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Original Research

Preoperative Postvoid Residual Is Not Predictive of Postoperative Urinary Retention in Primary Total Joint Arthroplasty Patients

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ABSTRACT

Background: Postoperative urinary retention is a common complication after total hip and knee arthroplasty. Postvoid residual (PVR) scanning is a noninvasive method commonly used to evaluate this complication. Preoperatively increased PVR (PrePVR) has been suggested as a risk factor for postoperative catheterization. The aim of this study was to prospectively assess the importance of PrePVR and its relationship with urinary catheter placement, urology consult, and length of stay postoperatively.
Methods: Data was prospectively and consecutively collected at a single institution. All patients were bladder scanned preoperatively to collect PrePVR and subsequently scanned on postoperative days zero and one to collect Postoperative PVR. Chart review was performed to determine the number of straight catheterizations, Foley placement, urology consult and length of stay as well as patient demographics.
Results: Ninety-four consecutive patients were included in this study. There was a significantly increased postoperative PVR as compared to PrePVR (48.0 mL vs 21.0 mL; $P < .0001$). A PrePVR >50 mL was not associated with a significant difference in PVR between before and after surgery ($P = .13$); length of stay ($P = .08$); need for straight catheterization ($P = .11$); postoperative Foley placement ($P = 1.0$); or urology consult ($P = 1.0$). The only significant risk factor identified for postoperative Foley catheter placement was age (77.7 vs 64.2; $P = .02$).
Conclusions: PrePVR >50 mL was not an accurate predictor of postoperative urinary retention after total joint arthroplasty. PVR significantly increased in all patients. Male sex and increasing age were associated with large increases in PVR postoperatively and an increased risk of catheterization.

Introduction

Arthroplasty continues to be among the most commonly performed orthopedic procedures in the United States and is rapidly increasing in per-capita utilization [1]. As these surgeries continue to increase in popularity, there has been an increased emphasis on improving and optimizing the perioperative care of these patients.

Postoperative urinary retention (POUR) is a common complication after total joint arthroplasty (TJA) with risk previously reported from 10%-84% [2,3]. POUR has been shown to delay hospital discharge, increase length of stay, and subsequently increase hospital costs [4,5]. The use of an ultrasound scanner ("Bladder Scan") has previously been described as an accurate assessment tool in measuring bladder urinary volume and has become the mainstay of POUR monitoring [6].

Postvoid residual (PVR) scanning is a simple, noninvasive method to evaluate urine volume within the bladder after voiding. In general, it is thought that PVR <30 mL is insignificant, whereas residual volumes >50 mL may indicate an increased risk of retention at a later time [7,8]. Currently, there is no consensus on a numeric value of PVR for acute urinary retention, though >150 mL is commonly used in clinical practice [9-11]. However, prior studies evaluating PVR in nonsurgical hospitalized geriatric patients found that values > 150 mL were common and were not predictive of a need for catheterization alone [10].

The evaluation of the importance of preoperative PVR (PrePVR) is scarce in orthopaedic literature, and its clinical significance in the

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setting of arthroplasty is unclear. Scholten et al. evaluated patients undergoing TJA and found that PrePVR volume was a significant risk factor for the incidence of postoperative catheterization for residual urine (>150 mL) but not POUR (>400 mL bladder volume) [11]. In this study, they defined a significant PrePVR as >150 mL, which may not be an adequate threshold for identifying patients at risk for bladder dysfunction as suggested by prior literature [7,8].

The aim of this study was to prospectively assess the importance of PrePVR and its relationship with urinary catheter placement, urology consult, and length of stay postoperatively. Our secondary outcomes were to evaluate the changes in PVR before and after surgery and identify risk factors associated with an increased difference in PVR. Furthermore, we identified other risk factors (age, body mass index [BMI], American Society of Anesthesiologist [ASA], etc.) associated with POUR. The authors' hypothesized that patients with a PrePVR >50 mL will have an increased risk of POUR.

Material and methods

After IRB approval from the Mayo Clinic institutional review board (IRB# 21-008599), data was prospectively and consecutively collected at a single institution by 2 physician assistants (N.P. and J.S.) from the patients of 2 fellowship-trained TJA surgeons (M.S. and J.B.) from February 2021 to July 2021. Patient demographics evaluated included age, sex, BMI, history of urologic problems, type of anesthesia planned, laterality, and type of surgical procedure (total hip, total knee, and unicompartmental knee arthroplasty). Anesthetic types included general anesthesia, general anesthesia with pain block of neuraxial spinal anesthesia, and regional anesthesia, which was a neuraxial spinal anesthetic with light sedation. All patients undergoing TJA were bladder-scanned preoperatively at their routine preoperative evaluation prior to and following voiding to collect PrePVR. They were subsequently scanned following surgery on postoperative days zero and one, and postoperative PVR (PostPVR) was measured. Chart review was performed to collect if a straight catheterization was performed and the number required, whether a Foley was placed, whether a urology consult was completed, and the patient's overall length of stay. Per institution protocol, straight catheterization is performed for a bladder volume >400 mL, and a Foley is placed after 3 consecutive straight catheterizations if a fourth catheterization is required after implementation of voiding techniques such as ambulation and scheduled restroom trips to promote voiding.

