The Perioperative Morbidity of Transurethral Resection of Bladder Tumor: Implications for Quality Improvement

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OBJECTIVES To characterize the perioperative morbidity of transurethral resection of bladder tumor (TURBT) in order to identify important determinants of both quality and cost in the delivery bladder cancer care.

METHODS We identified 24,100 patients aged 18-89 years who underwent TURBT from 2010 to 2015 in the National Surgical Quality Improvement Program database. Multivariable logistic regression was performed to evaluate the associations of patient features and tumor size (<2 cm, 2-5 cm, or >5 cm) with 30-day perioperative outcomes.

RESULTS Thirty-day postoperative complications occurred in 5.1% of patients, perioperative blood transfusion in 1.5% of patients, hospital readmission in 3.7% of patients, reoperation in 1.5% of patients, and mortality in 0.8% of patients. The most common reasons for readmission were bleeding (29%) and infectious (21%) complications. Although several patient features were associated with increased perioperative morbidity on multivariable analysis, including congestive heart failure, renal failure, higher American Society of Anesthesiology class, and dependent functional status, only larger tumor size was independently associated with increased risks of all perioperative endpoints.

CONCLUSION Perioperative morbidity following TURBT is substantial and represents an important target for quality improvement. Extent of resection, patient functional status, and specific comorbidities are independently associated with increased risks of perioperative morbidity and mortality. These results have implications for patient counseling, perioperative management, and quality improvement programs. UROLOGY 125: 131–137, 2019. © 2018 Elsevier Inc.

Bladder cancer is the sixth most common cancer in the United States with an estimated 79,000 new cases diagnosed in 2017[1] and one of the costliest diseases with estimated annual treatment costs of $4 billion in the United States.[2] Given that approximately 75% of incident cases represent non–muscle-invasive bladder cancer (NMIBC),[3] high treatment costs are primarily driven by the need for long-term cystoscopic surveillance and repeated endoscopic treatments for disease recurrence.[4-6] Transurethral resection of bladder tumor (TURBT) remains a critical component in the management of NMIBC. It is the standard of care for the diagnosis of initial and recurrent tumors, and reresection is recommended for high-risk NMIBC prior to intravesical therapy.[7] Consequently, TURBT is one of the most commonly performed urologic procedures.

Despite being regarded as a "minor" urologic procedure, there are limited data regarding the perioperative morbidity of TURBT. Prior studies evaluating readmission and reoperation rates following TURBT have largely been limited to institutional series,[8-15] and few population-level analyses have specifically characterized the perioperative morbidity of TURBT to identify modifiable risk factors.[16-20] This is particularly relevant within the current era of value-based care.[21] We therefore performed this study to characterize the perioperative morbidity of TURBT and to evaluate its

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determinants in order to identify potential targets for quality improvement.

MATERIALS AND METHODS

Data Source and Study Population

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) captures perioperative clinical data, including 30-day perioperative morbidity and mortality endpoints, for patients undergoing major surgical procedures at participating institutions. Data are abstracted by trained clinical reviewers, and the program employs various quality assurance measures to ensure data accuracy.[22]

After obtaining exempt status from our Institutional Review Board, we identified adults aged 18-89 years who underwent TURBT in NSQIP from 2010 to 2015 using current procedural terminology codes 52234, 52235, and 52240. Patients aged 90 years or older were excluded as they are collapsed into a single age category in NSQIP.

Baseline Characteristics

Perioperative variables recorded included age at surgery, year of surgery, bladder tumor size using current procedural terminology codes (52234: <2 cm, 52235: 2-5 cm, and 52240: >5 cm), race, sex, American Society of Anesthesiology (ASA) class, smoking status (current smoker/smoker within last year and former/never), functional status (independent and partially/totally dependent), discharge destination (home, rehab/skilled nursing facility, and death), chronic steroid use, operative time, and presence of the following comorbidities: diabetes, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), hypertension requiring medical treatment, renal failure (RF) or dialysis, and bleeding disorder.

