POSTOPERATIVE URINARY RETENTION AFTER PEDIATRIC ORTHOPEDIC SURGERY

by

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As members of the Master's Committee, we certify that we have read the thesis prepared by: Mohan V. Belthur
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and recommend that it be accepted as fulfilling the thesis requirement for the Master's Degree.

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Final approval and acceptance of this thesis is contingent upon the candidate's submission of the final copies of the thesis to the Graduate College.

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ABSTRACT:

Postoperative Urinary Retention after Pediatric Orthopedic Surgery

Background: Postoperative urinary retention is defined as an inability to void after surgery or the presence of a major residual volume after voiding that requires catheterization. Postoperative urinary retention prolongs hospital stay and often leads to bladder catheterization, which exposes patients to the risk of urinary tract infection. This study aims to describe the incidence of postoperative urinary retention among pediatric patients undergoing orthopedic surgery and to identify risk factors for this complication.

Methods: The Pediatric Health Information System (PHIS) was used to identify children aged 1-18 years who underwent orthopedic surgery during 2012-2015. Collected from each patient's record were demographic information, principal procedure during hospitalization, diagnosis codes for the hospitalization, the presence of neurologic/neuromuscular conditions and other complex chronic medical conditions, the total post-operative length of stay, and the presence of post-operative urinary retention.

Results: There were 232,551 pediatric patients undergoing orthopedic surgery from 2012-2015 that met our inclusion criteria. There were 892 cases of postoperative urinary retention, for an overall incidence of 0.38%. The average length of stay for

patients with postoperative urinary retention was 7.8 days compared to 1.7 days in those without. After adjusting for gender, race, and age, children with complex chronic neuromuscular conditions (OR 11.54 (95% CI 9.6-13.88), p = <0.001) and complex chronic non-neuromuscular medical conditions (OR 5.07 (95% CI 4.11 – 6.25 -), p = <0.001) had a substantially increased incidence of urinary retention. Surgeries on the spine (OR 3.98 (95% CI 3.28 - 4.82, p = <0.001) and femur/hip (OR 3.63 (95% CI 3.03 - 4.36), p = <0.001) were also associated with a substantially increased incidence of urinary retention.

Conclusions: While the overall incidence of postoperative urinary retention in children undergoing orthopedic surgery is low, children with complex chronic neuromuscular conditions have substantially increased risk of experiencing this complication. In addition, complex chronic non-neuromuscular medical conditions and surgeries to the spine, hip, and femur also carry a notably increased risk for postoperative urinary retention. Clinicians should be aware of these risk factors and recognize that occurrence of postoperative urinary retention is likely to increase patient's length of stay.

KEY WORDS: Postoperative, urinary retention, pediatric orthopedics, surgery, risk factors.

Level of Evidence: Prognostic Level III

Chapter 1: Introduction.

Postoperative urinary retention is defined as an inability to void after surgery or the presence of a major residual volume after voiding that requires catheterization.[1–4] Postoperative urinary retention causes significant patient discomfort and anxiety. Postoperative urinary retention usually requires treatment with bladder catheterization, which is associated with prolonged hospital stay, risk of urinary tract infection, and ultimately increased healthcare costs.[1–3,5–7]

For adult patients undergoing orthopedic surgery, the rate of postoperative urinary retention varies between 9 – 84% depending on the specific surgery and the definition of postoperative urinary retention used.[1,8,9] Risk factors have been studied extensively, and include increasing age, male gender, a history of anticoagulant medication, epidural analgesia, use of patient-controlled analgesia, and a history of diabetes mellitus.[1,8,10–16]

In contrast to adults, the overall incidence for postoperative urinary retention in pediatric orthopedic surgery has not been well-characterized. Single-center studies have reported the incidence of urinary retention at 29% among children undergoing lower extremity surgery, and 15-27% among young patients who underwent posterior spinal fusion.[4,17,18,27] In addition to being limited by small samples, these studies provide no information on the overall incidence of urinary

retention after pediatric orthopedic surgery or how incidence rates vary among different procedures.

