Readmissions after major urologic cancer surgery

Jeffrey J. Leow, MBBS,[1] Giorgio Gandaglia, MD,[2] Akshay Sood, MD,[3] Nedim Ruhotina, MD,[1] Dane E. Klett, MD,[3] Jesse D. Sammon, MD,[3] Marianne Schmid, MD,[4] Maxine Sun, PhD,[5] Steven L. Chang, MD,[1] Adam S. Kibel, MD,[1] Quoc-Dien Trinh, MD[1]

[1]Center for Surgery and Public Health and Division of Urology, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA
[2]Vita-Salute San Raffaele University, San Raffaele Scientific Institute, Urological Research Institute, Milan, Italy
[3]VUI Center for Outcomes Research, Analytics and Evaluation, Henry Ford Health System, Detroit, Michigan, USA
[4]Department of Urology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany
[5]Cancer Prognostics and Health Outcomes Unit, University of Montreal Health Center, Montreal, Quebec, Canada

LEOW JJ, GANDAGLIA G, SOOD A, RUHOTINA N, KLETT DE, SAMMON JD, SCHMID M, SUN M, CHANGE SL, KIBEL AS, TRINH Q-D. Readmissions after major urologic cancer surgery. *Can J Urol* 2014; 21(6):7537-7546.

Introduction: *We examine the incidence and predictors of readmission after major urologic cancer surgery using a national, prospective-maintained database specifically developed to assess quality of surgical care.*

Materials and methods: *Patients undergoing major urologic cancer surgery (radical prostatectomy [RP], radical nephrectomy [RNx], partial nephrectomy [PNx]), radical cystectomy [RC]) in 2011 were identified using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) using Current Procedural Terminology (CPT) codes. Those readmitted within 30 days after surgery were identified. Multivariable logistic regression models examined the association between patient characteristics and the odds of readmission.*

Results: *Overall, we identified 5356 RP, 1301 RNx, 918 PNx and 623 RC patients, of which 206 (3.8%), 533 (6.8%), 348 (6.3%) and 129 (20.7%) were readmitted within 30 days respectively. Independent predictors of readmission for RP included age (Odds Ratio [OR]: 1.02, p = 0.02), American Society of Anesthesiology (ASA) score 3-5 (versus 1-2, OR: 1.35, p = 0.04), smoking status (OR: 1.53, p = 0.04), and the occurrence of wound complications (OR: 9.31, p < 0.001), thromboembolic (OR: 14.7, p < 0.001), and renal failure (OR: 1.62, p = 0.01) complications during the index hospitalization. For RC patients, the only predictor of readmission was age (OR: 0.98, p = 0.04). Predictors of readmission for RNx included higher ASA score (OR: 1.77, p = 0.03), and the presence of any complications during the index hospitalization (OR: 2.21, p = 0.03).*

Conclusions: *Several patient characteristics have a significant impact on the risk of 30 day readmission after major urologic cancer surgery. Our data suggests that improving prevention and management of complications during the index hospitalization may lead to a substantial decrease in readmission rates.*

Key Words: cystectomy, nephrectomy, postoperative complications, prostatectomy, readmissions

Accepted for publication September 2014

Acknowledgements
The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Address correspondence to Dr. Jeffrey J. Leow, Center for Surgery and Public Health, Brigham and Women's Hospital, One Brigham Circle, 1620 Tremont Street, Suite 4-020, Boston, MA, 02120 USA

Introduction

In recent years, health policymakers and legislators have developed numerous initiatives to reduce hospital readmissions as a means of lowering health expenditures and, more importantly, improving quality-of-care.[1,2] In 2012, the Center for Medicare and Medicaid Services (CMS) initiated the Hospital Readmissions Reduction Program, reducing overall hospital reimbursements to hospitals with above-average risk-adjusted readmission rates for several medical conditions, such as congestive heart failure and pneumonia. Moreover, there are plans to expand covered conditions and increase penalties by 2014.[3,4] As such, several studies have attempted to identify predictors of readmissions, which in turn would allow targeted preventive measures for high risk patients.[3,4] However, such efforts have been mainly limited to medical and non-urological surgical conditions,[4-8] and relatively few studies evaluated the risk of readmissions after major urologic surgery. This is exceptionally relevant for major urologic cancer procedures such as radical prostatectomy (RP), radical nephrectomy (RNx), partial nephrectomy (PNx), and radical cystectomy (RC), which are associated with substantial postoperative morbidity, and thus represent potential areas for substantial quality improvement in urological care.[9-12]

Considering the paucity of data, we sought to assess the rates and predictors of readmissions after major urologic cancer procedures using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP), a large prospectively-maintained surgical outcomes program that was specifically developed to assess the quality of surgical care, and prospectively collects perioperative data on preoperative risk factors, intraoperative variables, and 30 day postoperative morbidity for patients undergoing major surgical procedures in the United States.[13]

Materials and methods

Data source

The ACS NSQIP collects a sample of risk-adjusted surgical patient data from member hospitals to facilitate the assessment of outcome measures after surgery. Trained Surgical Clinical Reviewers prospectively collect data in a standardized format from clinical records.[13] Validated data from patients' medical charts allows quantification of 30 day risk-adjusted surgical outcomes, including post-discharge information. Researchers are able to use de-identified data from the Participant Use File released by the ACS NSQIP. We utilized the 2011 Participant User File containing data from over 315 participating sites with more than 442,149 cases.

