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Predicting Length of Stay after Robotic Partial Nephrectomy

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Abstract

Introduction—To investigate factors predictive of length of stay (LOS) after robotic partial nephrectomy (RPN) in an effort to identify patients suitable for RPN with overnight stay at outpatient surgical facilities.

Materials and Methods—Retrospective chart review of patients who underwent RPN at Memorial Sloan Kettering Cancer Center from January 2007 to July 2012 was conducted. Univariate and multivariate analyses were performed to identify the main predictors of LOS. The discrimination of the multivariate model was measured using the area under the curve (AUC); 10-fold cross-validation was performed to correct for over-fit.

Results—One hundred and eighty-six patients were included in the analysis; 84 (45%) had LOS of 1 day (median LOS, 2 day; interquartile range, 1–2). On univariate analysis, preoperative variables associated with LOS >1 included larger tumors ($P < 0.0001$), lower estimated glomerular filtration rate ($P = 0.003$), older age ($P = 0.006$), female gender ($P = 0.035$), and higher comorbidity score ($P = 0.015$); operative variables associated with LOS > 1 day included greater estimated blood loss ($P < 0.0001$) and longer operative ($P < 0.0001$) and ischemia ($P < 0.0001$) times. The AUC of the preoperative model was 0.61 (95% CI, 0.52–0.69) after 10-fold cross-validation.

Conclusions—LOS after RPN is influenced by age, gender, medical co-morbidities, and tumor size. However, when analyzed retrospectively, these factors had limited ability to predict LOS after RPN with sufficient accuracy to develop a prediction tool.

Keywords

Kidney neoplasms; nephrectomy; length of stay; ambulatory care

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Informed consent: Informed consent was obtained from all individual participants included in the study.

INTRODUCTION

Kidney cancer is the 6th most common cancer in men and 8th in women, with an estimated 65,150 new cases and 13,680 resultant deaths in 2013 [1]. The increased availability of cross-sectional imaging has seen a migration toward incidentally discovered smaller and earlier stage renal masses [2]. This trend, together with the recognition of the deleterious consequences of chronic kidney disease (CKD) [3], have reinforced the compelling indications for nephron-sparing surgery including minimally invasive approaches such as robotic partial nephrectomy (RPN)[4] which has been shown to result in equivalent surgical and oncologic outcomes when compared to the traditional open approach [5-8].

There is a current shift in the delivery of surgical care from hospital-based practices to the outpatient setting [9,10]. In 2006 there were an estimated 57.1 million surgical and nonsurgical procedures performed during 34.7 million ambulatory surgery visits, with 19.9 million occurring in hospital-based surgical centers[11]. Concurrent with the allocation of surgical procedures to the outpatient setting, there has been a steady increase in the adoption of clinical care pathways, which have demonstrated a safe decrease in postoperative lengths of stay (LOS) while meeting patient care standards and providing safe discharges [12].

We sought to identify factors that may be predictive of shorter postoperative convalescence and hospital stays in patients with renal malignancies who underwent RPN in order to create a predictive model to identify patients most likely to have LOS of 1 day (overnight).

MATERIALS & METHODS

Study Population

After institutional review board approval, a retrospective chart review of 189 patients with renal cell carcinoma who underwent RPN from January 2007 to July 2012 at Memorial Sloan Kettering Cancer Center (MSKCC) was conducted. Data collected included age, gender, race, body mass index (BMI), American Society of Anesthesiologists (ASA) co-morbidity score, estimated glomerular filtration rate (eGFR) calculated with the Chronic Kidney Disease Epidemiology Collaboration equation [13], serum albumin level, tumor size, tumor stage, operative time (from skin incision to closure), warm ischemia time (after hilar clamping), estimated blood loss (EBL), peri-operative blood product transfusions, postoperative complications (Clavien-Dindo classification) [14], LOS, and number of hospital re-admissions. Renal cell carcinoma subtypes and tumor sizes were obtained from final pathologic diagnoses. Clear cell subtypes were assigned a Fuhrman grade [15]. The American Joint Committee on Cancer (AJCC) 2002 TNM staging system for renal cell carcinoma was used [16].