Outcomes

The following perioperative endpoints were recorded as part of NSQIP: 30-day complications, perioperative blood transfusion within 72 hours of surgery, length of stay, 30-day readmission, 30-day reoperation, and 30-day mortality. Readmission and reoperation data were available from 2012 to 2015, and analyses of these endpoints were restricted to these study years. Readmission and reoperation were only considered if related to the index surgical procedure. Postoperative complications were further categorized as cardiac, thromboembolic, infectious (urinary tract infection and sepsis), respiratory, renal, neurologic, and surgical site infection/wound infection. Suspected reasons for readmission as recorded in NSQIP were categorized as bleeding (hematuria and other bleeding), infectious (urinary tract infection, sepsis, and other infectious), renal (acute kidney injury and obstruction), cardiac, respiratory, deep vein thrombosis/pulmonary embolism, gastrointestinal, neurologic, other (urinary retention, bladder injury, fluid/electrolyte, pain, and catheter-associated), not otherwise classified, and unknown as described in Supplementary Table 1.

Statistical Analyses

Baseline characteristics were summarized using median/interquartile range (IQR) and frequency count/percentage, and compared across bladder tumor size categories using the Kruskal-Wallis test and Pearson chi-square test, respectively. Perioperative outcomes were summarized using frequency count/percentage and compared across tumor size categories using the Pearson chi-square test. Multivariable logistic regression was performed to evaluate the associations of patient characteristics and bladder tumor size with perioperative endpoints. Effect estimates were summarized using odds ratio (OR) with 95% confidence intervals. Models were adjusted for age at surgery (categorical), sex, year of surgery, race (white, black, and other), ASA class (1-2, 3, and 4-5), smoking status (current smoker/smoker within last year and former/never), functional status, steroid use, and presence of the following comorbidities: diabetes, COPD, CHF, hypertension, RF, and bleeding disorder. Observations with missing values were dropped as they accounted for less than 1% of each covariate with missing data, except for missing race, which was categorized as "Unknown."

We conducted an exploratory analysis to examine the determinants and timing of hospital readmissions. Readmission reasons were categorized as described above and summarized using frequency counts/percentages, and cumulative incidence plots of hospital readmission were generated.

Statistical analyses performed using R version 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided, and P values <.05 were considered to be statistically significant.

RESULTS

A total of 24,100 patients underwent TURBT from 2010 to 2015. Tumor size was distributed as follows: <2 cm in 10,491 (43.5%) cases, 2-5 cm in 8,427 (35.0%) cases, and >5 cm in 5182 (21.5%) cases. Baseline characteristics, stratified by tumor size, are summarized in Table 1. Median age at surgery was 72 (IQR 64, 80) years, and 75.5% of patients were male. There were statistically significant differences in several baseline characteristics between groups, including higher ASA classification and increased prevalence of CHF, COPD, RF/dialysis, and current smoker status with increasing tumor size. Median operative time was 25 (IQR 16, 41) minutes, and larger tumor size was associated with statistically significantly increased operative time. The rate of discharge to a skilled nursing facility was also higher among patients with larger tumor size.

Perioperative outcomes are summarized in Table 2. Overall, 30-day complications occurred in 5.1% of patients, and the most common complications category was infectious (3.7%). The rates of perioperative blood transfusion, hospital readmission, reoperation, and 30-day mortality were 1.5%, 3.7%, 1.5%, and 0.8%, respectively. Compared to patients undergoing resection of tumors <2 cm in size, those undergoing resection of tumors >5cm in size had statistically significantly increased rates of 30-day complications (7.1% vs 3.9%, P <.0001), perioperative blood transfusion (3.6% vs 0.7%, P <.0001), hospital readmission (5.4% vs 2.7%, P <.0001), reoperation (2.3% vs 1.0%, P <.0001), and 30-day mortality (1.7% vs 0.3%, P <.0001; Table 2). Larger tumor size was associated with a statistically significant increase in the rates of all complication categories, with the exception of SSI/wound complications.

