative) (%)	465 (19.8)	364 (20.7)	101 (17.2)	0.076	195 (17.9)	101 (18.5)	94 (17.2)	0.635
All-readmissions (%)	149 (6.4)	114 (6.5)	35 (6.0)	0.728	65 (6.0)	35 (6.4)	30 (5.5)	0.609
Procedure-related readmissions (%)	117 (5.0)	90 (5.1)	27 (4.6)	0.698	49 (4.5)	25 (4.6)	24 (4.4)	1
Reoperation (%)	31 (1.3)	25 (1.4)	6 (1.0)	0.6	9 (0.8)	4 (0.7)	5 (0.9)	1

Table 2 (continued)

	Before PSM			<i>p</i>	After PSM			<i>p</i>
	Overall	General anesthesia	Additional anesthesia		Overall	General anesthesia	Additional anesthesia	
Operative time (min): mean (SD)	163.7 (88.9)	166.6 (92.4)	154.7 (77.1)	0.005	159.7 (86.6)	164.1 (94)	155.4 (77.6)	0.096
Postoperative hospital stay (days): mean (SD)	4.9 (3.6)	4.8 (3.6)	5.3 (3.4)	0.004	5 (3.2)	4.8 (2.9)	5.3 (3.5)	0.007
Wound (%)	23 (1.0)	18 (1.0)	5 (0.9)	0.902	9 (0.8)	5 (0.9)	4 (0.7)	1

Bold values represent statistical significance ($p < 0.05$)

SSI surgical site infection, CVA cardiovascular accident

Table 3 Postoperative stay negative binomial regression analysis

	OR	(95% CI)	<i>p</i>
Additional anesthesia	1.107	1.042–1.176	0.001
Age	1.007	1.004–1.009	<0.001
Dyspnea	1.187	1.068–1.319	0.001
Hx. CHF	1.641	1.359–1.976	<0.001
Hx. COPD	1.12	0.98–1.277	0.092
ASA ≥ 3	1.086	1.011–1.168	0.025
Acute renal failure (%)	1.878	1.322–2.651	<0.001
Chronic dialysis	1.271	1.096–1.471	0.001
Operative time	1.001	1.001–1.001	<0.001
Preoperative hematocrit value	0.995	0.989–1	0.049

Bold values represent statistical significance ($p < 0.05$)

Table 4 Procedure-related readmissions: multivariable logistic regression analysis

	OR	(95% CI)	<i>p</i>
Additional anesthesia	0.966	0.537–1.736	0.909
Age	1.021	0.994–1.05	0.139
BMI	0.944	0.895–0.991	0.026
Dyspnea	2.589	1.064–5.661	0.024
Hypertension on meds	1.973	0.989–4.187	0.063
Operative time	1.004	1.001–1.007	0.004

Bold values represent statistical significance ($p < 0.05$)

patient's age, acute renal failure, and history of dyspnea were associated with prolonged hospitalization. These results are consistent with previous studies showing sex, older age, and multiple comorbidities to be significant predictors for complications and prolonged hospitalization [26, 27].

Our study design has several limitations. First and foremost, our data fail to capture postoperative pain control and opioid administration. In light of the ongoing opioid

Table 5 Any complication: multivariable logistic regression analysis

	OR	(95% CI)	<i>p</i>
Additional anesthesia	0.9	0.659–1.227	0.505
Age	1.012	0.998–1.026	0.091
Race			
White: reference			
Black or African American	0.68	0.333–1.318	0.27
Other	1.774	0.846–3.619	0.12
Unknown/not reported	0.777	0.548–1.097	0.155
Hx. CHF	4.103	1.448–12.375	0.009
Hx. COPD	1.807	0.954–3.346	0.063
ASA ≥ 3	1.496	1.019–2.226	0.043
Acute renal failure (%)	5.57	0.628–122.75	0.162
Chronic dialysis	0.393	0.154–0.9	0.036
Operative time	1.006	1.004–1.008	<0.001
Preoperative hematocrit value	0.879	0.854–0.905	<0.001

Bold values represent statistical significance ($p < 0.05$)

epidemic, the potential role of neuroaxial anesthesia in reduction of opioid administration cannot be overstated. Between 2000 and 2014 alone, drug overdose involving opioids rose 200% fueling widespread concern [28]. To put this in urologic context, in 2015 alone, there were more deaths related to opioid overdose (30,000) than to renal cell carcinoma (14,080) [29]. The distinguishing feature of the current epidemic of drug abuse is that many overdoses and deaths can be attributed to legal opioids that were prescribed by a physician [30]. Subtle reductions in opioid use postoperatively may produce large impact on this public health crisis.

Secondarily, we evaluated a large retrospective database, and while we have taken special care and adjusted in stepwise regression for all relevant confounding patient characteristics and clinical variables, there may be confounding with unobserved variables (not reported in NSQIP database). Furthermore, while NSQIP reports postoperative

outcomes, it does neither provide data on tumor stage, adjuvant chemoradiation, nor data on disease severity. Another inherent limitation lies in the uncertainty of quality of data collected from diverse population across multitude of locations. NSQIP database has been previously evaluated for heterogeneity and inter-observer agreement, with only 1.5% variance in 2008 [31], thus minimizing our concern. While there is evidence that neuroaxial anesthesia does not provide additional benefit in readmission rate, and complications, retrospective analysis does not imply causality. Despite the aforementioned limitations, this is the first and largest analysis in urologic literature on the use of adjunct anesthesia in open nephrectomy patients.

Conclusion

Using the 2014–2017 NSQIP database, we were able to demonstrate no difference in procedure-related readmissions and complications in the neuroaxial anesthesia group. Furthermore, patients who received neuroaxial anesthesia experienced a longer postoperative stay. Future prospective trials with increased focus on postoperative opioid consumption and early mobilization are encouraged.

Funding None.

Compliance with ethical standards

Conflict of interest All the authors declare that he/she have no conflict of interest.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

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