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Accuracy of the NSQIP risk calculator for predicting complications following adrenalectomy

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Abstract

Purpose Adrenalectomy is performed to treat functional pathology and remove tumors of malignant concern. The National Surgical Quality Improvement Program (NSQIP) risk calculator predicts 30-day complications and length of stay following index surgical procedures. We assess whether this tool accurately predicts complications following adrenalectomy procedures at a tertiary care academic medical center.

Methods A retrospective review was performed for all adrenalectomies at a single institution from 2004 to 2016. 197 patients underwent adrenalectomy without concurrent resections. Predicted risk for NSQIP complications was calculated for each patient. The mean predicted and observed risks (%) at 30 days across all patients within each category were determined, and these were compared with two-sided one-sample *t* tests.

Results Of 197 adrenalectomies, 180 were laparoscopic and 17 were open. For laparoscopic adrenalectomy, ten (5.5%) complications were observed including nine (5%) graded Clavien III or greater. All observed complication rates were significantly different than predicted (p values for all < 0.005). Mean observed length of stay was also significantly less than predicted (1.6 versus 2.1 days, $p < 0.001$). In the open adrenalectomy subgroup, there were no observed complications with observed mean length of stay equivalent to predicted (5.8 versus 5.3, $p = 0.08$) without a higher readmission rate (5.9 versus 6.0%).

Conclusions Statistical differences were noted between the actual complication rates of adrenalectomy versus those predicted by the NSQIP calculator. Certain observed differences may not necessarily have clinical significance. Urology procedure-specific calculators may better refine predictions for sub-specialty procedures with future work requisite to determine performance across all practice settings.

Keywords Adrenalectomy · Complications · NSQIP

Introduction

A current trend in patient counseling is to incorporate patient-specific information to personalize and better risk-stratify decision making. Traditionally, discussion of post-operative risks has been based on the literature review of complication rates and individual experience. The National Surgical Quality Improvement Program (NSQIP) of the American College of Surgeons helps participating hospitals track surgical complication data to aid health systems and surgeons identify areas for improvement [1]. The program has sought to improve the way we counsel patients pre-operatively by developing the NSQIP risk calculator [2]. This well-designed, easily accessible, online tool allows the provider to input a Current Procedural Terminology (CPT) code and a set of 19 patient characteristics to generate the

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predicted 30-day complication rates and length of stay in the context of a specific surgery.

Using data from 668 participating hospitals between 2011 and 2015, the database predicts complications based upon greater than 3.2 million operations. Original analysis of the calculator at the time of development supported its robustness in accurately predicting outcomes [3]. Multiple independent investigations have since compared the calculator's predicted outcomes for a given surgical procedure to those observed in a single or multi-institution's series. For example, in 2017, Winoker and colleagues reviewed a multi-institutional database and noted that the calculator appeared to underestimate complications following robot-assisted partial nephrectomy [4]. Subsequently, the calculator was found to poorly predict post-operative complications in patients undergoing radical cystectomy with urinary diversion [5]. In fact, multiple studies have examined the calculator's utility in other surgical specialties, often finding poor predictive capability in the context of specific procedures [6, 7]. The calculator's popularity, with 1500 hits per day [8], suggests that urologists would be interested in further assessment of the calculator's accuracy for urologic surgery.

Adrenalectomy is a surgery performed by urologists and general surgeons to treat functional pathology or to remove tumors of malignant concern [9]. The operative technique may be open or laparoscopic, with laparoscopic approach now considered the gold standard [10]. Limited research has evaluated the NSQIP risk calculator's accuracy for adrenalectomy whereby there may be less variability in operative technique than other investigated operative procedures. Thus, the objective of this study was to compare predicted and observed outcomes in a single institution of adrenalectomy procedures.