Statistics

Patient demographics and procedure characteristics were summarized descriptively.

A Wilcoxon rank-sum test was used to test whether there is a significant difference in PVR from presurgery to postsurgery. The difference in PVR was dichotomized based on a prespecified threshold of 50 mL, and 2 patients were excluded as they were missing presurgery PVR values. The binary variable was modeled using logistic regression with a backwards stepwise selection method in which variables were removed based on *P*-values, with a *P*-value threshold of .1. Possible parameters included sex, age, BMI, ASA score, history of urinary retention, use of an intraoperative catheter, and type of anesthesia. Odds ratios are presented for the parameters in the final model. The associations between case characteristics and outcome variables including length of stay (categorical), urological consult, straight catheter use, and Foley catheter use were explored via Fisher exact tests for categorical variables and nonparametric Kruskal-Wallis tests for continuous variables. Analyses were performed in SAS Studio 3.81 (SAS Institute, Cary, NC).

Results

Demographics

A total of 94 patients were included in this study. Patient demographics and procedure characteristics were summarized descriptively (Tables 1 and 2). The mean PrePVR was 32.2 mL and mean PostPVR was 101.1 mL (Table 3). There was a significantly increased median PostPVR as compared to PrePVR (48.0 mL vs 21.0 mL; $P < .0001$).

PrePVR

A PrePVR >50 mL was not associated with a significant difference in PVR before and after surgery ($P = .13$) (Table 4). Further, this same cohort was not associated with any significant differences in length of stay ($P = .08$), need for straight catheterization ($P = .11$), postoperative Foley placement ($P = 1.0$), or urology consult ($P = 1.0$). Logistic regression was used to model the increase in PostPVR to determine the predictive value of PrePVR. The model included PrePVR and sex. Similarly, a negative binomial regression model was used to model length of stay. PrePVR was not predictive in either model.

Risk factors for increased differences in PVR

The probability of a large (50 mL or greater) PVR increase was modeled using logistic regression with backwards stepwise model selection. Possible parameters included sex, age, BMI, ASA score, history of urinary retention, use of an intraoperative Foley catheter, and type of anesthesia. The final logistic regression model consisted only of sex being statistically significant ($P = .0164$), which was associated with an odds ratio of 0.251 (0.081, 0.776). Female patients had a 17% probability of a large increase in PVR compared to 45% of males.

Risk factors associated with POUR

No significant factors were identified in the need for straight catheterization after surgery though age was nearly significant with a $P = .054$ (Table 5). The only significant risk factor identified for postoperative Foley catheter placement was age with the mean age of a patient requiring a catheter being 78 vs 64 for those not requiring any intervention ($P = .02$) (Table 6). Notably, a history of

Table 1
Demographics and baseline characteristics.

Demographics	Total (N = 94)
Sex, n (%)	
M	44 (46.8%)
F	50 (53.2%)
Age	
Mean (SD)	64.6 (12.02)
Median (range)	65.5 (16.0, 89.0)
N	94
BMI	
Mean (SD)	30.3 (5.95)
Median (range)	29.7 (14.3, 45.8)
N	94
ASA score, n (%)	
1: A normal healthy patient	5 (5.3%)
2: A patient with mild systemic disease	63 (67.0%)
3: A patient with a severe systemic disease that is not life-threatening	25 (26.6%)
4: A patient with a severe systemic disease that is a constant threat to life	1 (1.1%)
Hx of urinary retention?, n (%)	
Yes	12 (12.8%)
No	82 (87.2%)

Table 2
Procedure characteristics.

Procedure	Total (N = 94)
Surgery, n (%)	
Revision hip arthroplasty	1 (1.1%)
Revision knee arthroplasty	1 (1.1%)
THA	48 (51.1%)
Total knee arthroplasty (TKA)	39 (41.5%)
Unicompartmental knee arthroplasty	5 (5.3%)
Laterality, n (%)	
Bilateral	1 (1.1%)
Left	43 (45.7%)
Right	50 (53.2%)
Type of anesthesia, n (%)	
General	60 (63.8%)
General with pain block	6 (6.4%)
Regional	28 (29.8%)
Intraoperative Foley, n (%)	
N	77 (81.9%)
Y	17 (18.1%)

THA, total hip arthroplasty.

urinary retention, type of surgery, type of anesthesia, and intraoperative Foley placement were not found to be significant factors.