We next examined the associations of baseline characteristics with perioperative outcomes. Univariable analyses are summarized in Supplementary Table 2. In multivariable analyses adjusting for baseline characteristics (Table 3), increasing tumor size was independently associated with increased risks of all perioperative endpoints, including 30-day complications (>5 cm: OR 1.84, P <.01; 2-5 cm: OR 1.38, P <.01 vs <2 cm), perioperative blood

Table 1. Baseline characteristics stratified according to bladder tumor size (N = 24,100)

	Total (N = 24,100)	Small (N = 10,491; 43.5%)	Medium (N = 8427; 35.0%)	Large (N = 5182; 21.5%)	*P* Value*
Year of surgery					<.0001
2010	1695 (7.0)	635 (6.1)	621 (7.4)	439 (8.5)	
2011	2593 (10.8)	1163 (11.1)	848 (10.1)	582 (11.2)	
2012	3464 (14.4)	1601 (15.3)	1153 (13.7)	710 (13.7)	
2013	4322 (17.9)	1854 (17.7)	1546 (18.4)	922 (17.8)	
2014	5279 (21.9)	2299 (21.9)	1884 (22.4)	1096 (21.2)	
2015	6747 (28.0)	2939 (28.0)	2375 (28.2)	1433 (27.7)	
Age					.06
<60	3734 (15.5)	1629 (15.5)	1297 (15.4)	808 (15.6)	
60-69	6207 (25.8)	2652 (25.3)	2237 (26.6)	1318 (25.4)	
70-79	7968 (33.1)	3522 (33.6)	2794 (33.2)	1652 (31.9)	
80-89	6191 (25.7)	2688 (25.6)	2099 (24.9)	1404 (27.1)	
Sex†					<.0001
Female	5884 (24.4)	2751 (26.2)	1936 (23.0)	1197 (23.1)	
Male (Missing = 9)	18207 (75.5)	7738 (73.8)	6487 (77.0)	3982 (76.9)	
Race					<.0001
White	17663 (73.3)	6661 (63.5)	6729 (79.9)	4273 (82.5)	
Black	1039 (4.3)	411 (3.9)	347 (4.1)	281 (5.4)	
Other	754 (3.1)	343 (3.3)	269 (3.2)	142 (2.7)	
Unknown	4644 (19.3)	3076 (29.3)	1082 (12.8)	486 (9.4)	
ASA class†					<.001
1-2	9637 (40.1)	4471 (42.7)	3289 (39.1)	1877 (36.3)	
3	12932 (53.8)	5444 (52.0)	4626 (55.0)	2862 (55.3)	
4-5 (Missing = 41)	1490 (6.2)	553 (5.3)	598 (5.9)	439 (8.5)	
Discharge destination‡					<.0001
Home	21912 (97.8)	9706 (98.5)	7651 (98.0)	4555 (96.0)	
Rehab/SNF	422 (1.9)	127 (1.3)	127 (1.6)	168 (3.5)	
Expired	36 (0.2)	4 (0.1)	14 (0.2)	18 (0.4)	
Unknown	35 (0.2)	19 (0.2)	14 (0.2)	2 (0.1)	
Current smoker	4822 (20.0)	1884 (18.0)	1687 (20.0)	1251 (24.1)	<.0001
Functional status					<.0001
Partially/Totally Dependent (Missing = 242)	712 (3.0)	260 (2.5)	223 (2.7)	229 (4.4)	
Diabetes	5315 (22.1)	2257 (21.5)	1917 (22.8)	1141 (22.0)	.13
COPD	2401 (10.0)	992 (9.5)	808 (9.6)	601 (11.6)	<.0001
CHF	254 (1.1)	93 (0.9)	87 (1.0)	74 (1.4)	.007
HTN	15085 (62.6)	6518 (62.1)	5315 (63.1)	3252 (62.8)	.40
Renal failure/Dialysis	305 (1.3)	108 (1.0)	94 (1.1)	103 (2.0)	<.0001
Steroid use	792 (3.3)	331 (3.2)	293 (3.5)	168 (3.2)	.46
Bleeding disorder	1054 (4.4)	447 (4.3)	388 (4.6)	219 (4.2)	.44
Operative time (min),					<.0001§
Mean (SD)	33.1 (31.6)	24.8 (28.0)	33.0 (27.8)	50.1 (36.9)	
Median (IQR)	25 (16, 41)	19 (12, 30)	27 (18, 41)	42 (27, 63)	

