Risk factors associated with 30 day hospital readmission following partial nephrectomy

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Introduction: *To assess risk factors for unplanned readmission following open and minimally invasive partial nephrectomy (PN).*

Materials and methods: *From the National Surgical Quality Improvement Program database, patients with renal malignancy undergoing PN in 2011 or 2012 were reviewed. Using multivariable logistic regression, we identified variables associated with 30 day hospital readmission.*

Results: *Of the 2124 patients identified who underwent PN, 1253 (59%) were minimally invasive PN (MIPN) and 871 (41%) open PN (OPN). There were no differences in preoperative comorbidities between MIPN and OPN patients. The rate of unplanned hospital readmission for the entire cohort was 5%, which varied from 7% for OPN to 4% for MIPN. Seven percent of OPN and 2% of MIPN patients developed a Clavien grade III-V complication. For OPN, developing an in-hospital Clavien grade III-V complication was associated with a 6-fold increase in the odds of requiring subsequent readmission (95% CI 2.22-14.47, p < 0.001). For MIPN, an in-hospital Clavien grade III-V complication was associated with nearly 16 times increased odds of unplanned readmission (95% CI 6.08-41.65, p<0.001) and history of chronic anticoagulation was associated with a five times increased odds of unplanned readmission (95% CI 1.44-18.25, p = 0.012). Finally, operative time for MIPN was associated with increased odds of readmission (OR 1.08, 95% CI 1.04-1.16, p < 0.001). Patient comorbidities and ASA score were not associated with unplanned readmission for OPN or MIPN.*

Conclusions: *Patients developing high grade complications are at increased risk of subsequent unplanned readmission. These patients who develop significant in-hospital complications may benefit from increased post-discharge contact with healthcare providers and from preoperative counseling regarding their risk of unplanned readmission.*

Key Words: kidney cancer, partial nephrectomy, complications, readmission

Introduction

Ninety percent of primary renal malignancies are renal cell carcinoma (RCC), with approximately 271,000 new cases of RCC diagnosed worldwide in 2008.[1] The remaining 10% of renal malignancies include transitional cell carcinoma and other neoplasms. The increased frequency of abdominal imaging has contributed to the worldwide rising incidence of diagnosed renal tumors by about 2% per year until a few years ago.[1,2] Low stage, localized RCC comprise the majority of this increase, and this increase in diagnosis has resulted in an increased number of surgical operations to remove these tumors.[3,4]

Partial nephrectomy (PN) is currently the standard of care for small, localized renal tumors.[5] PN is traditionally performed using open surgery although minimally invasive techniques have become increasingly common throughout the last decade, with robotic-assisted laparoscopy now surpassing laparoscopic PN[6]. Patients undergoing open PN (OPN) often have larger, more complex tumors compared with patients undergoing minimally invasive PN (MIPN). Recent PN cohorts suggest that postoperative complications occur in up to 23% of patients.[6] As complications and hospital readmission are significant drivers of healthcare expenditures, we sought to

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identify 30 day postoperative complications and potentially modifiable perioperative factors that are associated with hospital readmission following PN.

Materials and methods

Data source and population

The National Surgical Quality Improvement Program (NSQIP) is a previously validated program of the American College of Surgeons[7] that has included enrollment of non-federal hospitals since 2004.[8] NSQIP was established to help hospitals systematically track 30 day postoperative surgical outcomes. Nationally trained Surgical Clinical Reviewers (SCR) prospectively collect information using patient records and phone interviews. We identified all partial nephrectomy patients from the 2011 and 2012 NSQIP Participant User Files using the relevant current procedural terminology (CPT) codes (50240 and 50543). Only patients operated on for renal malignancy, identified by international classification of diseases version 9 (ICD-9) code 189.0 were included for study. Patients identified by the SCR as having disseminated cancer were excluded from the study.