Study population

Using Current Procedural Terminology (CPT) codes, we identified patients who underwent major urologic cancer surgery. Overall, there were a total of 10,298 patients who underwent RP (CPT codes: 55821; 55801; 55810; 55812; 55815; 55831; 55840; 55842; 55845; 55866), RNx (CPT codes: 50220-50236; 50545; 50546; 50548), PNx (CPT codes: 50240; 50543) and RC (CPT codes: 51590; 51595; 51596), during 2011. Extraction was limited to patients with a postoperative diagnosis of prostate cancer (International Classification of Disease 9th edition [ICD-9]: 185), and kidney cancer (ICD-9: 189), and bladder cancer (ICD-9: 188). This resulted in a final cohort of 8198 patients.

Covariates and outcomes

For each patient, data on age at surgery, gender (male, female), race (White, Other), American Society of Anesthesiology (ASA) physical status (1-2, 3-5), body mass index (BMI) (< 25, 25-30, > 30), smoking status (non-smoker, current smoker), alcohol use (< 2 or ≥ 2 drinks/day), preoperative comorbidities (diabetes mellitus, hypertension, cardiovascular disease, other), and postoperative complications that occurred during the index hospitalization (urinary tract infection [UTI], wound, cardiovascular, pulmonary, thromboembolic, renal failure, sepsis/shock) were collected. For patients treated with RC, the type of urinary diversion (continent diversion versus incontinent ileal conduit) was identified. The type of surgery was categorized in open versus minimally invasive. The primary outcome was the occurrence of readmission within 30 days after surgery, which was defined dichotomously and reported by participants to the NSQIP for procedures beginning January 2011.

Statistical analyses

Descriptive statistics of categorical variables focused on frequencies and proportions. Means, medians and interquartile ranges were reported for continuously coded variables. The chi-square and t-tests were used to compare proportions and medians, respectively.

Subsequently, multivariable logistic regression models were used to examine the association between preoperative covariates and the odds of 30 day readmission. Covariates consisted of age, gender (not for RP), race, ASA score, BMI, smoking status, type of urinary diversion (for RC), and type of surgical approach (open versus minimally invasive, not for RC). For RP, we also adjusted for the presence of each postoperative complication during the index admission. For the other three procedures (RNx, PNx and RC), due to the smaller number of readmission and complication events, we grouped all postoperative complications and adjusted for the presence of any complications.

As previously described, 30 day readmission is captured by NSQIP from the day of operation, not the day of discharge, inadvertently leading to immortal person-time bias where patients are not at risk of readmission ("immortal") until discharge.[4] Including immortal person-time equal to postoperative length of stay can underestimate the true 30 day post-discharge readmission rate. To circumvent this potential bias, we performed sensitivity analyses by excluding patients with a length of stay of over 14 days (n = 175), allowing most 30 day post-discharge readmissions to accrue, especially when most readmissions have been shown to occur in the 1st week post-discharge.[14]

All statistical analyses were performed using the R statistical package (R Foundation for Statistical Computing, Vienna, Austria), with a two-sided significance level set at $p < 0.05$. An institutional review board waiver was obtained prior to conducting this study, in accordance with institutional regulation when dealing with de-identified administrative data.

Results

Baseline characteristics

Overall, 5356 patients treated with RP, 1301 with RNx, 918 with PNx and 623 with RC during the year 2011 within the NSQIP database were identified. Of these, 206 (3.8%), 533 (6.8%), 348 (6.3%) and 129 (20.7%) patients treated with RP, RNx, PNx and RC experienced readmission after surgery, respectively. Table 1a-1d depicts the baseline characteristics of patients included in the study.

Among patients treated with RP, men who were readmitted within 30 days postoperatively were

TABLE 1a. **Baseline characteristics for 5356 patients treated with radical prostatectomy during 2011 in National Surgical Quality Improvement Program (NSQIP) hospitals**