Preoperative radiographs of all tumors were reviewed by the investigator (WMB) and assigned a R.E.N.A.L. nephrometry score [17], resulting in classification of complexity as related to resection: low (4–6), moderate (7–9), or high (10–12). This system has been shown to have a reasonable inter-observer reliability and an association with both operative and postoperative outcomes [18-20]. Three patients missing R.E.N.A.L. nephrometry scores were excluded and the study population consisted of 186 patients.

Surgical Technique

As previously described [7,21], depending on tumor location, RPN was completed via transperitoneal or retroperitoneal access using four to five ports (camera port, working arm ports [with a third arm if required for exposure], and assistant port). Bulldog clamps were applied to the renal artery for vascular control during the tumor resection. Interrupted absorbable sutures were applied to repair collecting system defects, followed by parenchymal hemostasis with hemostatic agents in bolster configuration. A closed suction drain was not placed unless there was clear entry into the collecting system [22].

MSKCC Clinical Pathway

All of the patients followed our institution's clinical care pathway for renal surgery, which was instituted in 2005. Preoperatively, patients were counseled regarding a potential 1- or 2-day stay and asked to follow a clear liquid diet on preoperative day 1. On the day of the surgery, immediately following the RPN, the patient was transferred to the post-anesthesia care unit (PACU), where postoperative vital signs were monitored closely and then every 4 hours, IV crystalloids were adjusted for weight and normal hemodynamic parameters. Laboratory testing was done at 1 hour following surgery. The evening after the RPN, clear liquid diet was initiated and patients were encouraged to be out of bed. Incentive spirometry was encouraged and supervised. Oral pain medications were given, and IV morphine was available on request for breakthrough pain; ketorolac was not routinely used. If a drain was present, drain fluid was sent for creatinine level testing at midnight. On postoperative day (POD) 1, laboratory studies were obtained; the drain was removed if creatinine levels were compatible with serum levels. The Foley catheter, if present, was removed and the patient's diet was advanced to full liquids.

Assistance with ambulation was provided until safe independence was demonstrated. Patients were cleared for discharge when they met the following criteria: clinically stable, pain controlled with oral pain medications, tolerance of a full liquid diet, able to perform activities of daily living independently, and cleared by physician. A rolling discharge policy was observed, allowing patients to be discharged home in the evening once they were cleared.

Statistical Analysis

After excluding 3 patients who were missing R.E.N.A.L. nephrometry scores, univariate and multivariate analyses based on individual data from 186 patients were performed to identify predictors of LOS. Rank-sum and chi-square tests were used to assess univariate significance with LOS greater than one day. A pre-specified multivariable logistic regression model was used to test for an association between LOS>1 day and the following preoperative variables: age, gender, race, BMI, ASA score (dichotomized as low [ASA I–II] or high [ASA III–IV]), eGFR, and R.E.N.A.L. nephrometry score (low vs. moderate vs. complex). Restricted cubic splines were used to test for nonlinearity in age, eGFR and BMI, but no evidence of non-linear relationship was found, therefore they were included in the model as linear variables. The area under the curve (AUC) was used to describe the discrimination of the multivariate model. Repeated ten-fold cross-validation was performed

to correct for over-fit. Statistical analyses were performed using the Stata 12.0 (StataCorp, College Station, TX).

RESULTS

Characteristics of the 186 patients included in the study are shown in Table 1: 84 patients (45%) had LOS $\leq$ 1 day (median age, 58 years) and 102 (55%) had LOS > 1 day (median age, 63 years). Median BMI was 30 kg/m² in both groups. Median preoperative tumor size was larger in patients who had LOS > 1 day (3.8 cm vs 2.4 cm). Among patients with LOS $\leq$ 1 day, 83% (70/84) had a pathological stage pT1 tumor and 8% (7/84) had pT3, whereas 72% (73/102) had pT1 and 18% (18/102) had pT3 disease in LOS > 1 day group.