Methods

Adrenalectomies performed between December 2004 and June 2016 at a single tertiary care academic medical center were retrospectively reviewed following IRB approval. Cases were identified by querying billing data based on the following CPT codes: 60650—"Laparoscopy, surgical, with adrenalectomy, partial or complete, or exploration of adrenal gland with or without biopsy, transabdominal, lumbar or dorsal"; and 60540—"Adrenalectomy, partial or complete, or exploration of adrenal gland with or without biopsy, transabdominal, lumbar or dorsal (separate procedure)." Cases were included for all 12 surgeons who performed these operations and for male and female patients aged 18 and older. Exclusion criteria included concurrent resections of organs other than the adrenal gland or concurrent surgical procedures (such as nephrectomy) as well as lack of patient data available in the electronic medical record.

Electronic patient charts were reviewed to identify the 19 patient characteristics and risk factors required for input into the NSQIP risk calculator (Table 1). Detailed definitions and descriptions of these variables including possible input categories are provided by NSQIP [11]. Information for each patient was individually entered into the risk calculator and the predicted 30-day complication rates were generated. Actual occurrence of these complications and mortality within 30 days, as well as length of stay, was reviewed in patient charts and recorded. Predicted versus observed rates of each complication were compared using two-sided one-sample *t* tests. Significance was set at 0.05.

Results

There were 272 adrenalectomies performed between December 2004 and June 2016. Seventy-five cases were excluded due to concurrent resections, with 197 patient cases forming the basis for this analysis. These included procedures were performed by 10 surgeons, with 148 (75%) performed by 2 surgeons. Clinical and pathologic informations for our cohort are summarized in Table 2. In summary, mean patient age was 54 years, and 62% of patients were female. 180 surgeries were laparoscopic (10 of which were robotically assisted) and 17 were open. 118 cases (60%) were left sided, 69 cases (35%) were right sided, and 10 cases (5%) were bilateral. Of the adrenal glands removed, 174 (88%) were benign and 23 (12%) contained malignancy. Eighty-one (41%) contained lesions that were deemed to be functional;

Table 1 NSQIP risk calculator variables

Age group
Sex
Functional status
Emergency case
American Society of Anesthesiologists classification
Steroid use for chronic condition
Ascites within 30 days prior to surgery
Systemic sepsis within 48 h prior to surgery
Ventilator dependent
Disseminated cancer
Diabetes
Hypertension requiring medication
Congestive heart failure in 30 days prior to surgery
Dyspnea
Current smoker within 1 year
History of severe chronic obstructive pulmonary disease
Dialysis
Acute renal failure
Body mass index

Table 2 Clinical characteristics

Total patients	197	
Patient age (mean, range)	54	19–82
Female gender (#, %)	122	62%
Laparoscopic technique (#, %)	180	91%
Open technique (#, %)	17	9%
Left sided (#, %)	118	60%
Right sided (#, %)	69	35%
Bilateral (#, %)	10	5%
Benign pathology (#, %)	174	88%
Malignant pathology (#, %)	23	12%
Functional lesions (#, %)	81	41%
Non-functional lesions (#, %)	116	59%
Tumor size, spherical, in (mean cm^3, std), $n=154$	37	74
Estimated blood loss—laparoscopic (mean ml, std), $n=180$	60	100
Estimated blood loss—open (mean ml, std), $n=17$	890	870
Operative time—laparoscopic (mean mins, std), $n=102$	152	63
Operative time—open (mean mins, std), $n=15$	224	89

Table 3 Pathologic diagnosis distribution

Pathologic diagnosis	Frequency	Percentage (%)
Adrenal adenoma, nonfunctional	38	19.3
Pheochromocytoma/paraganglionoma	35	17.8
Adrenal adenoma, cortisol producing	23	11.7
Adrenal adenoma, aldosterone producing	19	9.6
Adrenal cortical hyperplasia	19	9.6
Metastasis, other than renal cell carcinoma	13	6.6
Benign cyst	10	5.1
Myelolipoma	8	4.1
Other	7	3.6
Metastasis, renal cell carcinoma	6	3.0
Ganglioneuroma	5	2.5
Hematoma	5	2.5
Pseudocyst	5	2.5
Adrenal cortical carcinoma	4	2.0
Total	197	100

Table 4 Laparoscopic adrenalectomy—comparison of predicted and observed outcomes ($n=180$)