ASA, American Society of Anesthesiology; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; HTN, hypertension.
Figures represent # (%) or median (IQR).
* Pearson chi-square unless otherwise noted.
† Missing ignored if less than 1%.
‡ Data only available for 2011-2015 (n = 22,405).
§ Kruskal-Wallis equality-of-populations rank test.

transfusion (>5cm: OR 4.71, *P* <.01; 2-5cm: OR 1.77, *P* <.01 vs <2 cm), hospital readmission (>5 cm: OR 2.01, *P* <.01; 2-5 cm: OR 1.47, *P* <.01 vs <2 cm), reoperation (>5 cm: OR 2.16, *P* <.01; 2-5 cm: OR 1.72, *P* <.01 vs <2 cm), and 30-day mortality (>5 cm: OR 4.11, *P* <.01; 2-5 cm: OR 2.26, *P* <.01 vs <2 cm). Higher ASA score was associated with increased risk of all perioperative outcomes except reoperation, while a diagnosis of CHF was associated with increased risk of all perioperative outcomes except 30-day readmission. Dependent functional status or a diagnosis of RF were also independently associated with increased risks of 30-day complications, blood transfusion, and 30-day mortality (Table 3). Interestingly, older age was generally not associated with increased perioperative morbidity, except for age >80 years, which was significantly associated with increased risk of 30-day mortality.

Given the importance of hospital readmission in current quality measurement and performance-based reimbursement programs, we conducted exploratory analyses to examine the timing and determinants for hospital readmission following TURBT. The cumulative incidence of hospital readmission following TURBT is illustrated for the entire cohort (Supplementary Figure 1) and stratified by tumor size (Supplementary Figure 2). The figures demonstrate that hospital readmissions appear to occur at a constant rate throughout the 30-day postoperative period (Supplementary Figure 1) and that this rate increases with increasing tumor size (Supplementary Figure 2). More

Table 2. Perioperative outcomes stratified by bladder tumor size

Outcome (%)	Total (N = 24,100)	<2 cm (N = 10,491; 43.5%)	2-5 cm (N=8,427; 35.0%)	>5 cm (N = 5,182; 21.5%)	*P* value*
Postoperative complication					
Any	1221 (5.1)	406 (3.9)	445 (5.3)	370 (7.1)	<.0001
Cardiac	85 (0.4)	31 (0.3)	26 (0.3)	28 (0.5)	.04
DVT/PE	90 (0.4)	21 (0.2)	34 (0.4)	35 (0.7)	<.0001
Infectious	885 (3.7)	311 (3.0)	335 (4.0)	239 (4.6)	<.0001
Respiratory	150 (0.6)	41 (0.4)	54 (0.6)	55 (1.1)	<.0001
Renal	102 (0.4)	32 (0.3)	29 (0.3)	41 (0.8)	<.0001
Neurologic	36 (0.1)	6 (0.06)	16 (0.2)	14 (0.3)	.003
SSI/Wound	17 (0.07)	7 (0.07)	4 (0.05)	6 (0.1)	.38†
Blood Transfusion	359 (1.5)	71 (0.7)	104 (1.2)	184 (3.6)	<.0001
Readmission‡	742 (3.7)	239 (2.7)	278 (4.0)	225 (5.4)	<.0001
Reoperation‡	302 (1.5)	85 (1.0)	123 (1.8)	94 (2.3)	<.0001
30-day mortality	186 (0.8)	34 (0.3)	65 (0.8)	87 (1.7)	<.0001

DVT, deep vein thrombosis; PE, # pulmonary embolism.
* Pearson chi-square.
† Fisher's exact.
‡ Only for 2012-2015 (n = 19,812).

importantly, we further characterized the reasons for hospital readmission as summarized in Table 4. The most common reasons for readmission were bleeding (29.0%), infectious (20.8%), and renal (7.3%) complications.

