Joint Diseases and Related Surgery

Jt Dis Relat Surg
2026;37(1):98-106

ORIGINAL ARTICLE

Incidence and clinical predictors of postoperative urinary retention following total hip and total knee arthroplasty: A single-center, prospective study

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ABSTRACT

Objectives: This study aims to evaluate the incidence and clinical predictors of postoperative urinary retention (POUR) following total joint arthroplasty (TJA) and to evaluate whether preoperative bladder voiding efficiency (BVE) can independently predict POUR.

Patients and methods: Between September 2023 and May 2024, a total of 200 patients (66 males, 134 females; median age: 69 years; range, 32 to 90 years) scheduled for primary total hip or knee arthroplasty were prospectively analyzed. Patients were classified into POUR (n=33) and non-POUR (n=167) groups. Demographic characteristics, urological history, operative variables, the International Prostate Symptom Scores (IPSS), and bladder scanner measurements were collected and compared.

Results: The overall incidence of POUR was 16.5% (33/200). Compared to the non-POUR group, the POUR group exhibited significantly higher IPSS (p<0.001) and lower BVE (p=0.0016). Higher body mass index (p<0.001), hypertension (p<0.001), and diabetes mellitus (p<0.001) were significantly associated with POUR development.

Conclusion: Higher preoperative IPSS and lower BVE seem to be independently associated with POUR following TJA. Notably, BVE emerges as a novel and clinically meaningful predictor. Routine preoperative assessment of BVE and IPSS may aid in the early identification of high-risk patients, enabling the implementation of targeted strategies to prevent POUR and its associated complications.

Keywords: Incidence, periprosthetic joint infection, risk factor, total hip arthroplasty, total knee arthroplasty, total joint arthroplasty, urinary retention, urinary tract infection.

The incidence of postoperative urinary retention (POUR) following total joint arthroplasty (TJA) has been reported to range from 9.3 to 46.3%,[1-3] reflecting significant heterogeneity across studies. This wide variation is primarily attributable to the absence of a universally accepted definition of urinary retention. Moreover, the incidence of POUR is estimated to be nearly 20-fold higher in patients undergoing TJA compared to the general surgical population.[4,5] The discrepancies in the literature regarding POUR rates could stem from differences in patient populations, varying sample sizes, diverse postoperative pain management approaches, anesthesia methods employed, and the multitude of definitions used for characterizing POUR.[6]

Untreated or delayed recognition of POUR may result in bladder overdistension, potentially causing

Received: June 16, 2025
Accepted: September 11, 2025
Published online: November 05, 2025

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Citation: Tsai CE, Tseng WH, Chang WS, Ho CH, Chien CS. Incidence and clinical predictors of postoperative urinary retention following total hip and total knee arthroplasty: A single-center, prospective study. Jt Dis Relat Surg 2026;37(1):98-106. doi: 10.52312/jdrs.2026.2429.

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detrusor muscle injury, irreversible voiding dysfunction, and secondary urinary tract infections. In severe cases, these infections may progress to hematogenous seeding and lead to periprosthetic joint infection.[7] Although catheterization is the standard intervention for POUR, it is associated with increased risks of urethral trauma, patient discomfort, and catheter-associated urinary tract infections. Additionally, the occurrence of POUR has been linked to prolonged hospitalization, increased healthcare costs, delayed postoperative mobilization, and a higher risk of readmission.[8,9]

Early identification of POUR, prevention of associated complications, and risk reduction have become critical components of perioperative care, particularly within the framework of modern Enhanced Recovery After Surgery (ERAS) protocols. These protocols, which are increasingly implemented in European arthroplasty centers, aim to shorten hospital stays, reduce postoperative complications, and optimize surgical outcomes.[10-12] Therefore, a comprehensive understanding of POUR and its clinical management is essential for arthroplasty surgeons. Identifying reliable preoperative risk factors may facilitate targeted interventions, enabling orthopedic teams to better stratify patient risk and implement preventative strategies to improve postoperative recovery.[13]

Previous research has examined a variety of predictive factors for POUR, including patient comorbidities, anesthesia type, and postoperative pain management regimens. Urological determinants, such as preoperative bladder volume or post-void residual (PVR), have also been investigated. In their study, Scholten et al.[14] reported that patients with higher preoperative residual bladder volumes, measured via ultrasound, had a greater likelihood of requiring postoperative catheterization. Furthermore, a recent nationwide database study involving over one million patients confirmed the relevance of baseline urinary function as a predictor of POUR.[3] However, PVR alone does not account for individual variations in voided volume and bladder capacity.