Research is also lacking on the impact of pre-existing medical conditions on rates of urinary retention after pediatric orthopedic surgery. Brenn et al. found a 70% incidence of postoperative urinary retention among pediatric cerebral palsy patients after use of epidural analgesia, and it seems likely to be a risk factor for orthopedic procedures as well.[19] The presence of chronic medical conditions also has been documented in the literature as associated with postoperative urinary retention in adults, particularly renal failure and diabetes mellitus with diabetic complications.[5] While the same relationships may exist for pediatric patients, the influence of these medical conditions and other patient specific factors on the risk for urinary retention is poorly understood in the pediatric orthopedic surgery population. In addition, although postoperative urinary retention is associated with an increased length of stay in adults, the impact on pediatric orthopedic patients is less well characterized.[5] This lack of knowledge prevents targeted efforts at avoidance and early detection.

The present study evaluates the incidence of post-operative urinary retention among children undergoing orthopedic surgery at 49 free-standing children's hospitals participating in the Pediatric Health Information System (PHIS). These hospitals provide 85% of all pediatric specialty care delivered in the United States (Goodman et al., 2014). The study has three distinct objectives: (1) to determine the

incidence of post-operative urinary retention among children undergoing orthopedic surgery, (2) to identify surgical procedures and patient risk factors associated with an increased risk of postoperative urinary retention, and (3) to evaluate the impact of POUR on inpatient hospital stay following orthopedic surgery.

Chapter 2: Patients and Methods.

PHIS was used to perform a retrospective cohort study of children aged 1-18 years who underwent orthopedic surgery between 2012 and 2015. PHIS is a large administrative database maintained by the Children's Hospital Association that includes clinical, demographic, and billing information for all hospital discharges occurring in a network of >49 free-standing children's hospitals located in the United States. The data are based on billing charges, and all discharges for each hospital stay are included in the database.[20] The Institution Review Boards at Phoenix Children's Hospital reviewed this study and determined it was not human subjects research, as defined by the Common Rule (45CFR46.102[f]), because the data set was deidentified.

Eligible children were identified using *International Classification of Disease, Ninth Revision (ICD-9)* procedure codes for operations on the musculoskeletal system (*ICD-9* codes 76-84). For children with more than one encounter during the study period, only the first encounter was included.

For all eligible children, information was collected on the child's demographics, medical conditions, and surgical care. Demographic information included age at admission, gender, race, ethnicity, median household income by zip code of residence, and primary source of payment. Also collected was the principal

procedure during hospitalization, all diagnosis codes for the hospitalization, the presence of surgical complication flags (e.g., non-healing surgical wound, hemorrhage during procedure, seroma formation), medical complication flags (e.g., adverse effects of anesthesia, anaphylactic shock due to other serum, postvaccination fever), infection flags (e.g., Shigella dysenteriae, cryptosporidiosis), neurologic/neuromuscular flags (e.g., brain and spinal cord malformation, central nervous system disease, muscular dystrophies and myopathies), complex chronic conditions flags (e.g., heart and great vessel malformation, chronic kidney disease, cystic fibrosis), cerebral palsy (*ICD-9-CM* code 343.xx), and the total post-operative length of stay. Flags were applied to each patient's profile by PHIS and were not determined by the study authors.[21] The location of the surgery was determined by the principal procedure. The outcome variable was the occurrence of post-operative urinary retention; identified by the presence of diagnosis codes for retention of urine (*ICD-9* code 788.2).

Statistical Analysis:

Preliminary group comparisons were conducted using the two independent samples t-test for continuous variables and the Chi-squared test for categorical variables. Univariate logistic regression was performed to identify risk factors

associated with postoperative urinary retention. A multivariable logistic regression model was created incorporating risk factors identified from simple logistic regression to model the odds of postoperative urinary retention. The results were summarized using the odds ratio, the 95% confidence interval for the odds ratio and the p-value. The C-statistic or the area under the receiver operating characteristic curve was reported as a measure of model discrimination, with a higher C-statistic indicating that the model is more discriminative.

The Youden index was used to identify an optimal cut-off value for the age at admission and to dichotomize the variable. The significance level was set *a priori* at 0.05. Statistical Analyses were performed using the statistical software packages SAS 9.4 (SAS Institute, Cary, NC).

Chapter 3: Results.

