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신경축 마취하에 고관절전치환술을 받은 환자에서 수술 후 요폐의 위험인자

Risk factors for postoperative urinary retention after total hip replacement arthroplasty under neuraxial anesthesia

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ABSTRACT

Risk factors for postoperative urinary retention after total hip replacement arthroplasty under neuraxial anesthesia

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Introduction: Postoperative urinary retention (POUR) is a common complication among patients who undergo total hip replacement arthroplasty (THRA) under neuraxial anesthesia. POUR can cause urinary tract infections (UTIs), which are associated with adverse postoperative outcomes. Despite its clinical importance, diagnostic criteria for POUR are variable and inconsistent. The aim of this study was to identify risk factors for POUR among patients undergoing THRA under neuraxial anesthesia by introducing objective and delicate diagnostic criteria.

Methods: We retrospectively analyzed the medical reports of 881

patients who underwent THRA under neuraxial anesthesia. Foley catheters were removed on postoperative day 2, and voiding was assessed every 6 h to evaluate both the ability to void spontaneously and post-void residual urine volume. Patients were diagnosed with POUR if they were unable to void spontaneously or if the post-void residual urine volume measured by clean intermittent catheterization was >100 ml at least once. Potential risk factors for POUR were assessed by univariable and multivariable logistic regression analysis.

Results: POUR was detected in 211/881 (24%) patients. POUR was significantly associated with female sex (adjusted odds ratio (OR): 1.699; 95% confidence interval (CI): 1.122-2.573; P = 0.012), age/10 (adjusted OR: 1.256; 95% CI: 1.054-1.497; P = 0.011), history of diabetes mellitus (adjusted OR: 1.767; 95% CI: 1.073-2.909; P = 0.025), and the use of dexmedetomidine (adjusted OR: 2.417; 95% CI: 1.103-5.293; P = 0.027). Patients in the POUR group had a significantly higher risk of UTI (OR: 8.107; 95% CI: 1.561-42.096; P = 0.013) than those in the non-POUR group did. However, there was no significant difference in the duration of hospital stay between the two groups (P = 0.099).

Conclusion: Identified risk factors for POUR were female sex, older age, diabetes mellitus, and the intraoperative use of dexmedetomidine.

Keywords: postoperative urinary retention, neuraxial anesthesia, female, older age, diabetes mellitus, dexmedetomidine

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INTRODUCTION

Postoperative urinary retention (POUR) is a common complication that occurs after surgery. The incidence of POUR in the general population undergoing surgery is approximately 3.8%.[1] However, recent studies have found that the incidence rate of POUR in the patients undergoing total hip replacement arthroplasty (THRA) or total knee replacement arthroplasty is much higher (10.7-84%).[2-5] Lower joint arthroplasty is often performed under either general anesthesia or neuraxial anesthesia. It was suggested, however, that neuraxial anesthesia might show a stronger association with the occurrence of POUR than general anesthesia does.[6]

POUR is known to cause bladder over-distension, which may permanently impair the detrusor function. Urinary catheterization is often chosen for treating over-distension of the bladder, which along with urinary retention itself is known to be a risk factor for urinary tract infections (UTI). UTI in patients with joint prosthesis may cause more serious problems such as prosthetic joint infections.[7,8]

Because POUR is clinically important, many studies were performed to identify its risk factors. A serious problem faced by researchers, however, is that even the definition of POUR has not been established, because of which different studies use different diagnostic criteria. In addition, the subjects recruited for studies were rather heterogeneous.[1] Consequently, the reassessment of potential risk factors for POUR by using objective diagnostic criteria has become important.