COMMENT

In this study, we characterized the perioperative morbidity of TURBT using a large national cohort. TURBT was associated with substantial rates of 30-day complications (5.1%), hospital readmission (3.7%), and reoperation (1.5%), considering that it is traditionally regarded as a "minor" urologic procedure. Moreover, resection of tumors >5 cm in size was associated with even higher morbidity, with 7.1% of patients experiencing a 30-day complication, 5.4% requiring hospital readmission, and 2.3% requiring reoperation. To contextualize these morbidity rates, studies from NSQIP have reported similar rates of perioperative morbidity for patients undergoing "major" urologic oncologic surgeries, including minimally invasive partial nephrectomy (30-day complications: 4.9%, readmission: 4.4%, reoperation: 1.8%), and minimally invasive radical prostatectomy (30-day complications: 5.0%, readmission: 4.0%, reoperation: 1.2%).[23,24] Particularly given the high healthcare resource utilization associated with readmission and reoperation events, the perioperative morbidity of TURBT represents an important target for quality improvement.

Identification of both modifiable and nonmodifiable risk factors for perioperative morbidity is critical for quality improvement efforts. To this end, we identified several baseline characteristics that were associated with perioperative morbidity, including larger tumor size, higher ASA class, dependent functional status, CHF, RF, and age over 80 years. While the majority of these features are not modifiable, they represent potential targets for preoperative optimization (eg, multidisciplinary evaluation for elderly patients) as well as postoperative interventions such as intensified care coordination (eg, shorter interval postoperative visits, visiting nurse utilization, etc.). Furthermore, the association of increasing tumor size with perioperative morbidity suggests that efforts to improve early detection of bladder cancer may also reduce perioperative morbidity if they result in a shift to lower volume disease.

The overwhelming majority of complications were infectious, comprising 72% of all 30-day complications. Accordingly, infectious complications represent a critical target for quality improvement efforts. Interventions focusing on the prevention of infectious complications may include improving the judicious use of urinary catheters postoperatively and ensuring adherence to antimicrobial prophylaxis guidelines.[25-27] More importantly, these observations highlight the need to develop novel antimicrobial prophylaxis approaches to limit infectious complications following TURBT, similar to those reported for the reduction of infectious complications following prostate biopsy.[28]

Hospital readmissions have received special focus as a target for quality improvement given their cost and resource utilization.[21] To this end, we observed that the most common reasons for hospital readmission were bleeding (29.0%) and infectious (20.8%) complications. These data suggest that efforts to reduce bleeding and infectious complications should result in a substantial improvement in resource utilization from associated hospital readmissions. Furthermore, we observed that readmissions appeared to occur at a relatively steady rate during the 30-day postoperative period. This suggests the need for ongoing patient interventions for early identification and management of preventable readmissions. For example, the implementation of more frequent postoperative physician visits, visiting nurse home visits, or telemedicine approaches may facilitate reduction of preventable readmissions in high-risk patients.