	Total (n = 5356)	Readmitted (n = 206, 3.8%)	Not readmitted (n = 5150, 96.2%)	p value
Mean age at surgery (SD)	61.8 (7.2)	63.3 (7.7)	61.8 (7.1)	0.003
Race, n (%)				0.60
White	4230 (79.0)	166 (80.6)	4064 (78.9)	
Other	1126 (21.0)	40 (19.4)	1086 (21.1)	
ASA score, n (%)				0.001
1-2	3554 (66.4)	113 (54.9)	3441 (66.8)	
3-5	1802 (33.6)	93 (45.1)	1709 (33.2)	
Body mass index (kg/m^2), n (%)				0.06
< 25	1133 (21.2)	47 (22.8)	1086 (21.1)	
25-30	2473 (46.2)	79 (38.3)	2394 (46.5)	
> 30	1750 (32.7)	80 (38.8)	1670 (32.4)	
Smoking status, n (%)				0.03
Non smoker	4753 (88.7)	173 (84.0)	4580 (88.9)	
Current smoker	603 (11.3)	33 (16.0)	570 (11.1)	
Alcohol intake, n (%)				0.20
< 2 drinks/day	5225 (97.6)	198 (96.1)	5027 (97.6)	
> 2 drinks/day	131 (2.4)	8 (3.9)	123 (2.4)	
Preoperative comorbidities, n (%)				
Diabetes mellitus	582 (10.9)	32 (15.5)	550 (10.7)	0.04
Hypertension	2692 (50.3)	124 (60.2)	2568 (49.9)	0.004
Cardiovascular disease	157 (2.9)	10 (4.9)	147 (2.9)	0.10
Other medical comorbidities	216 (4.0)	15 (7.3)	201 (3.9)	0.03
Minimally invasive surgery	4309 (80.5)	150 (72.8)	4159 (80.8)	0.01
Postoperative complications during hospitalization				
Overall	104 (1.9)	28 (13.6)	76 (1.5)	< 0.001
Urinary tract infection	10 (0.2)	1 (0.5)	9 (0.2)	0.30
Wound complications	57 (1.1)	17 (8.3)	40 (0.8)	< 0.001
Cardiovascular	8 (0.1)	2 (1.0)	6 (0.1)	0.03
Pulmonary	13 (0.2)	1 (0.5)	12 (0.2)	0.40
Thromboembolic events	11 (0.2)	4 (1.9)	7 (0.1)	0.001
Renal failure	19 (0.4)	5 (2.4)	14 (0.3)	0.001
Sepsis/shock	16 (0.3)	3 (1.5)	13 (0.3)	0.02

TABLE 1b. **Baseline characteristics for 1301 patients treated with radical nephrectomy during 2011 in National Surgical Quality Improvement Program (NSQIP) hospitals**

	Total (n = 1301)	Readmitted (n = 87, 6.8%)	Not readmitted (n = 1214, 93.2%)	p value
Mean age at surgery (SD)	63.3 (12.3)	63.9 (14.2)	63.3 (12.1)	0.20
Gender, n (%)				0.70
Female	452 (34.8)	32 (36.8)	420 (34.6)	
Male	849 (65.2)	55 (63.2)	794 (65.4)	
Race, n (%)				0.80
White	1042 (80.1)	71 (81.6)	971 (80.0)	
Other	259 (19.9)	16 (18.4)	243 (20.0)	
ASA Score, n (%)				0.03
1-2	438 (33.7)	20 (23.0)	418 (34.4)	
3-5	863 (66.3)	67 (77.0)	796 (65.6)	
Body mass index (kg/m^2), n (%)				0.50
< 25	297 (22.8)	22 (25.3)	275 (22.7)	
25-30	446 (34.3)	25 (28.7)	421 (34.7)	
> 30	558 (42.9)	40 (46.0)	518 (42.7)	
Smoking status, n (%)				0.40
Non smoker	1053 (80.9)	86 (85.1)	1201 (80.6)	
Current smoker	248 (19.1)	1 (14.9)	13 (19.4)	
Alcohol intake, n (%)				0.80
< 2 drinks/day	1287 (98.9)	516 (98.9)	7206 (98.9)	
> 2 drinks/day	13 (1.1)	6 (1.1)	78 (1.1)	
Preoperative comorbidities, n (%)				
Diabetes mellitus	270 (20.8)	24 (27,6)	246 (20.3)	0.10
Hypertension	869 (66.8)	62 (71.3)	807 (66.5)	0.40
Cardiovascular disease	65 (5.0)	7 (8.0)	58 (4.8)	0.20
Other medical comorbidities	183 (14.1)	13 (14.9)	170 (14.0)	0.70
Minimally invasive surgery	777 (59.7)	51 (58.6)	726 (59.8)	0.60
Postoperative complications during hospitalization				
Overall	92 (7.1)	12 (13.8)	80 (6.6)	0.02
Urinary tract infection	5 (0.4)	1 (1.1)	4 (0.3)	0.30
Wound complications	27 (2.1)	4 (4.6)	23 (1.9)	0.10
Cardiovascular	15 (1.2)	3 (3.4)	12 (1.0)	0.07
Pulmonary	33 (2.5)	1 (1.1)	32 (2.6)	0.70
Thromboembolic events	13 (1.0)	2 (2.3)	11 (0.9)	0.20
Renal failure	26 (2.0)	3 (3.4)	23 (1.9)	0.20
Sepsis/shock	15 (1.2)	2 (2.3)	13 (1.1)	0.30

older current smokers, who had higher ASA scores, lower use of minimally invasive surgery, and higher prevalence of preoperative comorbidities and overall postoperative complications compared to their counterparts who were not readmitted, Table 1a; all $p \leq 0.05$.