Most studies about POUR emphasized on the inability to void

spontaneously as the diagnostic criteria without considering the post-void residual urine volume.[9-14] However, clinically significant POUR can be underestimated when defined only by inability to void, because large post-void residual urine volumes are also known to be associated with lower urinary tract dysfunction and UTI.[15,16] Many guidelines on the management of urinary retention also recommend the measurement of post-void residual urine volume.[15] Post-void residual urine volume can be measured by clean intermittent catheterization (CIC), the gold standard for the measurement of post-void residual urine volume.[17] Accordingly, the diagnostic criteria for POUR would be more reasonable if it includes abnormal post-void residual urine volume measured by CIC as well as inability to void spontaneously. The upper limits for acceptable post-void residual urine volume were defined as 30-150 ml.[18-21]

In this study, the systematic protocol for bladder volume management, which helps assess the ability to void spontaneously and post-void residual urine volume, was used to define POUR. Additionally, to define a specific group with a high incidence rate of POUR, we combined two components, namely THRA and neuraxial anesthesia, both of which were previously reported to increase the incidence rate of POUR. The purpose of this study was to identify the potential risk factors for POUR in patients undergoing THRA under neuraxial anesthesia.

METHODS

This retrospective study was approved by the Seoul National University Hospital (SNUH) Institutional Review Board (January 8, 2019; number H-1901-020-999). The requirement for written informed consent from the patients was waived, because this was a retrospective study and posed no risk to the patients. We reviewed the clinical data of 1,128 patients who underwent THRA, under neuraxial anesthesia, between July 1, 2013 and June 30, 2018 in Seoul National University Hospital. The exclusion criteria were as follows: American Society of Anesthesiologists physical status (ASA) classification of IV and V, conversion to general anesthesia, Foley catheters placed before anesthesia, chronic renal insufficiency with a preoperative glomerulus filtration rate of less than 30 $ml \cdot min^{-1} \cdot 1.73\ m^{-2}$, renal replacement therapy, and incomplete data. It is noted that if patients had undergone surgery more than two times, data on only the first procedure were reviewed.

Data Collection

Variables considered as potential risk factors for POUR were collected from the electronic medical records. The variables were classified as demographics, comorbidities, perioperative medication, and anesthesia/surgery-related factors. Under demographics, we recorded data on age, height, weight, body mass index, ASA classification at the time of surgery, and sex.

Data on comorbidities such as diabetes mellitus, cerebrovascular disease, benign prostatic hypertrophy (BPH), and

previous pelvic surgeries that are known to be the potential risk factors for POUR in previous studies, were collected.[1,6,22,23] Furthermore, data on a history of hypertension, coronary artery disease, chronic liver disease, chronic kidney disease, and pulmonary disease, which are routinely used for perioperative risk assessment, were collected. Data on the level of HbA1c, which reflects the control status of diabetes, were also recorded.

Perioperative medications that might potentially contribute to urinary retention, such as α/β blockers, angiotensin-converting-enzyme inhibitor (ACEi)/angiotensin Ⅱ receptor blocker (ARB), statins, nonsteroidal anti-inflammatory drugs (NSAIDs), and diuretics, were also considered.

Data on the duration of surgery and type of anesthesia were collected because they might affect the incidence rate of POUR.[1] In addition, we have investigated various anesthesia/surgery-related factors such as sedative agents, intraoperative hypotension and inotropes use, estimated blood loss, and urine output during surgery.

Bladder volume management protocol

THRA procedures were performed by two experienced orthopedic surgeons, under neuraxial anesthesia. After the surgery, all the patients were managed with the protocol for postoperative bladder volume management of SNUH Orthopedic Surgery (Figure 1, (a)). Except for the patients who had a Foley catheter placed in the preoperative period at the attending physician' s discretion, every patient had a Foley catheter placed after the induction of anesthesia in the operating room.

The Foley catheter was normally removed on postoperative day (POD) 2, and subsequently, the bladder volume management protocol was employed. To measure and regulate the bladder volume properly, voiding assessment was started 6 h after the removal of Foley catheter and was performed at least every 6 h (4 times a day). Voiding assessment involved two different steps: assessing the ability to void spontaneously and assessing post-void residual urine volume. If the patient was able to void spontaneously, the post-void residual urine volume was measured within 10 min via CIC. If the patients were unable to void spontaneously within 6 h, urine evacuation was done by CIC. Eventually all patients were allowed to urinate at least four times a day, either spontaneously or otherwise, which prevented the over-distension of bladder from lasting longer than 6 h.