Table 3. Multivariable associations of baseline characteristics with perioperative outcomes

Characterization	30-Day Complications		Blood Transfusion		30-Day Mortality		30-Day Readmission		30-Day Reoperation	
	OR [95%CI]	*P* Value	OR [95%CI]	*P* Value	OR [95%CI]	*P* Value	OR [95%CI]	*P* Value	OR [95%CI]	*P* Value
Tumor size										
<2 cm	ref.		ref.		ref.		ref.		ref.	
2-5 cm	1.38 [1.20, 1.59]	<.01	1.77 [1.29, 2.42]	<.01	2.26 [1.47, 3.45]	<.01	1.47 [1.23, 1.76]	<.01	1.72 [1.29, 2.28]	<.01
>5 cm	1.84 [1.59, 2.14]	<.01	4.71 [3.53, 6.29]	<.01	4.11 [2.72, 6.21]	<.01	2.01 [1.66, 2.44]	<.01	2.16 [1.60, 2.93]	<.01
Age										
<60	ref.		ref.		ref.		ref.		ref.	
60-69	0.96 [0.78, 1.18]	.71	0.74 [0.51, 1.06]	.10	0.86 [0.44, 1.71]	.68	1.03 [0.78, 1.34]	.85	0.79 [0.54, 1.15]	.22
70-79	1.03 [0.84, 1.26]	.76	0.69 [0.49, 0.99]	.05	1.23 [0.66, 2.32]	.51	1.15 [0.89, 1.50]	.28	0.85 [0.59, 1.22]	.38
80-89	1.22 [0.99, 1.51]	.06	1.05 [0.74, 1.50]	.78	2.89 [1.57, 5.31]	<.01	1.29 [0.98, 1.70]	.07	0.76 [0.51, 1.13]	.17
Sex										
Female	ref.		ref.		ref.		ref.		ref.	
Male	0.89 [0.78, 1.02]	.09	0.87 [0.68, 1.11]	.27	0.84 [0.60, 1.19]	.33	1.10 [0.92, 1.32]	.29	1.46 [1.08, 1.97]	.02
Year of surgery										
2010	ref.		ref.		ref.		-		-	
2011	1.00 [0.76, 1.32]	.99	0.72 [0.44, 1.20]	.21	1.43 [0.65, 3.17]	.37	-		-	
2012	0.82 [0.63, 1.08]	.16	0.94 [0.59, 1.49]	.79	1.64 [0.77, 3.48]	.20	ref.		ref.	
2013	1.09 [0.84, 1.40]	.52	0.89 [0.57, 1.39]	.61	1.67 [0.81, 3.47]	.17	1.16 [0.91, 1.48]	.23	1.10 [0.74, 1.63]	.64
2014	0.92 [0.72, 1.19]	.54	0.74 [0.48, 1.16]	.19	1.45 [0.70, 3.02]	.32	1.05 [0.82, 1.34]	.70	1.04 [0.71, 1.53]	.83
2015	0.96 [0.75, 1.23]	.75	0.90 [0.59, 1.37]	.63	1.69 [0.84, 3.40]	.14	1.27 [1.01, 1.59]	.04	1.42 [1.00, 2.02]	.05
Race										
White	ref.		ref.		ref.		ref.		ref.	
Black	1.03 [0.78, 1.35]	.86	1.63 [1.10, 2.43]	.02	0.50 [0.21, 1.18]	.11	1.20 [0.86, 1.69]	.29	0.97 [0.56, 1.69]	.92
Other	1.13 [0.97, 1.31]	.11	0.96 [0.70, 1.31]	.79	0.99 [0.65, 1.51]	.96	1.19 [0.99, 1.44]	.06	0.80 [0.58, 1.10]	.17
ASA class										
ASA 1-2	ref.		ref.		ref.		ref.		ref.	
ASA 3	1.27 [1.10, 1.47]	<.01	2.03 [1.50, 2.74]	<.01	4.58 [2.57, 8.18]	<.01	1.43 [1.19, 1.71]	<.01	1.30 [0.98, 1.72]	.06
ASA 4-5	1.74 [1.38, 2.20]	<.01	3.90 [2.62, 5.79]	<.01	12.29 [6.44, 23.46]	<.01	1.51 [1.10, 2.06]	.01	1.45 [0.89, 2.36]	.13
Diabetic	1.18 [1.03, 1.36]	.02	1.15 [0.89, 1.49]	.28	1.14 [0.81, 1.60]	.46	1.17 [0.98, 1.40]	.07	0.74 [0.55, 1.00]	.05
Current smoker	0.87 [0.74, 1.02]	.08	1.11 [0.84, 1.46]	.46	1.29 [0.86, 1.92]	.22	0.95 [0.78, 1.16]	.61	0.88 [0.65, 1.20]	.42
Dep func status*	1.82 [1.42, 2.33]	<.01	2.93 [2.09, 4.10]	<.01	3.21 [2.13, 4.84]	<.01	1.23 [0.85, 1.77]	.28	0.85 [0.43, 1.68]	.64
COPD	1.14 [0.95, 1.37]	.16	0.99 [0.72, 1.37]	.95	1.06 [0.71, 1.59]	.77	1.04 [0.82, 1.32]	.76	0.87 [0.59, 1.30]	.50
CHF	2.06 [1.42, 2.97]	<.01	2.28 [1.35, 3.83]	<.01	2.09 [1.12, 3.90]	.02	1.43 [0.85, 2.41]	.18	2.45 [1.23, 4.85]	.01
Hypertension	1.02 [0.89, 1.17]	.80	0.64 [0.50, 0.82]	<.01	0.61 [0.44, 0.85]	<.01	1.08 [0.91, 1.28]	.39	1.24 [0.94, 1.62]	.12
Renal failure	2.03 [1.43, 2.88]	<.01	5.05 [3.38, 7.54]	<.01	5.46 [3.28, 9.10]	<.01	1.63 [0.99, 2.70]	.06	1.21 [0.52, 2.82]	.66
Steroid use	1.30 [0.99, 1.72]	.06	1.44 [0.91, 2.28]	.12	0.93 [0.46, 1.87]	.84	1.80 [1.32, 2.46]	<.01	1.14 [0.65, 2.02]	.64
Bleeding disorder	1.37 [1.08, 1.73]	.01	2.12 [1.49, 3.02]	<.01	1.17 [0.68, 2.01]	.58	1.32 [0.97, 1.79]	.07	1.94 [1.29, 2.92]	<.01