Bladder voiding efficiency (BVE) offers a normalized assessment of voiding function by expressing the proportion of bladder capacity expelled per void. While BVE is a urological parameter and shares conceptual similarities with PVR, it may provide a more comprehensive measure of preoperative voiding performance. To the best of our knowledge, no previous study has systematically evaluated the predictive value of preoperative BVE for POUR in the TJA population.

In the present study, we aimed to determine the incidence of POUR following TJA and to evaluate whether preoperative BVE, along with other patient-specific and perioperative factors, independently predicts POUR in order to enhance risk stratification and guide targeted perioperative strategies to reduce the occurrence of POUR and improve patient outcomes.

PATIENTS AND METHODS

This single-center, prospective, observational study was conducted at Chi Mei Medical Center, Department of Orthopaedics, between September 2023 and May 2024. Patients scheduled to undergo primary total hip arthroplasty (THA) or total knee arthroplasty (TKA) were included. Bilateral arthroplasty cases were excluded, as these procedures have longer operative durations and, in our facility, require indwelling Foley catheterization for precise intraoperative urine output measurement to maintain accurate fluid balance. Such catheterization precludes standardized assessment of POUR and BVE and, therefore, these cases were not eligible. Additional exclusion criteria included chronic kidney disease Stage ≥III, medical conditions requiring indwelling urinary catheterization, and revision arthroplasty. As a tertiary care facility, the study site routinely manages patients with complex medical comorbidities, many of whom are at elevated risk for perioperative complications following TJA. Initially, a total of 222 patients were initially enrolled in the study. Twelve patients were excluded due to the need for urinary catheterization for medical monitoring, and an additional 10 patients with chronic kidney disease Stage ≥III were also excluded. Finally, a total of 200 patients (66 males, 134 females; median age: 69 years; range, 32 to 90 years) were included in the study (Figure 1). Written informed consent was obtained from each patient. The study protocol was approved by the Chi Mei Medical Center Institutional Review Board (Date: 21.09.2023, No: 11210-012). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Study procedure

Upon admission, each patient completed the International Prostate Symptom Score (IPSS) questionnaire as part of the baseline urological assessment. Although IPSS was originally

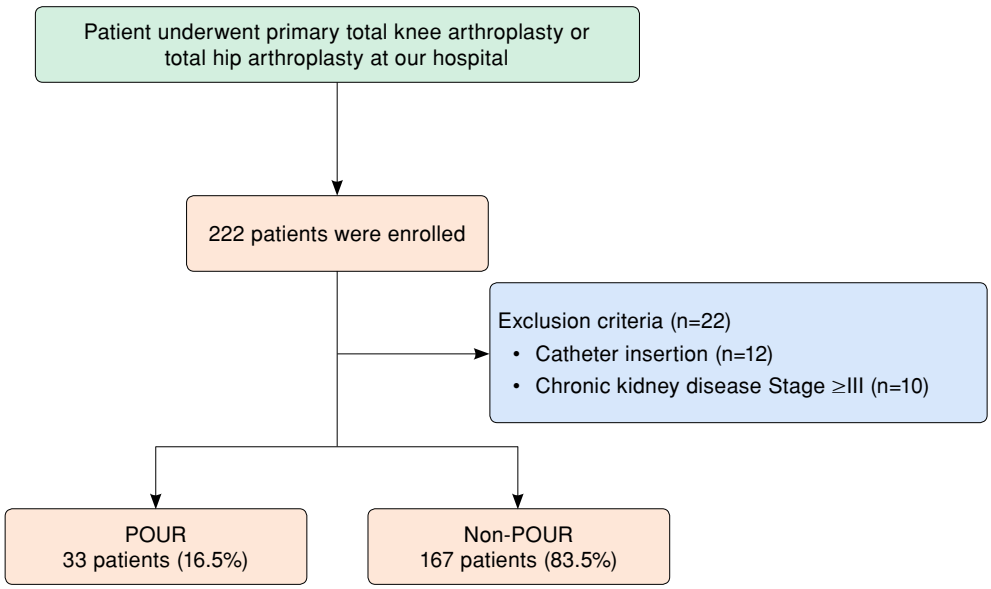


FIGURE 1. The study flowchart.
POUR: Postoperative urinary retention.

developed for males with lower urinary tract symptoms, it was administered to both sexes in this study as a validated, non-sex-specific tool for evaluating voiding and storage symptoms; in female participants, it was used to capture lower urinary tract symptom severity in a standardized manner.