The only significant factor associated with the need for a urology consult following surgery was the placement of an interoperative Foley ($P = .018$). No other factors were significant, though age was near significant with a $P = .058$.

When evaluating length of stay in this cohort of patients, significant factors for increasing length of stay included higher ASA score ($P = .03$) and type of surgery ($P = .0029$). PrePVR had a significant yet inverse relationship with length of stay, as a lower PrePVR (mean 27.7 mL vs 56.5 mL) was associated with a longer length of stay ($P = .044$).

Discussion

The findings of the present study suggest that a PrePVR >50 mL is not associated with an increased risk of future need for straight catheterization, postoperative Foley catheter placement, urologic consultation, or increased length of stay. Female patients had a 17% probability of a large increase in PVR (>50 mL) compared to 45% of males on final logistic regression model, and the only significant risk factor identified for postoperative Foley catheter placement was age with the mean age of the patient (78 vs 64; $P = .02$).

The results of this study highlight that the use of bladder scanning preoperatively with a PrePVR >50 as a threshold may not be an effective screening modality for the risk of POUR. This is contrary to prior evidence suggesting that PrePVR of greater than 50 mL may serve as a useful screening tool [12]. Notably, these findings depart from the principal conclusions of Magaldi et al. [12], who contend that PrePVR >50 mL is a predictor of POUR. Some methodological differences may account for this disagreement. Most notably, the cohort in the study by Magaldi et al. underwent spinal anesthesia exclusively (a well-documented risk factor for POUR [11-14]), whereas this study's cohort varied in receiving spinal and general anesthesia. Next, Magaldi et al. measured PrePVR immediately before surgery, whereas this study used PVR data from routine preoperative appointments in the 2 weeks prior to surgery. Lastly, there was a notable difference in statistical analysis utilized in our study where logistical regression was employed to account for multiple variables in this study, whereas Magaldi et al. did not.

Table 3
Difference in postvoid residual before and after surgery.

Statistic	Presurgery PVR, mL	Postsurgery PVR, mL	Difference in PVR (post − pre surgery)	*P*-value
Mean (SD)	32.2 (43.40)	101.1 (145.29)	76.6 (144.19)	
Median (range)	21.0 (1.0, 341.0)	48.0 (0.0, 602.0)	14.0 (−38.0, 559.0)	<.0001[a]
N	92	67	66	

[a] *P*-value from Wilcoxon signed rank test.

Prior literature has suggested that TJA is associated with increased PostPVR and POUR [12,14-16]. This association is also supported in this cohort of patients, where 14.9% met the common clinical practice threshold for catheterization of a PostPVR >150 mL on the day of surgery. Although this study did not find that PrePVR was a useful indicator in predicting POUR, more sensitive and specific screening tools are required if they are to meaningfully guide clinical practice. Further investigation of screening by evaluating patients' prior urologic histories has been promising in identifying high-risk patients [17].

It is possible that *less* monitoring and screening for urinary retention may be beneficial for patients after TJA. Urinary catheterization is a risky procedure with a well-established causal relationship to urinary tract infection [4,16,18]. In addition, increased risk of periprosthetic joint infection after TKA has been connected to placement of indwelling urinary catheters [19]. Similarly, stagnant urine in the context of POUR may theoretically act as a nidus of infection [15], while undertreating or failing to treat POUR can potentially lead to bladder overdistension, neurologic damage, and consequent persistent voiding difficulties [12,13,15]. A delicate balance must be achieved to avoid either of these extremes and, in turn, minimize possible sequelae.

Unfortunately, there is a lack of consensus on agreed catheterization thresholds based on bladder volume defining POUR. Most recommendations for catheterization at 400-500 mL are largely based on rodent models extrapolated to humans to avoid bladder wall damage and further urologic sequelae [20]. Prior literature has challenged these recommendations and found that increased catheterization thresholds up to 800 mL have resulted in significant decreases in catheterization without any persistent voiding difficulties [20,21].