Outcome and variables

The primary outcome of the study was unplanned hospital readmission within 30 postoperative days for patients undergoing PN. Variables included in the study were broken into preoperative demographic and patient characteristics, intraoperative variables, and postoperative complications. Demographic and patient characteristics included sex, age, race (White, Black, Hispanic, Other, and unknown), body mass index (BMI), diabetes (none, non-insulin dependent, insulin dependent), smoking within the previous year, history of chronic obstructive pulmonary disease (COPD), history of hypertension requiring medication, history of cardiac disease (percutaneous coronary intervention, cardiac surgery, angina, heart attack, or congestive heart failure), history of transient ischemic attack (TIA) or stroke, history of requiring chronic anticoagulation, American Society of Anesthesiologists (ASA) score, and preoperative creatinine. Intraoperative variables included operative time and minimally invasive surgery (MIS) approach. Postoperative variables included length of stay (LOS), unplanned readmission, and complications. Because complications are predefined by NSQIP and we are unable to identify the interventions used to manage them, all complications were grouped using an adapted modified Clavien-Dindo classification system.[9-11] Clavien V was defined as death within 30 postoperative days. Clavien IV was defined by complications that would necessitate management in an intermediate or ICU setting, which included pulmonary embolism (PE), unplanned re-intubation, acute renal failure requiring dialysis, stroke with deficit, myocardial infarction, cardiac arrest requiring CPR, and septic shock. Clavien III was defined by a patient requiring unplanned reoperation. Clavien I and II included all other complications: surgical site infection (SSI) (superficial incisional, organ space, or deep incisional), wound disruption, pneumonia, urinary tract infection (UTI), sepsis, deep vein thrombosis (DVT) requiring treatment, and renal insufficiency. Minimally invasive surgery was defined by CPT code 50543. Because of relying upon CPT codes, we are unable to distinguish between laparoscopic and robotic-assisted surgery. Definitions for the variables are available from NSQIP.[8]

Statistical analyses

Descriptive analysis was performed using Pearson's chi-squared test for categorical variables and Student's t-test for normally distributed continuous variables. BMI was assessed as both a linear and categorical variable with similar statistical findings, thus we chose to use it as a linear variable throughout the analyses. Patients with missing data were included in the descriptive analysis but were eliminated from regression models. This resulted in the exclusion of less than 5% of patients. Postoperative complications included in the descriptive analysis were all complications occurring within 30 postoperative days. We further identified the most common reasons for unplanned readmission to the hospital for patients operated upon in 2012 (this was not a variable in NSQIP until 2012). Readmission data were not reported for 21% of PN.

In order to determine which preoperative, intraoperative, and postoperative variables (demographics and comorbidities from Table 1, operative time, LOS, and Clavien grade) were associated with 30 day unplanned hospital readmission, we performed multivariable logistic regression. To provide the greatest clinical relevance and to eliminate the potential for including a complication that was the direct cause of readmission, we only included postoperative complications that occurred prior to initial discharge from the hospital. As we are unable to account for tumor pathology or complexity as it is not recorded in the NSQIP database, separate regression models were used for OPN and MIPN. A priori $p < 0.05$ was set as the threshold for statistical significance in the descriptive analyses and final multivariable logistic regression models. All statistical analyses were performed using

TABLE 1. **Demographic and preoperative characteristics of patients undergoing partial nephrectomy**

Factor	Partial nephrectomy Open n = 861 (%)	Partial nephrectomy MIS n = 1263 (%)	p value[a]
Sex (female)	338 (39)	510 (40)	0.604
Age, mean (SD)	59.0 (12)	59.3 (12)	0.612
Race			0.120
White non-Hispanic	656 (76)	949 (75)	
Black	72 (8)	101 (8)	
Hispanic	49 (6)	52 (4)	
Other	19 (2)	30 (2)	
Not reported/unknown	65 (8)	131 (10)	
BMI, mean (SD)	31.3 (7)	30.6 (7)	0.019
Diabetes			0.181
None	680 (79)	1038 (82)	
Non-insulin dependent	128 (15)	160 (13)	
Insulin dependent	53 (6)	65 (5)	
Current smoker	157 (18)	285 (23)	0.016
COPD	40 (5)	61 (5)	0.845
Medicated hypertension	541 (63)	759 (60)	0.203
Cardiac history[b]	21 (2)	29 (2)	0.831
TIA or CVA	12 (1)	14 (1)	0.557
Chronic anticoagulation	24 (3)	27 (2)	0.337
ASA class			0.841
Class I-II	375 (44)	565 (45)	
Class III	463 (54)	667 (53)	
Class IV	23 (3)	31 (2)	
Preop creatinine, mean (SD)	1.05 (0.5)	0.97 (0.4)	< 0.001

MIS = minimally invasive surgery (robotic-assisted or laparoscopic); SD = standard deviation; BMI = body mass index; COPD = chronic obstructive pulmonary disease; TIA = transient ischemic attack; CVA = cerebrovascular accident
[a]p value represents Pearson's chi squared test for categorical variables and Student's t-test for continuous variables
[b]cardiac history includes history of percutaneous coronary intervention, cardiac surgery, angina, heart attack, or congestive heart failure

Stata version 12.1 (Statacorp, College Station, TX, USA). Institutional Review Board approval was obtained from Indiana University.