A total of 232,551 pediatric orthopedic surgery patients met inclusion criteria. The mean age at admission was 9.2 years, and 55.6% of patients were male. Most patients, 62.5%, were white; 19.6% of patients were of Hispanic-Latino ethnicity. Chronic neuromuscular conditions were present in 6.4% of patients, while 11.2% had complex chronic medical conditions that were not neuromuscular. Prevalence of relevant patient demographic and medical conditions are presented in **Table 1.**

Post-operative urinary retention occurred following 892 procedures, resulting in an overall incidence of 0.38%. Patients with urinary retention were much more likely to have a chronic neuromuscular condition, which included cerebral palsy, spina bifida and muscular dystrophy (**Table 2**). Patients with cerebral palsy comprised 24.8% of all postoperative urinary retention cases in the present study.

The most common surgical locations that subsequently developed postoperative urinary retention were the spine, femur, and hip (**Figure 1**). The most common surgeries associated with postoperative urinary retention were posterior spinal fusion for spine deformity and hip reconstruction surgery.

On univariate analysis, the risk of postoperative urinary retention was highest among patients with a chronic neuromuscular condition. The risk was also increased by the presence of a non-neuromuscular complex chronic condition. If a surgical

complication, medical complication, or an infection occurred during the patient's admission, this also increased the risk of postoperative urinary retention. White race was also associated with an increased risk of postoperative urinary retention (**Table 3**). Increased age at admission was also associated with a higher risk of urinary retention; the average age of patients who developed postoperative urinary retention was 11.9 years compared to 9.2 years in children who did not ($p<0.001$).

The average length of stay in patients who had urinary retention was 7.8 days compared to 1.7 days in patients who did not (**Figure 2**).

On multivariate analysis, significant risk factors for post-operative urinary retention in order of decreasing odds ratio were presence of neuromuscular complex chronic conditions, presence of non-neuromuscular complex chronic conditions, surgery on the spine, surgery on the femur/hip, male gender, white race, and increasing age at admission (**Table 4**). A risk prediction profile developed with multivariate logistic regression analysis using the above identified risk factors returned a C-statistic of 0.87.

Chapter 4: Discussion.

For the pediatric population receiving orthopedic surgery, the presence of chronic medical conditions and the surgery location are strong predictors for developing postoperative urinary retention. The risk of developing postoperative urinary retention is particularly elevated for patients with neuromuscular conditions: presence of a neuromuscular condition was associated with 11.5-fold higher odds of postoperative urinary retention. While children with cerebral palsy represented only 4% of the study population, they accounted for one-fourth of all patients who developed postoperative urinary retention. While only 0.38% of all children developed postoperative urinary retention, the incidence of postoperative urinary retention was almost 4-fold higher for children undergoing femur or hip surgery and almost 4-fold higher for children undergoing spine surgery. These findings suggest surgeons should focus their concern for post-operative urinary retention to these select patient populations.

The risk factors identified in this study are similar to those documented in the literature. Sherburne et al.[18] found that older age increased the risk of postoperative urinary retention in pediatric patients undergoing lower extremity orthopedic surgery, while Keskinen et al.[19] found male gender to be associated with postoperative urinary retention in pediatric patients undergoing posterior spinal fusion for idiopathic scoliosis. The present study found these two factors to increase

risk of urinary retention for all pediatric orthopedic surgery patients. However, Sherburne et al. did not find gender to be significantly associated with postoperative urinary retention, which conflicts with both the results of Keskinen et al. as well as our own. Furthermore, Sherburne et al. did not find history of neurogenic bladder or previous bladder problems to be significantly associated while our results found an association between neuromuscular conditions, particularly cerebral palsy, and postoperative urinary retention. These conflicting findings may be due to differences in patient population – the present study included all pediatric orthopedic surgeries, while Sherburne et al studied only pediatric lower extremity surgeries.

Patients with cerebral palsy represented one-fourth of all patients with postoperative urinary retention in the present study, and the presence of neuromuscular conditions had the highest odds of developing postoperative urinary retention out of any risk factor. Urinary tract dysfunction is common in cerebral palsy patients with Brenn et al. finding a 70% incidence of postoperative urinary retention among pediatric cerebral palsy patients receiving epidural anaesthesia.[19,22–25] Thus, it seems likely that cerebral palsy is indeed a significant risk factor. The presence of chronic medical conditions also has been documented in the literature as associated with postoperative urinary retention in adults, particularly renal failure and diabetes mellitus with diabetic complications.[5] This study found a similar relationship between medical comorbidities and postoperative urinary retention.