In addition, BVE was objectively measured during hospitalization. It was defined as the ratio of voided volume to the total bladder volume (voided volume plus PVR urine), serving as a clinically meaningful metric for evaluating bladder emptying capacity. This measurement was performed once preoperatively, immediately prior to the patient's voluntary voiding. Post-void residual was measured using a portable ultrasound bladder scanner (Model: BVI 6100; Manufacture: Verathon Medical, UK) following a standardized protocol. The BVE was calculated using the following formula:

$$BVE = Voided\ volume\ /\ (Voided\ volume + PVR).$$ [15-17]

All bladder ultrasound measurements were performed by two nursing practitioners with more than three years of experience in bladder scanning and certification in device operation. Both operators underwent calibration training before study initiation to minimize inter-operator variability.

All patients who attempted spontaneous voiding during hospitalization prior to surgery were documented. Following voiding, bladder ultrasound was performed to measure PVR urine volume. The history of benign prostatic hyperplasia (BPH) was assessed only in male patients; in females, this variable was recorded as "not applicable" in the data tables.

All patients underwent general anesthesia, administered by an arthroplasty-specialized anesthesia team. This reflected the study-specific decision rather than an institutional standard of care. The potential implications of this anesthetic choice for POUR risk were followed as described in the literature, suggesting that general anesthesia may confer a lower POUR risk compared with neuraxial anesthesia.[3] No patients received preoperative indwelling urinary catheters or underwent straight catheterization prior to or during surgery. Prophylactic intravenous cefazolin was administered preoperatively in all cases, unless contraindicated due to allergy, in which case clindamycin was used as an alternative. Intraoperative parameters, including anesthetic technique, operative duration, total intravenous fluid volume, and blood transfusion requirements, were meticulously recorded. Immediately postoperatively, all patients underwent straight catheterization, and the volume of retained urine was measured and documented. This study protocol includes immediate postoperative intermittent catheterization in all patients to prevent bladder overdistension, even in the absence of clinical POUR, as a prophylactic measure against detrusor injury.

Following surgery, if spontaneous voiding had not occurred within 6 h of ward admission, nursing staff performed a bladder scan to assess urinary retention. A residual volume exceeding 400 mL was defined as POUR. Patients who did not meet the 400 mL threshold at the first check but remained unable to void were re-scanned to identify delayed POUR onset.

If spontaneous micturition was not achieved, even after administration of bethanechol, straight catheterization was performed. If the patient remained unable to void after an additional 6 h of observation, an indwelling Foley catheter was inserted. A bladder scan was also conducted in patients who reported suprapubic discomfort. The diagnostic threshold for POUR (residual volume >400 mL and/or inability to void) was consistently applied while deciding both straight catheterization and subsequent Foley catheter placement.

The patients were divided into two groups: those who developed POUR and those who did not (non-POUR). Demographic data collected included age, sex, American Society of Anesthesiologists (ASA) classification, body mass index (BMI), history of BPH, diabetes mellitus (DM), hypertension, and prior urological history. History of urological disease consisted of benign conditions such as urinary tract infections, urolithiasis, overactive bladder, and previous urethral stricture. Patients with known malignant urological conditions, including bladder or prostate cancer, were excluded from the cohort during the screening phase. Operative variables recorded comprised length of hospital stay, estimated blood loss, intraoperative fluid volume, total blood transfusion volume, operative duration, and the use of an intermittent catheterization protocol. The number of operating surgeons was recorded (n=2), along with their years of arthroplasty experience (range, 20 to 25 years), to account for possible surgeon-related variability in outcomes.

Perioperative fluid management was closely monitored, given that excessive intravenous fluid administration may contribute to bladder overdistension and increase the risk of urinary retention. Total intraoperative fluid input and postoperative fluid balance were recorded and analyzed to assess their association with the incidence of POUR. In addition, early postoperative mobilization was systematically documented to evaluate its potential role in promoting bladder function recovery. Early ambulation was encouraged as part of routine postoperative care, based on its physiological benefits in stimulating spontaneous voiding and reducing the need for catheterization.

Statistical analysis

Study power analysis and sample size calculation were performed using the G*Power version 3.1 software (Heinrich-Heine-Universität, Düsseldorf, Germany). Based on an expected POUR incidence of 20% in TJA, an anticipated odds ratio (OR) of 2.0 for the primary predictor (BVE), a two-tailed α of 0.05, and β of 0.20 (80% power) were calculated. This resulted in a minimum required sample size of 186 patients.