As for patients treated with RNx, compared to those were not readmitted, readmitted patients had higher ASA Scores, and higher rates of overall postoperative complications, Table 1b; all $p \leq 0.03$). For patients treated with PNx, readmitted patients were younger but had higher rates of diabetes mellitus compared to their counterparts who did not experience readmission after surgery, Table 1c; all $p \leq 0.03$). Lastly, among RC patients, readmitted ones were younger, had higher rates of continent diversion and occurrence of sepsis/shock compared to those who did not experience a readmission, Table 1d; all $p \leq 0.03$).

TABLE 1c. **Baseline characteristics for 918 patients treated with partial nephrectomy during 2011 in National Surgical Quality Improvement Program (NSQIP) hospitals**

	Total (n = 918)	Readmitted (n = 58, 6.3%)	Not readmitted (n = 860, 94.7%)	p value
Mean age at surgery (SD)	59.1 (12.5)	57.1 (13.4)	59.2 (12.4)	0.03
Gender, n (%)				0.80
Female	361 (39.3)	24 (41.4)	337 (39.2)	
Male	557 (60.7)	34 (58.6)	523 (60.8)	
Race, n (%)				0.30
White	744 (81.0)	44 (75.9)	700 (81.4)	
Other	174 (19.0)	14 (24.1)	160 (18.6)	
ASA score, n (%)				0.50
1-2	386 (42.0)	27 (46.6)	359 (41.7)	
3-5	532 (58.0)	31 (53.4)	501 (58.3)	
Body mass index (kg/m^2), n (%)				0.90
< 25	168 (18.3)	11 (19.0)	157 (18.3)	
25-30	326 (35.5)	19 (32.8)	307 (35.7)	
> 30	424 (46.2)	28 (48.3)	396 (46.0)	
Smoking status, n (%)				0.60
Non smoker	718 (78.2)	44 (75.9)	674 (78.4)	
Current smoker	200 (21.8)	14 (24.1)	186 (21.6)	
Alcohol intake, n (%)				NA
< 2 drinks/day	904 (98.5)	58 (100)	846 (98.4)	
> 2 drinks/day	14 (1.5)	0 (0)	14 (1.6)	
Preoperative comorbidities, n (%)				
Diabetes mellitus	156 (17.0)	17 (29.3)	139 (16.2)	0.01
Hypertension	552 (60.1)	33 (56.9)	519 (60.3)	0.60
Cardiovascular disease	24 (2.6)	1 (1.7)	23 (2.7)	0.90
Other medical comorbidities	80 (8.7)	5 (8.6)	75 (8.7)	0.90
Minimally invasive surgery	529 (57.6)	30 (51.7)	499 (58.0)	0.40
Postoperative complications during hospitalization				
Overall	45 (4.9)	4 (6.9)	41 (4.8)	0.50
Urinary tract infection	2 (0.2)	0 (0)	2 (0.2)	NA
Wound complications	10 (1.1)	1 (1.7)	9 (1.0)	0.40
Cardiovascular	10 (1.1)	1 (1.7)	9 (1.0)	0.40
Pulmonary	16 (1.7)	1 (1.7)	15 (1.7)	0.99
Thromboembolic events	3 (0.3)	0 (0)	3 (0.3)	NA
Renal failure	12 (1.3)	1 (1.7)	11 (1.3)	0.50
Sepsis/shock	5 (0.5)	0 (0)	5 (0.6)	NA

Multivariable analyses

Among patients treated with RP, age at surgery, ASA score, smoking status, and postoperative complications represented the only independent predictors of readmission. Particularly, older patients (Odds Ratio [OR]: 1.02; 95% Confidence Intervals [CI]: 1.004-1.04; p = 0.02), those with ASA score 3-5 (versus ASA score 1-2, OR: 1.35; 95% CI: 1.00-1.82; p = 0.04), and smokers (OR: 1.53; 95% CI: 1.02-2.30; p = 0.04) were more likely to be readmitted. Additionally, the occurrence of wound complications, cardiovascular complications, thromboembolic events, and renal failure during the index hospitalization was significantly associated with increased odds of readmission, Table 2; all p ≤ 0.01).

TABLE 1d. **Baseline characteristics for 623 patients treated with radical cystectomy during 2011 in National Surgical Quality Improvement Program (NSQIP) hospitals**