The incidence of postoperative urinary retention in this study is less than that reported from single-center studies in the literature.[18,19] Patients who underwent surgeries performed on the spine and femur/hip comprised 38% and 22%, respectively, of the patients who experienced post-operative urinary retention in this study. However, only 2.9% of all of the patients who underwent spine surgery and 1.2% of the patients who underwent femur/hip surgery experienced postoperative urinary retention. Sherburne et al. reported that of the 38 pediatric patients in their sample who underwent lower extremity orthopedic surgery, 29% required postoperative straight catheterization.[18] Keskinen et al. reported that of their sample of one hundred and eleven young patients (age 11 – 21 years) who underwent posterior spinal fusion for adolescent idiopathic scoliosis, 27% required postoperative intermittent catherization.[19] These different findings may be due to the use of ultrasound to accurately assess bladder volume as well as frequent monitoring and reporting of postoperative bladder volume in single center, procedure-focused studies.

Ultimately, postoperative urinary retention is a significant complication that substantially increases the cost of the healthcare provided. Wu et al. reports that adult patients who underwent total hip or knee arthroplasty and subsequently developed postoperative urinary retention stayed an extra 0.6 and 0.48 days in the hospital respectively.[5] Fernandez et al. found that adult patients who developed postoperative

urinary retention after total hip or knee arthroplasty had a mean length of stay of 6.7 days compared to 4.6 days without retention.[15] In our study the average length of stay of patients who had urinary retention was 7.8 days compared to 1.7 days in patients who did not develop postoperative urinary retention, an additional length of stay that is far greater than that found in adults with postoperative urinary retention. This suggests that pediatric orthopedic patients who develop postoperative urinary retention either take longer to resume normal micturition, or that clinicians are more inclined to observe them for longer periods than adult patients, possibly due to the lack of a defined postoperative urinary retention protocol. With an estimated hospital adjusted expense of $2,653 per day of inpatient admission for non-profit hospitals in the United States, the six additional days that pediatric patients with postoperative urinary retention remain in the hospital likely substantially increases healthcare cost and occupies key resources and personnel.[26]

Limitations of this study are inherent to the approach. First, as in the case of any research using administrative data, this study relied on accurate ICD-9-CM coding for identification of cases and characteristics. Local coding practice can influence the accuracy of diagnostic coding, and this bias cannot be excluded. This is particularly important for the ICD codes associated with postoperative urinary retention, whose inclusion in the database relies on accurate diagnosis by the treating physician and on correct coding for a relatively uncommon diagnosis. Both factors

suggest that postoperative urinary retention is under-reported in the present study. However, since factors leading to under-reporting of urinary retention are consistent across all patients, the relative estimates of post-operative urinary retention presented in this study are likely unbiased. In addition, although on multivariate analysis chronic medical conditions were found to be associated with postoperative urinary retention, the chronic medical condition flag from the PHIS database was used in order to classify the presence of chronic medical conditions. This did not allow for the determination of specific chronic medical conditions responsible for the development of postoperative urinary retention and is a potential area of focus for future research.

Chapter 5: Conclusion.

The incidence of postoperative urinary retention in this study was 0.38% in children ≤ 18 years of age. The presence of complex chronic medical conditions, and in particular neuromuscular conditions including cerebral palsy, spina bifida and muscular dystrophy, is a strong risk factor for developing postoperative urinary retention in pediatric orthopedic surgery patients. Procedures with the highest risk of developing postoperative urinary retention include femur, hip, and spine surgeries. If postoperative urinary retention occurs the length of stay increases significantly. As chronic damage can occur with even one episode of overdistention clinicians would be well-served to monitor the post-operative urination and bladder volume of pediatric patients with these risk factors.

Clinical Relevance:

Postoperative urinary retention following pediatric orthopedic procedures is a relatively uncommon complication that increases patient discomfort and length of stay in the hospital. This risk will be validated prospectively in future studies and will be used to implement a protocol for awareness, prevention, and management of postoperative urinary retention in the pediatric population following orthopedic surgery.