Statistical analysis was performed using the SPSS for Windows version 26.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were presented in mean ± standard deviation (SD) or median (min-max), while categorical variables were presented in number and frequency. The Shapiro-Wilk test was applied to assess the normality of data distribution before selecting parametric or non-parametric tests. For normally distributed data, comparisons between groups were performed using Student t-test; for non-normally distributed data, the Mann-Whitney U test was used. Categorical variables were analyzed using either the chi-square test or Fisher exact test, as appropriate based on sample size. Variables with a p value of <0.05 in the univariate analysis were further evaluated using binary logistic regression to identify independent predictors of POUR. A two-tailed p value of <0.05 was considered statistically significant with 95% confidence interval (CI).

RESULTS

Among all patients included in the study, 33 (16.5%) developed POUR following TJA, each requiring a single episode of intermittent catheterization. Thirty-two patients underwent THA and 168 underwent TKA. The median BMI was 26.6 (range, 14.7 to 38.2) kg/m². The median length of hospital stay was 5 (range, 1 to 11) days. Eleven patients (5.5%) required placement of an indwelling Foley catheter due to persistent urinary retention despite prior straight catheterization and pharmacologic intervention.

The relationship between patient demographic data and the development of POUR is demonstrated in Table I. In the male subgroup (n=66), 15 POUR events were observed (22.7%), resulting in a relatively low event-per-variable ratio. To address potential model overfitting, we

TABLE I
Patient demographic and clinical data

Variables	POUR (n=33) n	%	Mean±SD	Non-POUR (n=167) n	%	Mean±SD	*p*
Age (year)			69.94±7.60			68.87±9.37	0.5399
Sex							0.0959
Female	18			116	69.46		
Male	15			51	30.54		
Height			157.1±7.28			158.3±7.47	0.4063
Weight			70.96±8.33			65.83±12.03	**0.0042**
Body mass index (kg/m²)			28.79±3.15			26.21±3.94	**<0.001**
International Prostate Symptom Score			9.55±6.30			5.42±6.13	**<0.001**
Bladder voiding efficiency			0.87±0.13			0.94±0.11	**0.0016**
Benign prostate hyperplasia							
Yes	5	33.33		3	5.89		0.0304*
No	10	66.66		48	94.11		
Diabetes mellitus	20	60.61		37	22.16		**<0.001**
Hypertension	29	87.88		63	37.72		**<0.001**
History of urologic disease							
Yes	1	3.1		6	3.6		1.000
No	32	96.9		161	96.4		

POUR: Postoperative urinary retention; SD: Standard deviation; P-values highlighted in bold are statistically significant. BPH history was assessed only in male patients; in females, this variable was recorded as "not applicable" in the data tables. P-values were calculated using Student's t-test for continuous variables and Chi-square test for categorical variables.

reduced the number of covariates and applied penalized logistic regression (Firth's correction) for multivariate analysis.

There were no statistically significant differences between the POUR and non-POUR groups in terms of age (p=0.539), height (p=0.406), sex (p=0.095), ASA classification (p=0.973), history of urological disease (p=1.000), or history of urological surgery (p=1.000). However, univariate analysis revealed that patients who developed POUR were more likely to have a higher BMI (p<0.001), a history of hypertension (p<0.001), BPH (p<0.001), and DM (p<0.001). Additionally, the preoperative IPSS was significantly higher in the POUR group compared to the non-POUR group (p<0.001).

Seven patients (3.5%) had a history of urological disease, which included urinary tract infections, urinary stones, overactive bladder, or prior urethral strictures; this was equally distributed between the POUR and non-POUR groups (p=1.000), suggesting no significant association with POUR incidence.

Although the incidence of POUR was higher in men (22.7%) than in women (13.4%), the difference did not reach statistical significance (p=0.07). This clinically notable but underpowered finding is consistent with prior studies that identify male sex as a strong predictor of POUR, suggesting that a larger sample size may be required to detect a statistically significant association.

Postoperative management factors, including early ambulation and perioperative fluid administration, were evaluated in relation to the incidence of POUR. Although the mean intraoperative intravenous fluid volume did not differ significantly between the POUR and non-POUR groups, earlier postoperative mobilization was associated with a lower incidence of urinary retention, suggesting that early ambulation may play a more prominent role than fluid volume in reducing POUR risk.

Furthermore, univariate analysis revealed that the non-POUR group had a significantly higher preoperative BVE index compared to the POUR group (OR 0.92, 95% CI: 0.88-0.96, p=0.0016).