OD, odds ratio.

* Partially or completely dependent functional status vs independent functional status (ref.).

Table 4. Reasons for hospital readmission and median days of occurrence

Readmission Reason	N (% of All Surgeries)	Percent of All Readmissions	Days to Readmission, Median (IQR)†
Any Readmission*	742 (3.8)	100%	11 (4,20)
Bleeding	215 (1.1)	29.0%	9 (3,16.5)
Hematuria	205 (1.0)	27.6%	9 (3,17)
Other	10 (0.05)	1.4%	10 (3.25,14.75)
Infectious*	154 (0.8)	20.8%	13 (7,21)
UTI*	90 (0.5)	12.1%	13 (7,21)
Sepsis	54 (0.3)	7.3%	16 (8.25,21)
Other Infection	10 (0.05)	1.4%	16 (8.25,21)
Renal	54 (0.3)	7.3%	7.5 (3,19.75)
AKI	38 (0.2)	5.1%	8.5 (4,18.75)
Obstruction	16 (0.08)	2.2%	4 (2,21.75)
Cardiac	37 (0.2)	5.0%	10 (6,17)
Respiratory	35 (0.2)	4.7%	14 (8,24)
DVT/PE	22 (0.1)	3.0%	12.5 (7.25,17)
Gastrointestinal*	21 (0.1)	2.8%	7.5 (4,15)
Neurologic	17 (0.09)	2.3%	8 (2,14)
Other	66 (0.3)	8.9%	6 (2.25,11.75)
Urinary Retention	20 (0.1)	2.7%	4 (1,11.5)
Bladder Injury	16 (0.08)	2.2%	3 (1.75,5.25)
Fluid/Electrolyte	13 (0.07)	1.8%	9 (7,13)
Pain	9 (0.05)	1.2%	3 (1,11)
Catheter Associated	8 (0.04)	1.1%	10 (5.5,16.25)
Not otherwise classified	90 (0.5)	12.1%	17 (8.75,28)
Unknown*	31 (0.2)	4.2%	11.5 (3.25,21)

IQR, interquartile range; UTI, urinary tract infection.
Data available for 2012-2015 (N = 19,812).
* Less than 5% of readmission date data missing.
† Among patients with readmission.