Table 1: Risk Factors by Postoperative Urinary Retention

Risk Factor	Postoperative Urinary Retention		P-value
	No (N=231659)	Yes (N=892)	
Male			0.22031
No	102891 (44.4%)	378 (42.4%)	
Yes	128742 (55.6%)	514 (57.6%)	
Race			**<0.0001**
Asian	5550 (2.4%)	17 (1.9%)	
Black	33246 (14.4%)	108 (12.1%)	
Native American	1365 (0.6%)	12 (1.3%)	
White	144809 (62.5%)	617 (69.2%)	
Other	46689 (20.2%)	138 (15.5%)	
White			**<0.0001**
No	86850 (37.5%)	275 (30.8%)	
Yes	144809 (62.5%)	617 (69.2%)	
Ethnicity			**0.0001**
Hispanic or Latino	45307 (19.6%)	133 (14.9%)	
Not Hispanic or Latino	167053 (72.1%)	700 (78.5%)	
Unknown	19299 (8.3%)	59 (6.6%)	
Age at Admission (years)			**<0.0001**
N	231659	892	
Mean (SD)	9.2 (5.0)	11.9 (4.3)	
Range	(1.0-18.0)	(1.0-18.0)	
Primary Source of Insurance			0.2510
Government	158404 (68.4%)	590 (66.1%)	
Private	69325 (29.9%)	289 (32.4%)	
Other	3930 (1.7%)	13 (1.5%)	
Median Household Income ($)			**0.0003**
N	231659	892	
Mean (SD)	47766.8 (18851.9)	49864.4 (19366.6)	
Range	(6320.0-196032.0)	(6320.0-139915.0)	
Surgical Location			**<0.0001**
Spine	11601 (5.0%)	340 (38.1%)	
Femur	13316 (5.7%)	137 (15.4%)	
Hip	3363 (1.5%)	58 (6.5%)	
Tibia	5834 (2.5%)	16 (1.8%)	
Humerus	6781 (2.9%)	9 (1.0%)	
Soft tissue	12035 (5.2%)	50 (5.6%)	
Other	178729 (77.2%)	282 (31.6%)	
Medical Complication Flag			**<0.0001**
No	231490 (99.9%)	884 (99.1%)	
Yes	169 (0.1%)	8 (0.9%)	

Surgical Complication Flag			**<0.0001**
No	226091 (97.6%)	601 (67.4%)	
Yes	5568 (2.4%)	291 (32.6%)	
Infection Flag			**<0.0001**
No	222328 (96.0%)	751 (84.2%)	
Yes	9331 (4.0%)	141 (15.8%)	
Complex Chronic Condition (CCC)			**<0.0001**
Neuromuscular CCC	13618 (5.9%)	333 (37.3%)	
Non-neuromuscular CCC	23033 (9.9%)	325 (36.4%)	
No CCC	195008 (84.2%)	234 (26.2%)	
Cerebral Palsy			**<0.0001**
No	223022 (96.3%)	671 (75.2%)	
Yes	8637 (3.7%)	221 (24.8%)	
Length of Stay (days)			**<0.0001**
N	231659	892	
Mean (SD)	1.7 (2.6)	7.8 (10.4)	
Range	(1.0-259.0)	(1.0-128.0)	

CCC = complex chronic condition

Table 2. Percentage of patients with the neurological and neuromuscular flag who had cerebral palsy, spina bifida or muscular dystrophy

Risk Factor	Neurological and Muscular		Total
	Yes	No	
Cerebral Palsy			
Yes	66.6%	0.0%	24.8%
No	33.4%	100.0%	75.2%
Spina Bifida			
Yes	5.5%	0.2%	2.1%
No	94.6%	99.8%	97.9%
Muscular Dystrophy			
Yes	7.2%	0.0%	2.7%
No	92.8%	100.0%	97.3%

Table 3: Logistic Univariate Analysis for Postoperative Urinary Retention

Risk factor	OR (95% CI)	P-value
Male vs Female	1.09(0.95-1.24)	0.2204
Race		
Asian vs White	0.72(0.44-1.16)	0.1801
Black vs White	0.76(0.62-0.94)	**0.0094**
Native American vs White	2.06(1.16-3.66)	**0.0134**
Other vs White	0.69(0.58-0.83)	**0.0001**
White vs Not	1.35(1.17-1.55)	**<.0001**
Age at Admission (years)	1.12(1.11-1.14)	**<.0001**
Primary Insurance		
Government vs Other	1.13(0.65-1.95)	0.6728
Private vs Other	1.26(0.72-2.2)	0.4155
Cerebral Palsy vs Not	8.5(7.29-9.91)	**<.0001**
Surgical Complication Flag vs Not	19.66(17.05-22.67)	**<.0001**
Medical Complication Flag vs Not	12.4(6.08-25.27)	**<.0001**
Infection Flag vs Not	4.47(3.73-5.36)	**<.0001**
Complex Chronic Condition (CCC)		
Neuromuscular CCC vs No CCC	20.38(17.23-24.11)	**<0.0001**
Non-Neuromuscular CCC vs No CCC	11.76(9.93-13.92)	**<0.0001**