If the patient failed to void spontaneously or if the post-void residual urine volume measured by CIC was larger than 100 ml, it was considered as inadequate voiding. If the post-void residual urine volume measured by CIC was less than 100 ml, it was considered an adequate voiding. This protocol for postoperative bladder volume management was discontinued when two consecutive, adequate voidings were confirmed (Figure 1, (a)).

Diagnostic criteria for postoperative urinary retention

We reviewed the voiding diary of each patient, and recorded data on various variables that were related to the protocol: the total number of CICs, the number of CICs required for urine

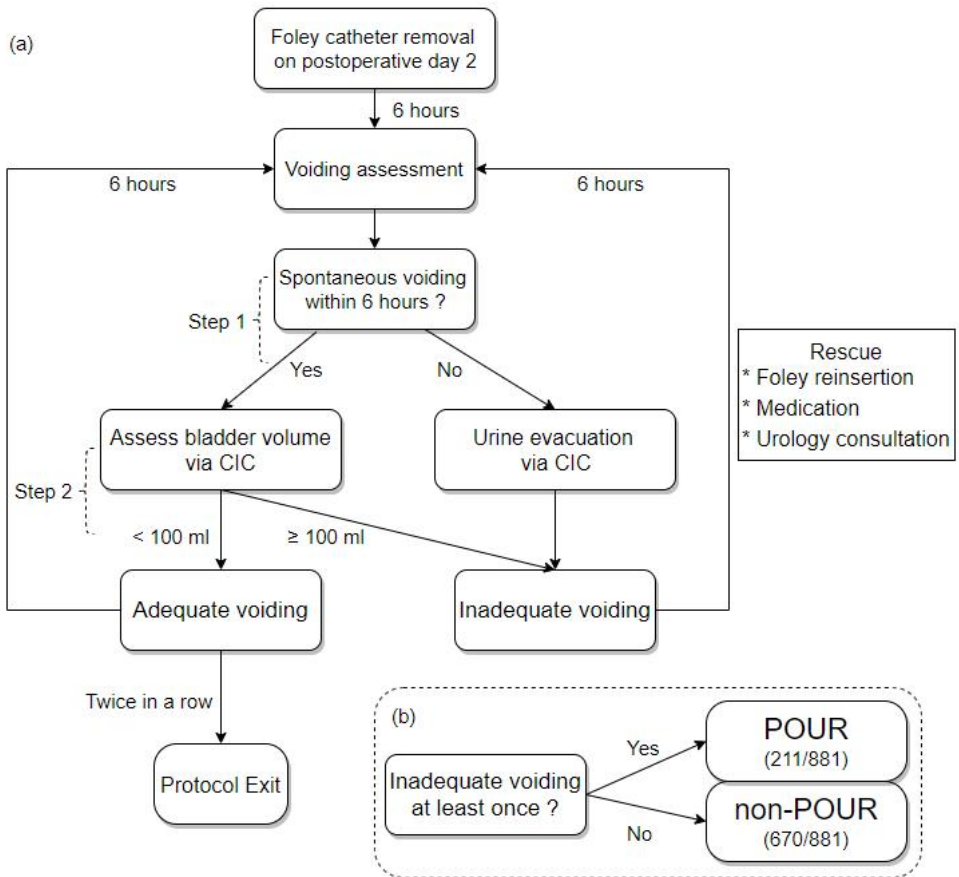
evacuation, the number of CICs required for measuring the post-void residual urine volume, and the post-void residual urine volume measured in each CIC. Each voiding assessment was evaluated as either adequate voiding or inadequate voiding. Subsequently, POUR was diagnosed when the patient had inadequate voiding at least once during the employment of the protocol (Figure 1, (b)).

Severity of postoperative urinary retention

To determine the risk factors according to the severity of POUR, we have divided the POUR group into two subgroups: high-grade POUR group with a total number of CICs > 5 (median of the total number of CICs in the POUR group) and low-grade POUR group with a total number of CICs ≤ 5 (Figure 2).