Operative variables are summarized in Table II. There were no statistically significant differences between the POUR and non-POUR groups in

TABLE II
Operative variables

Variables	POUR Mean±SD	Non-POUR Mean±SD	*p*
ICP after operation (mL)	236.4±155.3	213.1±183.2	0.4950
Hospitalization (day)	5.15±1.09	5.07±1.33	0.7282
Operation time (min)	92.94±29.27	94.59±27.82	0.7574
Estimated blood loss (mL)	81.06±183.0	70.20±174.7	0.7463
Intraoperative IV fluid volume (mL)	803.0±400.6	704.5±320.6	0.1240
Blood transfusion amount (Units)*	1.15±1.48	1.19±1.41	0.9001

POUR: Postoperative urinary retention; SD: Standard deviation; ICP: Intermittent catheterization program; IV: Intravenous. * pRBCs (packed red blood cells) used for blood transfusion.

TABLE III
Multivariate analysis

Variables	Odds ratio	95% CI	*p*
Age	1.01	0.97-1.06	0.538
Body mass index	1.18	1.07-1.31	<0.001*
Benign prostate hyperplasia	4.08	1.21-13.7	0.0234*
Diabetes mellitus	5.41	2.46-11.89	<0.001*
Hypertension	11.97	4.02-35.64	<0.001*
International Prostate Symptom Score	6.49	2.79-15.11	<0.001*
Bladder voiding efficiency	0.92	0.88-0.96	0.0016
Estimated blood loss	1.10	0.52-2.34	0.745
Intraoperative IV fluid volume	1.83	0.80-4.23	0.127

CI: Confidence interval; * P-values statistically significant.

terms of hospitalization duration, operative time, estimated blood loss, intraoperative intravenous fluid volume, or blood transfusion requirements, indicating that intraoperative factors did not play a significant role in the development of POUR. Instead, patient-related characteristics, such as elevated BMI, higher preoperative IPSS, and a history of hypertension or DM, appeared to be more influential. Identifying such high-risk patients preoperatively facilitated targeted preventative strategies and optimize perioperative management.

Multivariate logistic regression using the Firth's correction confirmed that DM (OR 5.41, 95% CI: 2.46-11.89, p<0.001), hypertension (OR=11.97, 95% CI: 4.02-35.64, p<0.001), BPH (OR=4.08, 95% CI: 1.21-13.7, p=0.023), higher BMI (OR=1.18, 95% CI: 1.07–1.31, p<0.001), higher IPSS score (OR=6.49, 95% CI: 2.79-15.11, p<0.001), and lower BVE (OR=0.92, 95% CI: 0.88-0.96, p=0.0016) were independent predictors of POUR (Table III).

DISCUSSION

In the present study, the incidence of POUR following TJA was 16.5%, consistent with previously reported rates in the literature, which emphasize the clinical relevance of POUR as a common postoperative complication.[18-22] Lower BVE and higher IPSS were identified as independent risk factors, along with higher BMI, hypertension, BPH, and DM. These systemic and functional parameters are known to contribute to impaired detrusor contractility, autonomic dysfunction, or bladder outlet obstruction, which may predispose patients to perioperative voiding difficulties. These findings highlight the importance of incorporating BVE and IPSS assessments into preoperative evaluation to identify high-risk individuals and implement targeted interventions aimed at reducing POUR

incidence and its associated morbidity. Consistent with previous reports identifying IPSS as a predictive factor for POUR,[23,24] our study reinforces its utility in preoperative risk stratification. More importantly, our results also address a notable gap in the literature by introducing BVE as a novel predictive parameter.

Our results build on prior work which has linked IPSS, PVR, and BPH to POUR in orthopedic cohorts, while addressing a clear knowledge gap: the lack of preoperative voiding-efficiency metrics in this population. Bladder voiding efficiency, unlike raw PVR, accounts for individual variations in voided volume and bladder capacity, providing a normalized functional assessment of bladder emptying. Recognizing the predictive value of BVE alongside IPSS is essential for refining perioperative risk stratification, particularly in patients with metabolic or urological comorbidities.

A review of the current literature did not identify any prior studies that recognized BVE as a predictive factor for POUR. This novel observation suggests that functional bladder metrics, when assessed prospectively, can add meaningful value to risk models currently dominated by demographic and anesthetic factors. Bladder voiding efficiency is a non-invasive, objective, and easily calculated parameter that reflects the effectiveness of bladder emptying.[25] Given its potential utility, future large, multi-center studies should evaluate whether incorporating BVE into routine preoperative assessments can improve postoperative outcomes in arthroplasty populations.