Results

There were 2124 patients who underwent PN for renal malignancy in the 2011 and 2012 NSQIP user files. Fifty-nine percent of PN patients were operated upon using minimally invasive surgery (MIS). There were no demographic differences between MIS and open patients although MIS patients had a lower BMI, Table 1. Aside from a smaller proportion of open patients being smokers, there were no differences in comorbidities between the groups. While operative time for MIS cases was 20 minutes longer than for open, LOS was 2 days longer for open PN ($p < 0.001$ each), Table 2.

Five percent of PN patients required unplanned readmission to a hospital, which was significantly higher among the open than MIS patients (7% versus 4%, $p = 0.006$), Table 2. Six percent of PN patients developed a 30 day postoperative complication, 11% of open and 3% of MIPN ($p < 0.001$). Fifty-nine (7%) open PN patients developed a Clavien grade III-V complication compared with 31 (2%) of MIPN ($p < 0.001$), Table 2. The most common reason for unplanned readmission following MIPN and OPN

TABLE 2. **Perioperative characteristics and 30 day postoperative complications of patients undergoing partial nephrectomy**

Factor	Partial nephrectomy		p value[a]
	Open n = 861 (%)	MIS n = 1263 (%)	
Operative time, mean (SD)	181.0 (80)	200.7 (72)	< 0.001
Length of stay, mean (range)	4.9 (0-30)	2.9 (0-34)	< 0.001
Unplanned readmission	57 (7)	50 (4)	0.006
Clavien grade I-II			
Surgical site infection[b]	20 (2)	11 (1)	0.004
Wound disruption	23 (3)	13 (1)	0.004
Pneumonia	24 (3)	6 (0.5)	< 0.001
Urinary tract infection	15 (2)	10 (1)	0.046
Deep vein thrombosis	11 (1)	2 (0.2)	0.003
Renal insufficiency	16 (2)	6 (0.5)	0.003
Sepsis	10 (1)	8 (0.6)	0.230
Clavien grade III			
Unplanned reoperation	28 (3)	26 (2)	0.086
Clavien grade IV			
Pulmonary embolism	4 (0.5)	3 (0.2)	0.451
Unplanned intubation	17 (2)	5 (0.4)	0.001
Acute renal failure requiring dialysis	10 (1)	0	--
Myocardial infarction	9 (1)	2 (0.2)	0.010
Cardiac arrest requiring CPR	5 (0.6)	2 (0.2)	0.127
Septic shock	6 (0.7)	1 (0.1)	0.020
Stroke with deficit	4 (0.5)	0	--
Clavien grade V			
Death within 30 days	5 (0.6)	2 (0.2)	0.127
Any Clavien grade III-V complication	59 (7)	31 (2)	< 0.001
Any complication	92 (11)	40 (3)	< 0.001

MIS = minimally invasive surgery (robotic-assisted or laparoscopic); SD = standard deviation
[a]p value represents Pearson's chi squared test for categorical variables, Student's t-test for the continuous variables, and Fisher's exact test when less than 10 occurrences
[b]superficial, organ space, or deep SSI

in 2012 was bleeding complications, although wound disruption and infection were also common for the OPN, Figure 1.

Among patients undergoing MIPN, presence of an in-hospital Clavien III or IV complication was associated with 16 times increased odds of unplanned readmission to the hospital, Table 3. History of chronic anticoagulation (OR 5.12) and 10 minute increases in operative time (OR 1.08) were additionally associated with unplanned readmission following MIPN. Examining the patients undergoing OPN, presence of an in-hospital Clavien III or IV complication was associated with nearly six times increased odds of unplanned hospital readmission, Table 3. Patient comorbidities and the ASA score were not significant predictors of unplanned readmission following MIPN or OPN.