Figures

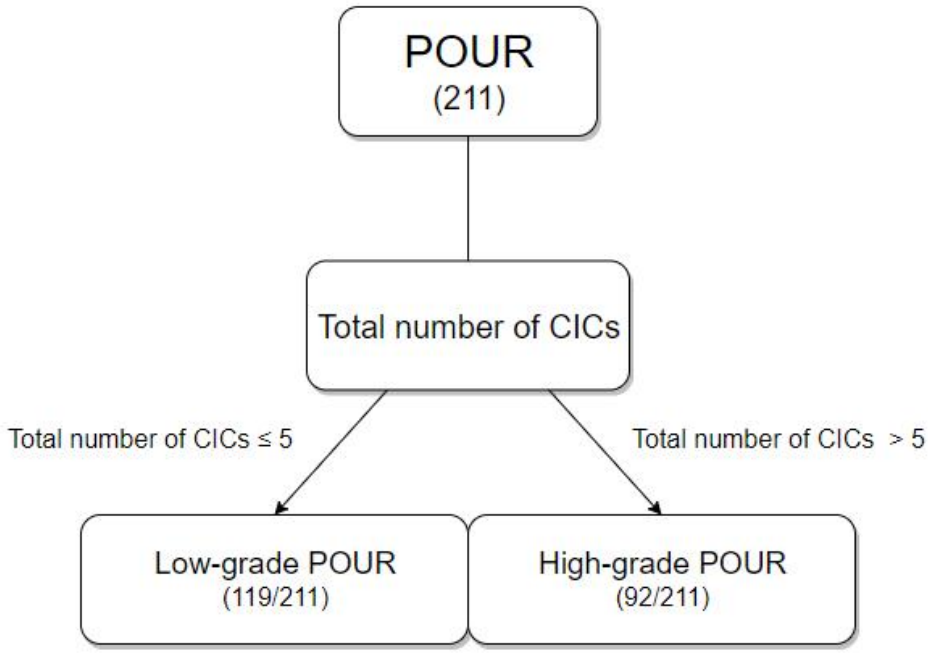
Figure 1. Flow chart for the bladder volume management protocol and the diagnostic criteria for postoperative urinary retention.



(a) The bladder volume management was implemented by voiding assessment that consisted of 2 steps: assessing ability to void spontaneously and assessing post-void residual urine volume. This bladder volume was measured by CIC. If the patient failed to void spontaneously or the post-void residual urine volume was larger than 100 ml, it was considered an inadequate voiding. If the post-void residual urine volume was less than 100 ml, it was considered an adequate voiding. The protocol could be discontinued when two consecutive

adequate voidings were confirmed.
(b) POUR was retrospectively diagnosed when the patient had inadequate voiding at least once during the employment of protocol, and the incidence rate was 24% (211/881).
CIC: clean intermittent catheterization, POUR: postoperative urinary retention.

Figure 2. The grade of postoperative urinary retention according to total number of clean intermittent catheterizations.



If the total number of CICs ≤ 5, the patient was classified as low-grade POUR (119/211, 56%). If the total number of CICs > 5, the patient was classified as high-grade POUR (92/211, 44%).
POUR: postoperative urinary retention, CIC: clean intermittent catheterization.

Statistical Analysis

Statistical analyses were performed by the primary investigator, using SPSS software (version 23; IBM SPSS Inc., Armonk, NY). All the variables included in the analysis were firstly compared between the POUR group and non-POUR group. Distribution normality was tested using Kolmogorov-Smirnov test. Because all the continuous variables did not show a normal distribution, the data of continuous variables were expressed as median (interquartile range). The data of categorical variables were expressed as proportions (percent).

We performed univariable logistic regression analysis for each variable. Subsequently, we constructed the multivariable logistic regression model using the variables that have a P value of <0.1 in the univariable analysis. We established the final model to identify the risk factors for POUR by using backward stepwise selection, with a type 1 error threshold of <0.1.

We dichotomized the whole cohort into high-grade POUR group vs. low-grade POUR plus non-POUR group to investigate risk factors associated with high-grade POUR. The logistic regression analysis was performed in the same way as in the statistical analysis for dichotomization into POUR group vs. non-POUR group.