On univariate analysis we found that higher age ($p=0.0006$), higher ASA (0.015), female gender (0.035), and lower eGFR ($p=0.003$) were all significantly related to LOS > 1 day after RPN (Table 1). After performing repeated 10-fold cross validation we found an AUC of 0.64 (95% C.I. 0.56-0.72), indicating our model cannot discriminate well between patients with LOS $\leq$ 1 and LOS > 1 day patients. However, when we investigated the unadjusted AUC, we saw that it was 0.71. The repeated 10-fold cross validation corrected the discrimination estimate by a large margin, suggesting that we have limited data available to create such a prediction tool. If a similar model was developed using the same set of predictors with more patient data available, we would expect the discrimination of that model to be higher.

Surgical Complications

In order to assure that we provided safe discharges for our patients, complications were captured within 30 days of surgery and graded according to the Clavien-Dindo classification for surgical complications [14]. As shown in Table 3, 5 (6%) patients with LOS $\leq$ 1 day experienced a complication with 90-days of surgery, and 15 (15%) with LOS > 1 day suffered complications, a difference that misses conventional levels of statistical significance (-9% , 95% CI -17% to -0.2% , $p=0.055$). After closely examining grade 2 and above complications, LOS $\leq$ 1 day had 4 (4.8%) vs. 12 (12%) in LOS > 1 day again with no statistically significant difference (-7% , 95% CI -15% to 0.7% , $p=0.09$).

DISCUSSION

There has been a shift in the delivery of surgical procedures away from hospitals to outpatient centers where effective care may be safely offered [9-11]. Several investigators have demonstrated that standardized care pathways can improve efficiency in delivery of care, decrease length of hospitalization, and provide safe discharge of patients with no increase in post-discharge complications [12,23-25]. Recent study has demonstrated the safety of 1-day hospitalization after RPN under such circumstances although analysis for patient factors influencing discharge were not evaluated [26].

This study identifies several features associated LOS among this patient population managed under a care pathway that is patient-centric, accounting for willingness and acceptance of such strategies. Findings indicated longer LOS was associated with pre-operative factors of

increased age, female gender, higher ASA scores, lower preoperative eGFR, and larger tumors. Both groups had similar re-admission and peri-operative blood products transfusion rates. We also noted no statistically significant differences in any complication between the two groups after stratifying post-operative complications by the Clavien-Dindo classification [14].

The association of higher co-morbidity scores with LOS > 1 day is well supported by reports in both the surgical [27,28] and urologic literatures [29] indicating medical co-morbidities prolong hospitalization. Women in our study tended to have longer LOS after RPN compared to men. This finding is in concordance with Sammon et al. [30] review of the Healthcare Cost and Utilization Project-Nationwide Inpatient Sample database noting female gender association with longer hospitalization after nephrectomy. This is an interesting topic that needs to be explored in future studies, as there is still paucity of data.

In this study, operative factors associated with LOS > 1 day were higher EBL, longer operative and ischemia times on univariate analysis and larger tumor size on multivariate analysis. To test the hypothesis that prolonged hospitalization was related to increased tumor complexity, we stratified the tumors using the R.E.N.A.L. [17] nephrometry score but then noted no significant differences between the two LOS groups on multivariable analysis. This finding may be either due to limitations of the R.E.N.A.L. scoring stratification or that tumor complexity only partially explained prolonged hospitalization, or both.

This study is limited by its retrospective nature and its inherent surgical selection bias as patients with complex tumors are more likely to undergo an open surgical approach, also patients with small renal masses and severe medical co-morbidities are more likely to undergo active surveillance with serial cross-sectional imaging. Similarly the inability to develop an accurate prediction model could be related to the small size of our cohort.