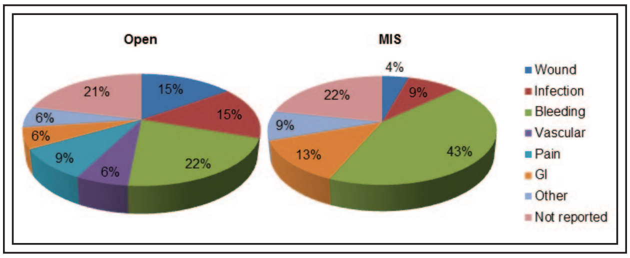

Figure 1. Reasons for unplanned readmission in 2012.

TABLE 3. **Variables associated with unplanned readmission following partial nephrectomy(PN)**

	Open PN		Minimally invasive PN	
	Odds ratio (95% CI)	**p value**	**Odds ratio (95% CI)**	**p value**
Sex (female)	1.31 (0.73-2.34)	0.364	1.35 (0.72-2.54)	0.354
Age[a]	0.82 (0.64-1.05)	0.113	0.79 (0.59-1.07)	0.126
Body mass index	1.02 (0.98-1.06)	0.344	0.97 (0.92-1.02)	0.244
Diabetes	0.94 (0.45-1.96)	0.871	1.92 (0.89-4.12)	0.096
Smoker	0.81 (0.39-1.70)	0.582	1.18 (0.57-2.46)	0.650
COPD	omitted	--	0.74 (0.15-3.59)	0.706
Medicated hypertension	1.28 (0.67-2.45)	0.464	0.85 (0.40-1.81)	0.670
Chronic anticoagulation	2.56 (0.66-9.93)	0.175	5.12 (1.44-18.25)	0.012
ASA score				
I-II	Reference	--	Reference	--
III	0.61 (0.33-1.12)	0.112	1.14 (0.55-2.35)	0.727
IV	omitted*	--	0.88 (0.13-6.05)	0.898
Length of stay	0.90 (0.80-1.02)	0.091	1.07 (0.97-1.19)	0.177
Operative time[b]	1.03 (1.00-1.06)	0.094	1.08 (1.04-1.16)	< 0.001
Clavien complication[c]				
No complication	Reference	--	Reference	--
Clavien I-II	2.57 (0.78-8.48)	0.121	1.48 (0.16-13.88)	0.732
Clavien III-IV	5.67 (2.22-14.47)	< 0.001	15.92 (6.08-41.65)	< 0.001

Multivariable logistic regression models are adjusted for all variables in the table.
COPD = chronic obstructive pulmonary disease; ASA = American Society of Anesthesiologists
*for open PN, ASA class was considered binary (ASA I-II versus ASA III-IV) as all patients with ASA IV required unplanned readmission
[a]age is in 10 year increments; [b]operative time is in 10 minute increments; [c]in-hospital complication

Discussion

In this study we explored postoperative complications and how these complications along with patient comorbidities are related to subsequent hospital readmission in OPN and MIPN patients. Presence of a high grade complication during the index hospitalization was the strongest predictor of patients requiring subsequent unplanned readmission following open and MIPN, independent of comorbidities. As reimbursement patterns evolve with recent policy changes, it is important that we understand that a significant proportion of patients developing high grade complications (Clavien III-V) will require subsequent readmission and that this should not negatively influence hospital and provider reimbursement.

According to a recent systematic review, the overall complication rate following OPN is 14%.[12] Similarly, we report that 11% of OPN patients in the NSQIP database developed a postoperative Clavien grade I-V complication. The most common Clavien I-II complications we report were surgical site infections, which were present in 2% of the OPN cohort. This corresponds with the findings of Kim et al who reported SSI in 1.3% of OPN.[13] Three percent of the OPN patients required unplanned reoperation and 7% required unplanned readmission. This is similar to the findings of Tan et al who reported that 9% of OPN required readmission within 30 days.[14]