We subjected the clinical outcomes such as the rate of Foley catheter reinsertion, medication use for urinary problem, urology consultation, and incidence of UTI to logistic regression to calculate odds ratios. Because the duration of hospital stay (DOS) did not show a normal distribution, we used the Mann Whitney U test to compare the DOS between the POUR group

and non-POUR group. The logistic regression and Mann Whitney U test were repeated to compare the clinical outcomes between the high-grade and low-grade POUR groups. It is noted that a two-sided P value of <0.05 was considered to be statistically significant.

RESULTS

In this study, we analyzed the medical records of 881 patients who underwent THRA. Table 1 presents the data on the baseline patient characteristics, comorbidities, perioperative medication, HbA1c level, and intraoperative conditions of the two groups—the POUR and non-POUR groups. There were 211/881 (24%) patients in the POUR group. There were 73 male patients (35%) with a median age of 64 (56-72) years in the POUR group and 331 male patients (49%) with a median age of 57 (48-66) years in the non-POUR group.

The univariable analysis (with the POUR group vs. non-POUR group) showed that POUR was associated with sex, age, height, weight, ASA classification, hypertension, diabetes mellitus, cerebrovascular disease, pulmonary disease, pelvic surgery history, ACEi/ARB, statin, level of HbA1c, and dexmedetomidine. The multivariable analysis showed that POUR was significantly associated with the female sex (adjusted odds ratio (OR): 1.699; 95% confidence interval (CI): 1.122-2.573; P = 0.012), age/10 (adjusted OR: 1.256; 95% CI: 1.054-1.497; P = 0.011), diabetes mellitus (adjusted OR: 1.767; 95% CI: 1.073-2.909; P = 0.025), and dexmedetomidine use (adjusted OR: 2.417; 95% CI: 1.103-5.293; P = 0.027) (Table 2).

Table 3 shows the results of the logistic regression analysis with the high-grade POUR group vs. low-grade POUR plus non-POUR group. In the univariable analysis, high-grade POUR was associated with sex, age, height, weight, ASA classification, hypertension, diabetes mellitus, cerebrovascular disease, chronic kidney disease, pelvic surgery history, α blocker/β blocker,

ACEi/ARB, statin, level of HbA1c, and estimated blood loss. Multivariable analysis showed that high-grade POUR was significantly associated with female sex (adjusted OR: 2.118; 95% CI: 1.113-4.029; P = 0.022), age/10 (adjusted OR: 1.499; 95% CI: 1.138-1.974; P = 0.004), and ASA classification III (compared to ASA classification I; adjusted OR: 6.741; 95% CI: 2.237-20.310; P = 0.001).

Table 4 shows the clinical outcomes that may be related to POUR. In this study, 5/211 (2.4%) patients in the POUR group and 2/670 (0.3%) in the non-POUR group were diagnosed with UTI after THRA surgery. The POUR group was associated with significantly higher odds of UTI incidence (OR: 8.1; P=0.013) than the non-POUR group was.

Among the patients with POUR, 119/211 (56%) patients showed low-grade POUR and 92/211 (44%) showed high-grade POUR. The patients with high-grade POUR showed significantly higher odds of requirement for medication because of urinary problem and for urology consultation than those with low-grade POUR (OR: 9.4 vs. 14.4, respectively). Furthermore, 4/92 (4.3%) patients with high-grade POUR and 1/119 (0.8%) patient with low-grade POUR were diagnosed with UTI, but there was no statistical significant difference in the incidence of UTI between the two groups (Figure 2 and Table 4).

The median DOS was 10 (9-11) days in the POUR group and 9 (8-10) days in the non-POUR group. There was no significant difference in the DOS between the POUR group and non-POUR group (P = 0.099). However, there was a significant difference in the DOS between the high-grade POUR group and low-grade POUR group (high-grade POUR: 10 (8.5-11.5); low-grade

POUR: 9 (8-10); P = 0.018) (Table 4).

Tables

Table 1. Baseline characteristics, comorbidities, perioperative medication, and anesthesia/surgery-related factors.