There is a significant heterogeneity in the literature regarding contributing factors to a patient's risk of developing POUR after TJA. Previous studies have identified increasing patient age as a significant risk factor for the onset of POUR [12,14,15,22-24], and male sex is equally well-described as a predisposing factor [12,14,15,25]. Other commonly identified risk factors include administration of high volumes of fluid intraoperatively and postoperatively [12-14,23,26], previous history of urologic disease such as benign prostatic hyperplasia or weak urinary stream [13-15,24-29], intraoperative catheter placement [23], the use of opioid analgesics during or after surgery (especially patient-controlled analgesia) [12,14,25,30,31], spinal or epidural anesthesia [11-14], poor ASA grade [14], and other medical comorbidities such as diabetes, renal disease, or even psychiatric disease [14,15]. Most of these factors are consistent with what is expected physiologically. For example, increasing age and male sex are known to be associated with the obstructive symptoms of benign prostatic hyperplasia and neuronal dysfunction that weakens detrusor activity and the micturition reflex [30,32]. The present study is certainly in agreement with prior literature in its conclusions that increasing age and male sex are likely to contribute to POUR risk, but beyond these primary factors, we did not observe similar elevations in risk. There is no strong consensus in the literature for any one of these factors definitively increasing risk for POUR, and many studies find no association or even paradoxical inverse relationships for several of the abovementioned characteristics. Further investigation is warranted to better define the highest-risk patients.

Limitations for this study include that patients treated at our facility may not be representative of broader populations given a two-surgeon

Table 4
Postoperative outcomes/interventions by presurgery postvoid residual (PrePVR).

Variable	Presurgery PVR		Total (N = 92)	*P*-value
	<50 (N = 80)	50+ (N = 12)		
Difference in postvoid residual (postsurgery - presurgery)				.1321[a]
Mean (SD)	75.6 (136.30)	87.2 (225.65)	76.6 (144.19)	
Median (range)	16.5 (−38.0, 559.0)	−23.5 (−32.0, 537.0)	14.0 (−38.0, 559.0)	
N	60	6	66	
Length of stay (d)				.0805[a]
Mean (SD)	1.3 (1.00)	0.8 (0.94)	1.2 (1.00)	
Median (range)	1.0 (0.0, 5.0)	1.0 (0.0, 3.0)	1.0 (0.0, 5.0)	
N	80	12	92	
Straight catheter, n (%)				.1140[b]
No	62 (77.5%)	12 (100.0%)	74 (80.4%)	
Yes	18 (22.5%)	0 (0.0%)	18 (19.6%)	
Postoperative Foley catheter, n (%)				1.0000[b]
No	77 (96.3%)	12 (100.0%)	89 (96.7%)	
Yes	3 (3.8%)	0 (0.0%)	3 (3.3%)	
Any postoperative catheter, n (%)				.0624[b]
No	60 (75.0%)	12 (100.0%)	72 (78.3%)	
Yes	20 (25.0%)	0 (0.0%)	20 (21.7%)	
Urology consult, n (%)				1.0000[b]
No	76 (95.0%)	12 (100.0%)	88 (95.7%)	
Yes	4 (5.0%)	0 (0.0%)	4 (4.3%)	

[a] Kruskal-Wallis *P*-value.
[b] Fisher exact *P*-value; 2 patients missing from this table due to lack of PrePVR values.

Table 5
Risk factors for straight catheterization.

Variable	Straight catheterization		*P*-value
	No (N = 76)	Yes (N = 18)	
Sex, n (%)			1.0000[a]
M	36 (47.4%)	8 (44.4%)	
F	40 (52.6%)	10 (55.6%)	
Age			.0538[b]
Mean (SD)	63.6 (12.39)	68.8 (9.46)	
Median (range)	64.5 (16.0, 89.0)	71.0 (46.0, 84.0)	
N	76	18	
BMI			.2315[b]
Mean (SD)	30.7 (6.05)	28.6 (5.30)	
Median (range)	30.0 (14.3, 45.8)	28.1 (16.0, 38.4)	
N	76	18	
ASA score			.8796[b]
Mean (SD)	2.2 (0.59)	2.2 (0.43)	
Median (range)	2.0 (1.0, 4.0)	2.0 (2.0, 3.0)	
N	76	18	
Hx of urinary retention?, n (%)			1.0000[a]
Yes	10 (13.2%)	2 (11.1%)	
No	66 (86.8%)	16 (88.9%)	
Surgery, n (%)			.183[a]
Revision hip arthroplasty	1 (1.3%)	0 (0.0%)	
Revision knee arthroplasty	1 (1.3%)	0 (0.0%)	
THA	39 (51.3%)	9 (50.0%)	
TKA	33 (42.3%)	6 (33.3%)	
Unicompartmental knee arthroplasty	2 (2.6%)	3 (16.7%)	
Laterality, n (%)			.5441[a]
Bilateral	1 (1.3%)	0 (0.0%)	
Left	33 (43.4%)	10 (55.6%)	
Right	42 (55.3%)	8 (44.4%)	
Type of anesthesia, n (%)			.3041[a]
General	51 (67.1%)	9 (50.0%)	
General with pain block	5 (6.6%)	1 (5.6%)	
Regional	20 (26.3%)	8 (44.4%)	
Presurgery postvoid residual			.1971[b]
Mean (SD)	35.3 (47.46)	19.3 (14.01)	
Median (range)	24.5 (1.0, 341.0)	15.5 (3.0, 49.0)	
N	74	18	
Intraoperative Foley, n (%)			1.0000[a]
N	62 (81.6%)	15 (83.3%)	
Y	14 (18.4%)	3 (16.7%)	