Complications following MIPN vary by when the operation was performed, early during the adoption of minimally invasive techniques to more recently once adoption has become fairly universal in the treatment of small renal masses.[5,14] Based on the findings of a recent systematic review, nearly 19% of laparoscopic PN develop complications.[12] This represents the number for pure laparoscopic PN rather than including robotic assisted PN, which has become increasingly accepted as standard in recent years because of the reconstructive nature of the procedure and studies demonstrating improved complication rates.[15] In our study, only 3% of MIPN patients developed complications, which likely underestimates the true number as it does not include patients who developed urinary fistula or pseudoaneurysms (unavailable from NSQIP). Our findings are in line with other recent studies, however, such as Lesage et al who reported a comparably low incidence of surgical site infections[16] and Ficarra et al who noted a 4.5% incidence of high grade complications[17] among robotic assisted PN. Four percent of the MIPN patients required unplanned readmission, which is comparable to numbers reported recently by Brandao et al who found a 4.5% 30 day readmission rate at their institution following robotic assisted PN.[18]

Few studies have examined potentially modifiable factors associated with readmission following PN. In a recent study examining factors associated with readmission following robotic assisted PN, Brandao et al reported that only the Charlson Comorbidity Score (≥ 5) was significantly associated with increased odds of readmission.[18] Although we were unable to calculate a Charlson Comorbidity Score, we generally found that individual comorbidities were not associated with increased risk of readmission. The one exception to this was the fact that patients undergoing MIPN with a history of chronic anticoagulation were at five times increased odds of unplanned readmission. In contrast we report that in-hospital Clavien III-IV complications are the most significant predictors of unplanned readmission after both open and MIPN.

In an unexpected finding, we found that increasing operative time was associated with small increases in the odds of unplanned readmission. Operative time may be a proxy for operative complexity or an inexperienced surgeon performing the operation.[19] This relationship, however, might also be explained by an independent relationship between operative time and complications as recent surgical literature has suggested that operative time can be a significant risk factor for complications and increased LOS.[20-22] Because NSQIP does not provide pathologic details, we are unable to control for confounding associated with differences in pathologic stage or tumor complexity, which is certainly a limitation of our study, and likely contributes to the operative time. However, Stephenson et al reported an association between longer operating times and increased risk of postoperative complications following PN after controlling for tumor pathology.[23] Additionally, they found increased risk of readmission associated with increasing postoperative complication severity, which leads us to believe that there may be an added risk of complications and readmission associated independently with operative time.

Identifying modifiable risk factors of unplanned readmission is important for optimizing patient care and minimizing hospital and provider penalties. Tumor complexity is non-modifiable, and although it will impact the surgeon's approach, it cannot be readily influenced or improved prior to intervention. Smaller tumors that are amenable to PN can provide time for patient optimization for the surgical procedure. Patient comorbidities and ASA score have previously been shown to be independently associated with postoperative readmission in surgical patients.[24-26] For instance, poor glycemic control in the perioperative period is associated with increased rates of postoperative infectious complications.[25] Additionally, patients undergoing nephrectomy who are on chronic anticoagulation are known to be at increased risk of postoperative complications.[26] Interestingly, aside from chronic anticoagulation in the MIPN cohort, we found that no patient comorbidities were associated with increased risk of unplanned readmission. Rather, only presence of a Clavien III or IV complication consistently predicted readmission, which highlights the importance of in-hospital prophylaxis and care pathways in preventing subsequent readmissions.

This study has limitations that are worth discussing. As the data is from a national database, the quality of data is reliant upon the data collected at individual hospitals. Although NSQIP surgical clinical reviewers are trained in a standardized fashion and audited annually, variation may remain. There were only 107 unplanned readmissions for PN cases; thus, the strength of our conclusions is based on a limited number of events. NSQIP does not include pathologic information, so we were unable to explore the impact of tumor complexity or pathology on unplanned readmission; however, by using PN which is performed primarily in the setting of small renal masses and separating the open and MIS approaches, we have attempted to minimize the impact of this limitation. Regardless of these limitations, we feel that this study represents a significant contribution to our understanding of factors pre-disposing PN patients to unplanned hospital readmission.

Conclusions

Seven percent of patients undergoing OPN and 4% of patients undergoing MIPN required unplanned readmission to the hospital. Predictors of readmission following PN were operative time and Clavien grade III-V complications. Chronic anticoagulation was additionally associated with readmission following MIPN. Counseling patients and family members of expected rates of complications and their influence on unplanned readmission is critical during preoperative counseling. Additionally, closer post-discharge monitoring of patients with significant in-hospital complications may aid in preventing subsequent readmission and avoiding monetary penalties associated with readmission. □

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