The use of general anesthesia in this study reflected a study-specific decision rather than institutional policy. This approach was jointly determined by the orthopedic and anesthesiology teams, based on advantages such as standardized hemodynamic control, predictable recovery, and fewer delays in patients with contraindications to neuraxial anesthesia (e.g., anticoagulation, spinal pathology). Notably, prior studies have reported higher POUR rates with neuraxial anesthesia. Bjerregaard et al.[24] reported that spinal anesthesia increased the odds of POUR (OR=1.5; 95% CI: 1.02-2.3; p=0.04) in fast-track arthroplasty settings. Thus, the relatively lower risk profile of general anesthesia may have influenced the overall POUR incidence observed in our cohort and should be considered while interpreting our results.

In our analysis, sex, age, and history of urological disease were not significantly associated with the incidence of POUR. Although men exhibited a higher incidence of POUR (22.7% *vs.* 13.4% in women), this difference did not reach statistical significance, likely due to limited power in sex-stratified analysis. This finding aligns with published literature that identifies male sex as a strong predictor of POUR, underscoring the need for adequately powered studies to clarify the role of sex as an independent risk factor. These results suggest that POUR development may be more closely linked to functional bladder parameters and systemic comorbidities than to demographic or procedural factors alone.

Although voiding efficiency may theoretically be influenced by sex-related differences in lower urinary tract anatomy and function,[26] in our cohort preoperative BVE did not differ significantly between men and women. Therefore, our analysis focused on the relationship between BVE and POUR irrespective of sex. The cited study does not conclude that BVE inherently differs between sexes; rather, it notes that mechanisms of lower urinary tract symptoms in women remain to be elucidated and that pressure-flow studies may reveal differences in voiding patterns in both sexes. Future studies with larger, sex-stratified samples could further explore potential sex-specific variations in BVE in arthroplasty patients.

Although BVE incorporates residual urine volume in its calculation, it was assessed preoperatively as a baseline indicator of bladder function, whereas POUR was defined based on residual volume measured ≥6 h postoperatively. This temporal separation, along with the fact that BVE reflects the ratio of voided to total bladder volume, provides a more nuanced evaluation of voiding capacity than residual volume alone. Furthermore, despite partial mathematical overlap, BVE remained an independent predictor of POUR in multivariate analysis, supporting its validity and unique clinical relevance.

Non-pharmacological strategies such as hot/cold pack applications or sensory stimulation were not employed in this study, as they are not part of our institution's standardized protocol and are currently difficult to standardize in terms of temperature, volume, and duration. However, their potential as adjunctive conservative therapies warrants further investigation in future trials comparing non-pharmacologic and pharmacologic approaches.

In the context of modern fast-track joint arthroplasty protocols, ensuring comprehensive

perioperative care is critical to optimizing patient outcomes and minimizing complications. Incorporating functional bladder assessment into ERAS workflows can facilitate early intervention, shorten hospital stays, and reduce readmission rates related to urinary complications. Early recognition of high-risk patients allows for timely implementation of preventive strategies, such as bladder scanning schedules, pharmacologic support, and fluid management adjustments, to mitigate POUR risk.

Despite the prospective design of this study, several limitations should be acknowledged. First, the relatively small sample size may limit the generalizability of the findings to broader populations undergoing TJA. Additionally, as a single-center study, institutional practices and patient demographics may have introduced selection bias, potentially affecting the external validity of the results. These limitations highlight the need for larger, multi-center studies to validate our findings and enhance their applicability across diverse clinical settings.

In conclusion, our study identified several independent risk factors for POUR, including IPSS, BVE, BMI, hypertension, BPH, and DM. Notably, BVE emerged as a novel and clinically meaningful predictor. Routine preoperative assessment of BVE and IPSS may aid in the early identification of high-risk patients, enabling the implementation of targeted strategies to prevent POUR and its associated complications. Future research should focus on refining predictive tools and integrating bladder function metrics into perioperative pathways for TJA.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Contributed to the conception and design of this study, contributed to preparation and critical revision of the manuscript: C.E.T., C.S.C.; Data collection and/or processing: C.E.T., W.S.C., W.H.T.; Analysis and/or interpretation: C.E.T., C.H.H.; Literature review: C.E.T., W.S.C.; Materials and resources: C.E.T., W.S.C. The final version of the article was read and approved by all the authors.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

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