Table 4: Multivariate model for Postoperative Urinary Retention

Risk factor	OR (95% CI)	P-value
Male vs Female	1.46(1.27-1.68)	<0.0001
White vs Not	1.26(1.09-1.45)	0.0018
Neuromuscular CCC vs NO CCC	11.54(9.6-13.88)	<0.0001
Non-Neuromuscular CCC vs NO CCC	5.07(4.11-6.25)	<0.0001
Spine vs other location	3.98(3.28-4.82)	<0.0001
Femur/Hip vs other location	3.63(3.03-4.36)	<0.0001
Admit Age (years)	1.06(1.04-1.08)	<0.0001

Note: AUROC=0.87.

Figure 1. Percentage of postoperative urinary retention by location

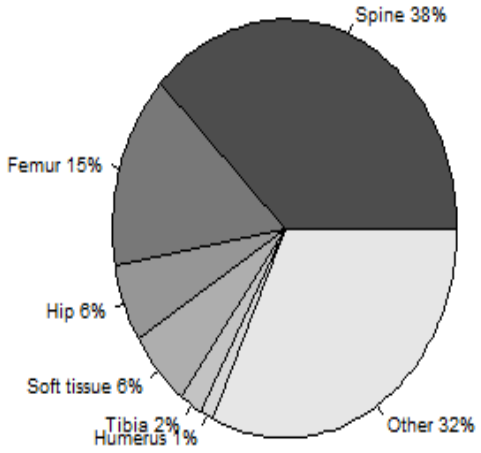
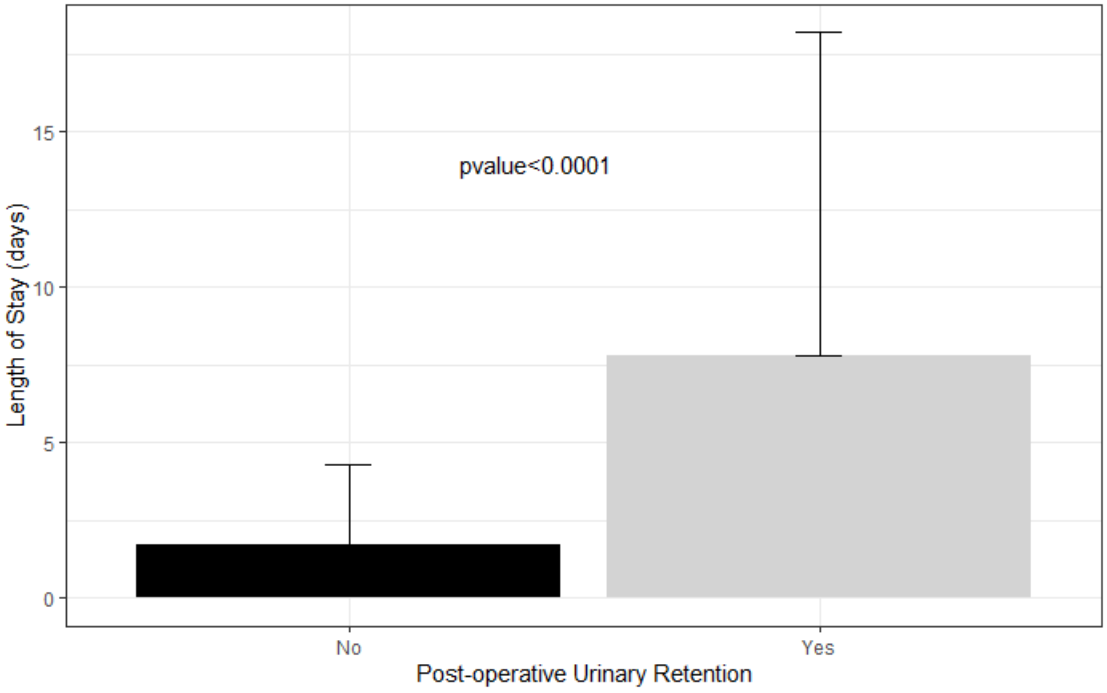


Figure 2. Length of stay in patients with postoperative urinary retention versus not



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