Outcome	Predicted risk %	Observed %	p value*
Serious complication	4.2	5.0	<0.001
Any complication	5.0	5.6	<0.001
Venous thromboembolism	0.66	1.1	<0.001
Pneumonia	0.74	1.7	<0.001
Urinary tract infection	1.1	2.2	<0.001
Surgical site infection	0.93	1.7	<0.001
Readmission	4.9	6.1	<0.001
Discharge to rehabilitation	1.4	1.7	<0.005
Cardiac complication	0.19	0.0	<0.001
Renal failure	0.33	0.0	<0.001
Return to operating room	0.86	0.56	<0.001
Death	0.23	0.0	<0.001
Length of stay (days)	2.1	1.6	<0.001

*One-sample t test for mean predicted risk as compared to the observed value

Table 5 Open adrenalectomy—comparison of predicted and observed outcomes ($n=17$)

Outcome	Predicted risk %	Observed %	p value*
Serious complication	10	0.0	<0.001
Any complication	13	0.0	<0.001
Venous thromboembolism	1.1	0.0	<0.001
Pneumonia	2.2	0.0	<0.001
Urinary tract infection	2.3	0.0	<0.001
Surgical site infection	4.3	0.0	<0.001
Readmission	6.0	5.9	0.825
Discharge to rehabilitation	8.2	0.0	<0.001
Cardiac complication	0.58	0.0	<0.001
Renal failure	0.60	0.0	<0.001
Return to operating room	1.9	0.0	<0.001
Death	0.58	0.0	<0.001
Length of stay (days)	5.3	5.8	0.081

*One-sample t test for mean predicted risk as compared to the observed value

the patient exhibited signs or symptoms related to the pathology of the gland removed. The remaining 116 (59%) were functionally normal. Pathologic diagnoses of all specimens are reported in Table 3.

For the 180 (91.4%) patients who underwent laparoscopic adrenalectomy, 10 patients (5.5%) had complications including 9 (5%) serious by NSQIP criteria (Table 4). Observed rates were greater than predicted for serious and any complications, venous thromboembolism, pneumonia, urinary tract infection, surgical site infection, readmission, and discharge to rehabilitation (p for all <0.001). Observed rates were less than predicted rates for cardiac complications, renal failure, return to operating room, and death (p for all <0.001). Mean observed length of stay was significantly less than predicted (1.6 versus 2.1 days, $p<0.001$).

There were only 17 patients of 197 who underwent adrenalectomy by an open approach. None of these patients had complications, and therefore the complication rates were significantly less than predicted by the NSQIP calculator (Table 5). The observed and predicted readmission rates for the open group were not significantly different, and the

observed length of stay of 5.8 days was not significantly different than the predicted stay of 5.3 days ($p=0.081$).

Discussion

Approximately 4000 adrenalectomies are performed annually according to a Nationwide Inpatient Sample (NIS) study with 60% being performed by urologists [12]. Based upon prior analysis of a cohort of almost 5000 adrenalectomies recorded in the NSQIP database, the overall complication rate of adrenalectomy is 7.5% [13]. Forty percent of these occurred following discharge after a median length of stay of 2 days. Although 95.7% of the adrenalectomies in the NSQIP database were performed by general surgeons, there was found to be no difference in complication rates between urology and general surgery specialties [12].

The overall complication rate for patients undergoing laparoscopic adrenalectomy at our institution is comparatively low—5.5%. For a gold standard procedure, these data are reassuring. However, all observed complication rates for the laparoscopic approach in our series were significantly different than predicted by the NSQIP risk calculator. Specifically, the calculator provided overestimations of risk for four of its predicted outcomes, while underestimating the risk for eight others. For example, our average length of stay of 1.6 days following laparoscopic approach was significantly shorter than predicted (2.1 days), while predicted and observed lengths of stay following open approach were not significantly different. All the open cases were without complications; however, these observed complications rates were from an admittedly small sample size thereby limiting interpretation of the differences for the open approach.