	Total (n = 623)	Readmitted (n = 129, 20.7%)	Not readmitted (n = 494, 79.3%)	p value
Mean age at surgery (SD)	67.8 (10.9)	65.1 (11.9)	68.5 (10.6)	< 0.001
Gender, n (%)				0.80
Female	124 (19.9)	26 (20.2)	98 (19.8)	
Male	499 (80.1)	103 (79.8)	396 (80.2)	
Race, n (%)				0.10
White	534 (85.7)	116 (89.9)	418 (84.6)	
Other	89 (14.3)	13 (10.1)	76 (15.4)	
ASA score, n (%)				0.10
1-2	159 (25.5)	40 (31.0)	119 (24.1)	
3-5	464 (74.5)	89 (69.0)	375 (75.9)	
Body mass index (kg/m^2), n (%)				0.10
< 25	195 (31.3)	34 (26.4)	161 (32.6)	
25-30	237 (38.0)	47 (36.4)	190 (38.5)	
> 30	191 (30.7)	48 (37.2)	143 (28.9)	
Smoking status, n (%)				0.90
Non smoker	614 (76.5)	127 (76.0)	487 (76.5)	
Current smoker	9 (23.6)	2 (24.0)	7 (23.5)	
Alcohol intake, n (%)				0.90
< 2 drinks/day	3684 (98.6)	762 (98.4)	2922 (98.6)	
> 2 drinks/day	54 (1.4)	12 (1.6)	42 (1.4)	
Preoperative comorbidities, n (%)				
Diabetes mellitus	118 (18.9)	27 (20.9)	91 (18.4)	0.50
Hypertension	381 (61.2)	81 (62.8)	300 (60.7)	0.70
Cardiovascular disease	43 (6.9)	5 (3.9)	38 (7.7)	0.10
Other medical comorbidities	83 (13.3)	13 (10.1)	70 (14.2)	0.20
Postoperative complications during first hospitalization				
Overall	132 (21.2)	29 (22.5)	103 (20.9)	0.70
Urinary tract infection	25 (4.0)	4 (3.1)	21 (4.3)	0.80
Wound complications	71 (11.4)	14 (10.9)	57 (11.5)	0.99
Cardiovascular	11 (1.8)	1 (0.8)	10 (2.0)	0.50
Pulmonary	29 (4.7)	4 (3.1)	25 (5.1)	0.50
Thromboembolic events	12 (1.9)	3 (2.3)	9 (1.8)	0.70
Renal failure	18 (2.9)	4 (3.1)	14 (2.8)	0.80
Sepsis/shock	41 (6.6)	3 (2.3)	38 (7.7)	0.03
Type of urinary diversion, n (%)				0.01
Incontinent ileal conduit	479 (76.9)	87 (67.4)	392 (79.4)	
Continent diversion	144 (23.1)	42 (32.6)	102 (20.6)	

As for those treated with RNx, ASA score 3-5 (versus 1-2, OR: 1.77; 95% CI: 1.35-2.32; p = 0.03) and the occurrence of postoperative complications during the first hospitalization (OR: 2.21; 95% CI: 1.56-3.14; p = 0.03) represented the only independent predictors of readmission, Table 2. Our multivariate logistic regression model failed to identify significant predictors of readmission among patients treated with PNx, Table 2; all p ≥ 0.4). Finally, in patients treated with RC, younger age at surgery (OR: 0.98; 95% CI: 0.96-0.99; p = 0.04) represented the only independent predictor of readmission, Table 2.

TABLE 2. **Multivariable logistic regression analyses for 30 day readmission in patients treated with radical prostatectomy (RP), radical cystectomy (RC), radical nephrectomy (RN), and partial nephrectomy (PN) during 2011**

	RP (n = 5356) OR (95% CI)	p value	RN (n = 1301) OR (95% CI)	p value	PN (n = 918) OR (95% CI)	p value	RC (n = 623) OR (95% CI)	p value
Age at surgery	1.02 (1.00-1.05)	0.02	0.99 (0.98-1.00)	0.20	0.99 (0.97-1.01)	0.30	0.98 (0.96-0.99)	0.04
Gender								
Female	NA	NA	1 (ref)		1 (ref)		1 (ref)	
Male			0.89 (0.56-1.41)	0.60	0.93 (0.54-1.62)	0.80	0.95 (0.57-1.57)	0.80
Race								
White	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Other	0.86 (0.59-1.23)	0.40	0.87 (0.65-1.16)	0.60	1.39 (0.74-2.61)	0.30	0.63 (0.34-1.20)	0.20
ASA score								
1-2	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
3-5	1.35 (1.00-1.82)	0.04	1.77 (1.35-2.32)	0.03	0.86 (0.49-1.52)	0.60	0.76 (0.49-1.20)	0.20
Body mass index (kg/m^2)								
< 25	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
25-30	0.79 (0.54-1.15)	0.20	0.74 (0.54-1.01)	0.30	0.91 (0.41-1.98)	0.80	1.04 (0.63-1.74)	0.90
> 30	1.02 (0.69-1.51)	0.90	0.84 (0.63-1.12)	0.50	1.01 (0.47-2.11)	0.90	1.39 (0.83-2.36)	0.20
Smoking status								
Non smoker	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Current smoker	1.53 (1.02-2.30)	0.04	0.73 (0.51-1.03)	0.90	1.11 (0.57-2.14)	0.80	0.87 (0.53-1.43)	0.60
Type of urinary diversion								
Incontinent ileal conduit	NA	NA	NA	NA	NA	NA	1 (ref)	
Continent diversion							1.48 (0.93-2.39)	0.10
Minimally invasive surgery	0.78 (0.56-1.10)	0.10	1.05 (0.83-1.32)	0.90	0.79 (0.46-1.37)	0.40	NA	NA
Any postoperative complication during index admission	NA	NA	2.21 (1.56-3.14)	0.02	1.46 (0.49-4.34)	0.50	1.04 (0.64-1.67)	0.90
Urinary tract infection	0.11 (0.006-1.58)	0.10						
Wound complications	9.31 (4.85-17.85)	< 0.001						
Cardiovascular	12.66 (2.21-72.53)	0.004						
Pulmonary	0.16 (0.01-2.35)	0.20	NA	NA	NA	NA	NA	NA
Thromboembolic events	14.70 (3.64-59.31)	< 0.001						
Renal failure	5.22 (1.51-18.06)	0.01						
Sepsis/shock	1.62 (0.27-9.65)	0.60						