THA, total hip arthroplasty.
[a] Fisher exact *P*-value.
[b] Kruskal-Wallis *P*-value.

series at an academic institution. However, the inclusion of patients with both spinal and general anesthesia may be more generalizable than previously published reports. Further, there is a possibility of a type II error to detect difference for rarer outcomes evaluated.

Conclusions

The findings in this study suggest that PrePVR >50 mL was not an accurate predictor of POUR after TJA. PVR significantly increased in all patients. Male sex and increasing age were associated with large increases in PVR postoperatively and an increased risk of catheterization.

Conflicts of interest

M. Spangehl receives research support from Stryker and DepuySynthes and is an editorial/governing board member of the Journal of Arthroplasty and Arthroplasty Today. All other authors declare no potential conflicts of interest.

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CRediT authorship contribution statement

Sailesh V. Tummala: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Erik M. Verhey:** Writing – review & editing, Investigation, Data curation. **Mark J. Spangehl:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Jeffrey D. Hassebrock:** Writing – review & editing, Conceptualization. **Jennifer Swanson:** Resources, Project administration, Investigation. **Nicholas Probst:** Supervision, Resources, Project administration, Conceptualization. **Anna M. Joseph:** Methodology, Formal analysis, Data curation. **Heidi Kosiorek:** Methodology, Formal analysis, Data curation. **Joshua S. Bingham:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Table 6
Risk factors for postoperative Foley catheterization.

Variable	Postoperative Foley catheterization		*P*-value
	No (N = 91)	Yes (N = 3)	
Sex, n (%)			.5979[a]
M	42 (46.2%)	2 (66.7%)	
F	49 (53.8%)	1 (33.3%)	
Age			**.0213**[b]
Mean (SD)	64.2 (11.93)	77.7 (6.43)	
Median (range)	65.0 (16.0, 89.0)	75.0 (73.0, 85.0)	
N	91	3	
BMI			.3384[b]
Mean (SD)	30.2 (5.95)	33.4 (6.19)	
Median (range)	29.5 (14.3, 45.8)	36.2 (26.3, 37.7)	
N	91	3	
ASA score			.7444[b]
Mean (SD)	2.2 (0.56)	2.3 (0.58)	
Median (range)	2.0 (1.0, 4.0)	2.0 (2.0, 3.0)	
N	91	3	
Hx of urinary retention?, n (%)			.3393[a]
Yes	11 (12.1%)	1 (33.3%)	
No	80 (87.9%)	2 (66.7%)	
Surgery, n (%)			.194[a]
Revision hip arthroplasty	1 (1.1%)	0 (0.0%)	
Revision knee arthroplasty	1 (1.1%)	0 (0.0%)	
THA	46 (50.5%)	2 (66.7%)	
TKA	39 (42.9%)	0 (0.0%)	
Unicompartmental knee arthroplasty	4 (4.4%)	1 (33.3%)	
Laterality, n (%)			.6070[a]
Bilateral	1 (1.1%)	0 (0.0%)	
Left	41 (45.1%)	2 (66.7%)	
Right	49 (53.8%)	1 (33.3%)	
Type of anesthesia, n (%)			.1266[a]
General	59 (64.8%)	1 (33.3%)	
General with pain block	5 (5.5%)	1 (33.3%)	
Regional	27 (29.7%)	1 (33.3%)	
Presurgery postvoid residual			.1159[b]
Mean (SD)	32.9 (43.92)	9.3 (4.51)	
Median (range)	21.0 (1.0, 341.0)	9.0 (5.0, 14.0)	
N	89	3	
Intraoperative Foley, n (%)			.4543[a]
N	75 (82.4%)	2 (66.7%)	
Y	16 (17.6%)	1 (33.3%)	

THA, total hip arthroplasty.
Bolded indicated statistically significant with a *P*-value < .05.
[a] Fisher exact *P*-value.
[b] Kruskal-Wallis *P*-value.

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