CONCLUSIONS

LOS after RPN is influenced by age, gender, medical co-morbidities, and tumor size. These variables, however, showed limited ability to predict LOS > 1 day after RPN with sufficient accuracy to develop a prediction tool for use in short-stay units or in conventional settings. Prospective studies are needed to identify novel, reliable preoperative predictors of postoperative course of RPN.

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Table 1

Characteristics of the 186 patients included in the analysis

	LOS 1 day (N=84; 45%)	LOS > 1 day (N=102; 55%)	P Value
Median age at nephrectomy, y (range)	58 (48-65)	63 (54-69)	0.006
Gender (%)			
Male	64 (76%)	63 (62%)	0.035
Female	20 (24%)	39 (38%)	
ASA score (%)			
1	10 (12%)	5 (5%)	0.015
2	39 (46%)	34 (33%)	
3	35 (42%)	59 (58%)	
4	0 (0%)	4 (4%)	
Median BMI, kg/m² (range)	30 (27-33)	30 (27-35)	0.7
Race (%)			
Caucasian	75 (89%)	87 (85%)	0.4
Other	9 (11%)	15 (15%)	
Median preoperative eGFR	79 (66-94)	67 (55-88)	0.003
R.E.N.A.L. nephrometry score (%)			
Low	36 (43%)	30 (29%)	0.11
Moderative	40 (48%)	55 (54%)	
High	8 (10%)	17 (17%)	
Median preoperative albumin, g/dL (range)	4.4 (4.2, 4.6)	4.4 (4.2, 4.6)	0.9
Median estimated blood loss, mL (range)	50 (28, 100)	175 (75, 300)	<0.0001
Blood transfusions received (%)	0 (0%)	3 (2.9%)	0.3
Median operative time, minutes (range)	148 (120-170)	186 (154-242)	<0.0001
Median preoperative tumor size, cm	2.5 (1.8, 3.5)	3.8 (2.4, 5.1)	<0.0001
Median procedure partial clamp duration/warm ischemia time, minutes (range)	18.0 (13.0-24.0)	28.0 (18.0-35.0)	<0.0001
Pathological stage (%)			
T0	4 (5%)	6 (6%)	0.3
T1	70 (83%)	73 (72%)	
T2	1 (1%)	3 (3%)	
T3	7 (8%)	18 (18%)	
Tx	2 (2%)	2 (2%)	
No. of re-admissions (%)	5 (6.0%)	9 (8.8%)	0.5

LOS, length of stay; ASA, American Society of Anesthesiologists; BMI, body mass index; eGFR, estimated glomerular filtration rate

Table 2

Results of multivariable analysis

Variable	Multivariable analysis		
	OR	95% CI	P value
Age	1.02	0.99-1.06	0.2
Gender (<i>male is the reference category</i>)	1.67	0.84-3.34	0.14
Other race (<i>Caucasian is the reference category</i>)	1.84	0.71-4.75	0.2
BMI	1.00	0.95-1.05	0.9
ASA score (<i>I-II is the reference category</i>)	1.58	0.78-3.20	0.2
Preoperative eGFR	0.98	0.97-1.00	0.076
R.E.N.A.L. nephrometry score			
Low	Ref	Ref	0.3
Moderate	1.60	0.81-3.13	
Complex	2.02	0.71-5.78	

OR, odds ratio; CI, confidence interval; BMI, body mass index; ASA, American Society of Anesthesiologists; eGFR, estimated glomerular filtration rate

Table 3

Postoperative complications stratified according to the Clavien-Dindo classification system

	LOS 1 (N=84)	LOS > 1 (N=102)	Difference	95% CI	p-value
Any Complication	5 (6.0%)	15 (15%)	−9%	−17%, −0.2%	0.055
Grade 2 Complication	4 (4.8%)	12 (12%)	−7%	−15%, 0.7%	0.090