In sensitivity analyses excluding patients with length of stay > 14 days, the results were similar (data not shown). For RC, age was no longer a statistically significant predictor for readmissions (OR: 0.98; 95% CI: 0.96-1.002; p = 0.07).

Discussion

The National Committee for Quality Assurance has identified readmission following hospitalization as a target for health care quality improvement.[15]

Hospital readmissions may represent failures in discharge planning and follow up care, as well as missed opportunities for effective and coordinated managed care. Moreover, readmissions may indicate poor quality of care during the index admission, and are associated with increased perioperative morbidity and mortality. Taken together, readmissions lead to substantial - and potentially avoidable – health care expenditures.[16] In this light, the CMS have started publically reporting risk-adjusted readmission rates.[16] Additionally, a simple integer-based model consisting of ASA class and length of stay has recently been developed to identify individuals at higher risk of readmission after general, vascular, and thoracic surgery.[4] Conversely, evidence is scarce regarding the rates and predictors of readmission following major urologic cancer procedures. In this context, we sought to examine readmission rates and predictors of readmission in a large contemporary cohort of patients included in the ACS NSQIP undergoing major urologic cancer procedures.

Our findings are several-fold. First, we found substantial variations in the 30 day readmission rates across patients treated with RP, RNx, PNx and RC. Specifically, the incidence of 30 day readmissions was 3.8%, 6.8%, 6.3% and 20.7% for RP, RNx, PNx, and RC respectively. These figures corroborate findings from single,[10,11] multi-institutional series[17] and nationally representative series.[18] For example, a retrospective cohort study of patients who underwent inpatient urologic cancer surgery between 2003 and 2007 across 61 hospitals in the state of Washington recorded 30-day readmissions rates after RP, RNx and RC of 3.0%, 6.9% and 23.7% respectively.[17] Taken together, these study findings highlight the need for substantial efforts to reduce the risk of postoperative readmission in urological patients, particularly for RC where the readmission rate was the highest among all four procedures.

Second, several predictors of 30 day readmission were identified in patients treated with RP. Although many of these represent non-modifiable factors, namely age and ASA status, others are potentially modifiable. For example, our findings indicate that current smokers are at substantially higher odds of experiencing 30 day readmission after RP relative to their non-smoking counterparts. Smoking cessation prior to surgery, recommended by the American College of Surgeons, may decrease readmission rates. This might be mediated by decreased postoperative complications;[19] studies have found that preoperative smoking cessations reduces postoperative morbidity, with at least 4 weeks of abstinence reducing respiratory and wound complications.[20] Most importantly, the occurrence of postoperative complications during the index hospitalization was an independent predictor of 30 day readmission after surgery. These findings suggest that prevention and appropriate management of inpatient complications may avert subsequent readmissions.[4,21] More specifically, we showed that wound, cardiovascular, thromboembolic, and renal events were independently associated with 30 day readmissions in patients treated with RP. Of these, the strongest predictor of readmission was the occurrence of thromboembolic complications during the index hospitalization, with a 15-fold increased likelihood of readmission. As such, prevention of thromboembolic events through evidence-based process measures (e.g. thromboembolic prevention protocols) may result in lower readmission rates and prevent these undesirable expenditures. However, a study examining the association between hospital performance on Medicare's Hospital Compare process quality measures and 30 day readmission rates for patients undergoing major surgery showed that hospitals with greater compliance to standards did not achieve lower 30 day readmission rates.[5] The 9 process of care quality measures specific to surgery derived from CMS' Surgical Care Improvement Project all relate to perioperative care, e.g. receipt of prophylactic antibiotic 1 hr prior to incision and postoperative venous thromboembolism prophylaxis. This underscores that other mechanisms or interventions in preventing readmissions (e.g. discharge planning, home health services, outpatient follow up, care coordination) warrant further investigation.[3,4,22]