Multiple factors may explain the calculator's ability to accurately predict our outcomes. Admittedly, these include factors such as (1) sample size of population studied as well as associated comorbidities of this patient population; (2) individual surgeon expertise and experience from a high volume tertiary care medical center; and (3) specific indications for surgery including tumor characteristics which are not captured in the NSQIP database. We elaborate, in greater detail, these considerations below.

While predicted rates are based on a large sample size of aggregated data, the low complication rate for an adrenalectomy permits each patient event to cause a marked change in observed rates. The risk factors used for the calculator tend to be more severe comorbidities such as renal failure, ventilator dependency, and systemic sepsis that are not seen in the typical relatively healthy patient undergoing adrenalectomy. Thus, despite incorporating 19 different variables into the calculator, most comparisons were made when patients had very few of the included risk factors. Perhaps the calculator's robustness would be more appropriate for surgery in medically comorbid patients with higher complication rates than for elective surgery in healthy patients with expectedly lower complication rates.

Additionally, given the design of the NSQIP risk calculator, it fails to take into account the factors specific to adrenalectomy which may be more pertinent to specific peri-operative risks. For example, a patient with hormonal abnormalities related to functional pathology may be more likely to experience adverse outcomes such as renal failure or post-operative adrenal insufficiency [14]. Tumor pathology (primary versus metastatic) or tumor size may affect operative time and complexity, and thus complication rates. Certainly, surgeon and institutional strengths and weaknesses can also influence each measured outcome. The calculator's predictive model averages data across many centers, whereas risk for an individual patient is likely influenced by the surgeon's experience and skill and the qualities and surgical volume of the institution. Specifically, the overall complication rate for our entire series of 197 patients was 4.6% (9 patients). When considering high volume versus low volume surgeons, we noted that the complication rate was 3.3% for high volume surgeons and 7.8% for the lower volume surgeons. ($p=0.26$) Thus, although not statistically significant, the difference when expanded to a population may cause differences in observed versus expected rates. Furthermore, patients presenting at a tertiary referral center such as ours may have inherent case selection bias not captured by the risk calculator that could further explain the differences that we observed.

Finally, it may be considered that the NSQIP risk calculator provides adequate estimates when considered for clinical significance. Absolute risk does not seem to differ greatly between the predicted and observed groups, often differing by less than a percentage point. One could suspect that such small differences would do little to impact patient selection or patient counseling. Furthermore, it may be valuable for the calculator to provide an estimated risk corridor as would be reasonable for any forecasting tool. Despite statistically significant differences in predicted and observed rates, the practicing urologist who recognizes the limitations of the calculator still may find benefit in utilizing it for certain patients. In 2017, Cohen et al. examined a series of studies such as ours that have found poor predictive ability of the calculator [8]. They identified common limitations of study design including small sample size, single institution data, and homogeneity of cases series. They conclude that despite demonstrable differences in outcomes in specific populations and settings, the NSQIP calculator maintains its utility as a broadly available objective tool for any surgeon to better understand the expected risk for an individual patient. Indeed, it would seem that particular differences observed in discrete study populations should not necessarily invalidate the tool's intended design for generalized use across

diverse practice settings and patient populations. It may also be impractical to expect that a multitude of risk stratification tools should be developed to account for each procedure and patient population. Furthermore, we acknowledge that there are many factors that may be impacting these complications outcomes including care pathways, post-operative protocols, as well as coordination of care to reduce readmissions. Collectively, these factors must be studied to improve outcomes and reduce complications. Finally, it is important to recognize that the adrenalectomy operation has indeed become far more safe over time. Indeed, complication rates from our experience and the NSQIP database are far lower than those reported for older cohorts with less contemporary surgical expertise. [15].

Conclusions

The NSQIP risk calculator both overestimates and underestimates post-operative complications following unilateral adrenalectomy at our institution. A procedure-specific risk stratification tool may be more appropriate for patient selection and counseling. The clinical significance of the differences observed, however, may be debated. Without more specific tools available, urologists may still find generally reliable utility in the NSQIP risk calculator in characterizing risk for their patients.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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