Prior studies on the perioperative morbidity of TURBT have reported varying results, with rates of complications ranging from 4% to 29%, unplanned readmission or ER visits from 5% to 24.7%, transfusion rates from 0.3% to 2.8%, and mortality rates from 0% to 1.3%.[10-12,14-18,20] This wide variation is multifactorial, reflecting in part case mix, variation in clinical practice, and study design considerations (eg, ascertainment of endpoints). Specifically, institutional series have generally reported higher rates of complications and readmission, likely reflecting more complex case mix with larger or more advanced tumors seen at referral or academic centers.[9,10,12,14,15] For example, in one study where 15% of patients were found to have muscle-invasive tumors, the complication rate was 29%,[14] while in another study where only 7% of patients were found to have muscle-invasive tumors, the complication rate was 8%.[12] In concordance with our findings, institutional series have reported that larger tumor size is associated with an increased rate of complications.[9,11,13] Importantly, the present study reinforces these observations and reflects the experience of a national set of hospitals participating in NSQIP; accordingly the results may hold greater external validity than any single institutional study.

Several studies have previously examined the perioperative morbidity of endoscopic or outpatient urologic surgeries, including TURBT, using NSQIP,[16,19,20] although few have specifically focused on TURBT.[17,18] While such studies have generally reported similar rates of 30-day complications, perioperative blood transfusion, and 30-day mortality,[16-18,20] data regarding hospital readmission and reoperation have been lacking as these endpoints were not routinely assessed until 2012. For example, Hollenbeck et al examined the perioperative morbidity of TURBT using NSQIP data from 1991 to 2002.[17] The authors reported similar 30-day complication (4.3%) and mortality (1%) rates to those in the present study. However, the NSQIP data in that study was restricted to Veterans Administration hospitals, potentially limiting the generalizability to patients treated at civilian hospitals. To this end, the present study provides the most comprehensive, contemporary characterization of the perioperative morbidity of TURBT. Furthermore, this is the first study, to our knowledge, to characterize the reasons for hospital readmission using population level data to identify potential targets for quality improvement efforts.

The present study has several limitations. Most importantly, we were unable to adjust for a number of clinicopathologic features that are not available in the NSQIP dataset. This includes both measures of case mix, such as pathologic stage and tumor grade, as well as certain patient characteristics such as comorbidity severity, socioeconomic status, or performance status, which may impact perioperative morbidity. In addition, neither surgeon nor hospital volume is captured in NSQIP, which precludes adjustment for these potentially important variables. Importantly, NSQIP does not assess the Clavien grade of postoperative complications, although additional morbidity endpoints such as readmission, reoperation, and mortality reflect a degree of complication severity. Furthermore, certain complications of

TURBT, such as hematuria or bladder perforation, are not specifically captured in NSQIP and could not be individually assessed outside of readmission events. In addition, we were unable to adjust for potentially important processes of care, such as antibiotic administration or utilization of bladder catheters, which may impact complication rates. Finally, we did not examine endpoints beyond 30 days postoperatively. Despite these limitations, our study provides a contemporary, comprehensive characterization of the perioperative morbidity of TURBT, and utilizes a national data source with standardized ascertainment of morbidity endpoints.

CONCLUSION

Perioperative morbidity following TURBT is substantial and represents an important target for quality improvement. Larger tumor size and several patient characteristics, such as functional status, ASA class, and specific comorbidities, are independently associated with increased risks of perioperative morbidity and mortality. Bleeding and infectious complications represent the most common reasons for hospital readmission. These results have implications for patient counseling, perioperative management, and quality improvement programs.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.urology.2018.10.027.

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