Third, for RNx, we again demonstrated that the occurrence of any postoperative complication predicted subsequent readmission. Patients who suffered any type of complication during their index admission for RNx had approximately 2-fold higher odds of readmission relative to those who did not experience any complication, Table 2. This phenomenon is similar to what has been observed in the general surgery literature, where postoperative complications have been identified to be the most significant independent risk factor.[23] A recent ACS-NSQIP study on the 20 procedures that account for the greatest number of readmissions showed that by reducing complication rates by just 5% would prevent 2092 readmissions and would to Medicare savings of $31.0 million annually.[21] Another approach to reduce postoperative complications after surgery, and consequently to reduce the risk of readmission, is the selective referral to specialized tertiary centers.[24] Unfortunately, the lack of data on hospital characteristics (e.g. hospital volume) in the ACS NSQIP prevented us from comprehensively addressing this issue. On the other hand, a recent study has found that hospitals with high surgical volume and low surgical mortality have lower rates of surgical readmissions,[2] thus highlighting the role of centralization of care for complex surgical procedures, such as RP, RNx, PNx and RC.[25] For RP, which is commonly being performed in the community, alternative approaches for decreasing complications may be necessary, such as shared learning of improve processes through regional surgical collaborative efforts.[26]

Fourth, patient selection plays an important role in outcomes after major urologic cancer surgery. We note that a substantial proportion of procedures were performed on old (all mean ages > 60), smoking (up to 23.6%) with high ASA scores (33.6% for RP, 66.3% for RNx, 58% for PNx and 74.5% for RC) and other comorbidities, Tables 1a-1d. More than 80% of RPs were minimally invasive procedures. Improved patient selection and being operated on by high-volume surgeons and hospitals may reduce complications and thereby readmissions.

Despite its strengths, our study is not devoid of limitations. First, the relatively small sample size and the low rate of events prevented us to identify independent predictors of readmission after RC and PNx. This was likely because ACS NSQIP only started collecting readmission data starting 2011. Nevertheless, for PNx, this finding was congruent with another recent SEER-Medicare study that found that laparoscopic PNx was not associated with lower readmission rates compared to open PNx.[27] Second, the ACS NSQIP assesses the occurrence of readmission within 30 days after surgery. However, a non-negligible proportion of patients might experience readmission after a longer time interval. Additionally, as previously reported, the lack of data on hospital characteristics prevented us to adjust our analyses for this important covariate. As such, it should be highlighted that the voluntary participation in ACS NSQIP requires resources, which may select for larger, high-volume institutions,[28] known to have lower rates of complications after surgery. That said, the ACS NSQIP consists of a wide variety of institutions from tertiary care centers, to smaller community hospitals. Third, for postoperative complications, we were not able to report the recommended standardized Clavien classification system,[29] nor were we able to report specific ones such as urine leak after PNx or lymphoceles and strictures after RP. Finally, although we utilized numerous important patient-level demographic and clinical factors in our multivariable model, we are limited by data captured by ACS NSQIP. There exists a risk of misclassification bias where procedures or diagnoses may be coded inaccurately. Additionally, several unmeasured confounders that may be associated with readmission include 1) disease severity (e.g. tumor stage or grade); 2) health care factors (e.g. perioperative care, nursing, discharge planning) and 3) social factors (e.g. discharge setting, informal caregivers, social support).[3,4,22]

While these limitations are important, the ACS NSQIP represents a prospectively collected cohort of patients that circumvents the potential pitfalls of previous studies relying on smaller institutional series or other population-based cohorts that utilize administrative data. Readmission data captured by the ACS NSQIP has also been externally validated at Northwestern Memorial Hospital,[30] showing very high agreement with chart review for identifying all-cause readmission events. The advantage of a clinical database like ACS NSQIP lies also in its ability to identify causes of readmission, as evidenced by strong concordance with chart review, while an administrative dataset was found to be much poorer.[30] These results can be used as baseline values for future quality initiatives and pay-for-performance standards.

Conclusions

Our study demonstrates that the risk of experiencing readmission after surgical procedures for urological malignancies is non-negligible, with the highest rates seen in RC. Preoperative patient characteristics have a significant impact on the risk of 30 day readmission. In addition, preventing in-hospital complications may reduce the incidence of readmissions after discharge, particularly for RP and RNx. □

References

1. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race and site of care. *JAMA* 2011;305(7):675-681.
2. Tsai TC, Joynt KE, Orav EJ, Gawande AA, Jha AK. Variation in surgical-readmission rates and quality of hospital care. *N Engl J Med* 2013;369(12):1134-1142.
3. Kansagara D, Englander H, Salanitro A et al. Risk prediction models for hospital readmission: a systematic review. *JAMA* 2011;306(15):1688-1698.
4. Lucas DJ, Haider A, Haut E et al. Assessing readmission after general, vascular, and thoracic surgery using ACS-NSQIP. *Ann Surg* 2013;258(3):430-439.
5. Stefan MS, Pekow PS, Nsa W et al. Hospital performance measures and 30-day readmission rates. *J Gen Intern Med* 2013;28(3):377-385.

6. Krumholz HM, Lin Z, Keenan PS et al. Relationship between hospital readmission and mortality rates for patients hospitalized with acute myocardial infarction, heart failure, or pneumonia. *JAMA* 2013;309(6):587-593.
7. Goodney PP, Stukel TA, Lucas FL, Finlayson EV, Birkmeyer JD. Hospital volume, length of stay, and readmission rates in high-risk surgery. *Ann Surg* 2003;238(2):161-167.
8. Rochefort MM, Tomlinson JS. Unexpected readmissions after major cancer surgery: an evaluation of readmissions as a quality-of-care indicator. *Surg Oncol Clin N Am* 2012;21(3):397-405.
9. Sejima T, Iwamoto H, Masago T et al. Oncological and functional outcomes after radical nephrectomy for renal cell carcinoma: a comprehensive analysis of prognostic factors. *Int J Urol* 2013;20(4): 382-389.
10. Roghmann F, Trinh QD, Braun K et al. Standardized assessment of complications in a contemporary series of European patients undergoing radical cystectomy. *Int J Urol* 2014;21(2):143-149.
11. Sugihara T, Yasunaga H, Horiguchi H et al. Comparisons of perioperative outcomes and costs between open and laparoscopic radical prostatectomy: a propensity-score matching analysis based on the Japanese Diagnosis Procedure Combination database. *Int J Urol* 2013;20(3):349-353.
12. Moran PS, O'Neill M, Teljeur C et al. Robot-assisted radical prostatectomy compared with open and laparoscopic approaches: a systematic review and meta-analysis. *Int J Urol* 2013;20(3):312-321.
13. Henderson WG, Daley J. Design and statistical methodology of the National Surgical Quality Improvement Program: why is it what it is? *Am J Surg* 2009;198(5 Suppl):S19-S27.
14. Schneider EB, Hyder O, Brooke BS et al. Patient readmission and mortality after colorectal surgery for colon cancer: impact of length of stay relative to other clinical factors. *J Am Coll Surg* 2012;214(4):390-398; discussion 398-399.
15. NCQA. 2012 Insights for Improvement - Reducing Readmissions: Measuring Health Plan Performance. Washington, DC: National Committee for Quality Assurance;2012.
16. Jencks SF. Defragmenting care. *Ann Intern Med* 2010;153(11): 757-758.
17. Gore JL, Wright JL, Daratha KB et al. Hospital-level variation in the quality of urologic cancer surgery. *Cancer* 2012;118(4):987-996.
18. Prasad SM, Gu X, Kowalczyk KJ, Lipsitz SR, Nguyen PL, Hu JC. Morbidity and costs of salvage vs. primary radical prostatectomy in older men. *Urol Oncol* 2013;31(8):1477-1482.
19. Thomsen T, Villebro N, Moller AM. Interventions for preoperative smoking cessation. *Cochrane Database Syst Rev* 2010(7):CD002294.
20. Wong J, Lam DP, Abrishami A, Chan MT, Chung F. Short-term preoperative smoking cessation and postoperative complications: a systematic review and meta-analysis. *Can J Anaesth* 2012;59(3): 268-279.
21. Lawson EH, Hall BL, Louie R et al. Association between occurrence of a postoperative complication and readmission: implications for quality improvement and cost savings. *Ann Surg* 2013;258(1):10-18.
22. Martin RC, Brown R, Puffer L et al. Readmission rates after abdominal surgery: the role of surgeon, primary caregiver, home health, and subacute rehab. *Ann Surg* 2011;254(4):591-597.
23. Kassin MT, Owen RM, Perez SD et al. Risk factors for 30-day hospital readmission among general surgery patients. *J Am Coll Surg* 2012;215(3):322-330.
24. Stitzenberg KB, Wong YN, Nielsen ME, Egleston BL, Uzzo RG. Trends in radical prostatectomy: centralization, robotics, and access to urologic cancer care. *Cancer* 2012;118(1):54-62.
25. Stitzenberg KB, Sigurdson ER, Egleston BL, Starkey RB, Meropol NJ. Centralization of cancer surgery: implications for patient access to optimal care. *J Clin Oncol* 2009;27(28):4671-4678.
26. Share DA, Campbell DA, Birkmeyer N et al. How a regional collaborative of hospitals and physicians in Michigan cut costs and improved the quality of care. *Health Aff (Millwood)* 2011;30(4): 636-645.
27. Tan HJ, Wolf JS, Jr, Ye Z, Hafez KS, Miller DC. Population level assessment of hospital based outcomes following laparoscopic versus open partial nephrectomy during the adoption of minimally invasive surgery. *J Urol* 2014;19(5):1231-1237.
28. Sun M, Ravi P, Karakiewicz PI et al. Is there a relationship between leapfrog volume thresholds and perioperative outcomes after radical cystectomy? *Urol Oncol* 2014;32(1):27.
29. Gakis G, Efstathiou J, Lerner SP et al. ICUD-EAU International Consultation on Bladder Cancer 2012: Radical cystectomy and bladder preservation for muscle-invasive urothelial carcinoma of the bladder. *Eur Urol* 2013;63(1):45-57.
30. Sellers MM, Merkow RP, Halverson A et al. Validation of new readmission data in the American College of Surgeons National Surgical Quality Improvement Program. *J Am Coll Surg* 2013;216(3):420-427.