	Non-POUR (n = 670)	POUR (n = 211)
Male sex, n	331 (49%)	73 (35%)
Age, yr	57 (48-66)	64 (56-72)
Height, cm	161 (153-169)	158 (151-165)
Weight, kg	62.6 (54.7-70.5)	61 (53.0-69.0)
BMI, kg/m^2	24.3 (22.1-26.5)	24.9 (22.8-27.0)
ASA classification, n		
I	188 (28%)	35 (17%)
II	435 (65%)	134 (63%)
III	47 (7%)	42 (20%)
Comorbidities, n		
Hypertension	221 (33%)	96 (46%)
Diabetes mellitus	66 (10%)	45 (21%)
Coronary artery disease	24 (4%)	10 (5%)
Cerebrovascular disease	23 (3%)	21 (10%)
Chronic liver disease	21 (3%)	6 (3%)
Chronic kidney disease	23 (3%)	11 (5%)
Pulmonary disease	36 (5%)	20 (9%)
BPH	17 (2%)	9 (4%)
Pelvic surgery history	66 (10%)	33 (16%)
Medication, n		
α blocker/β blocker	60 (9%)	22 (10%)
ACEi/ARB	157 (23%)	67 (32%)
Statin	109 (16%)	56 (26%)
NSAIDs	126 (19%)	49 (23%)
Diuretics	11 (2%)	3 (1%)
Laboratory data		
HbA1c, %	5.6 (5.25-5.95)	5.7 (5.2-6.2)
Sedatives, n		
Midazolam/Propofol	132 (20%)	35 (17%)
Dexmedetomidine	546 (81%)	185 (88%)

Intraoperative event		
Hypotension, n	448 (67%)	140 (66%)
Inotropes use, n	431 (64%)	133 (63%)
Duration of surgery, min	80 (66–94)	83 (68–98)
Estimated blood loss, ml	500 (300–700)	500 (250–750)
Urine output, ml	150 (40–260)	150 (25–275)
Anesthesia type, n		
Spinal	644 (96%)	197 (93%)
Combined	26 (4%)	13 (6%)
Epidural	0 (0%)	1 (0%)

Values are number (percentage) or median (interquartile range).
POUR: postoperative urinary retention, BMI: body mass index, ASA: American Society of Anesthesiologists physical status, BPH: Benign prostatic hypertrophy, ACEi: angiotensin–converting–enzyme inhibitor, ARB: angiotensin II receptor blocker, NSAIDs: nonsteroidal anti–inflammatory drugs.

Table 2. The logistic regression analysis of risk factors for postoperative urinary retention.

Variables	POUR Odds ratio (95% CI)	*P*-value
Univariable analysis		
Female sex	1.846 (1.338-2.546)	< 0.001
Age (yr/10)	1.408 (1.242-1.597)	< 0.001
Height	0.975 (0.959-0.991)	0.002
Weight	0.984 (0.971-0.998)	0.024
ASA classification		<0.001
I	Reference	
II	1.655 (1.099-2.492)	0.016
III	4.8 (2.767-8.326)	< 0.001
Hypertension	1.696 (1.237-2.324)	0.001
Diabetes mellitus	2.481 (1.637-3.761)	< 0.001
Cerebrovascular disease	3.109 (1.684-5.741)	< 0.001
Pulmonary disease	1.791 (1.016-3.16)	0.044
Pelvic surgery history	1.697 (1.082-2.661)	0.021
ACEi/ARB	1.52 (1.082-2.137)	0.016
Statin	1.859 (1.287-2.687)	0.001
HbA1c	1.417 (1.140-1.762)	0.002
Dexmedetomidine	1.616 (1.026-2.546)	0.038
Multivariable analysis		
Female sex	1.699 (1.122-2.573)	0.012
Age (yr/10)	1.256 (1.054-1.497)	0.011
Diabetes mellitus	1.767 (1.073-2.909)	0.025
Pulmonary disease	1.776 (0.909-3.469)	0.093
Dexmedetomidine	2.417 (1.103-5.293)	0.027

The whole cohort was dichotomized into POUR group vs. non-POUR group. The age variable was converted to age/10 for the statistical analysis. The odds ratio of POUR according to each ASA classification was calculated based on ASA classification I as a reference. Pulmonary disease was excluded from the final multivariable model.

POUR: postoperative urinary retention, CI: confidence interval, ASA: American Society of Anesthesiologists physical status, ACEi: angiotensin-converting-enzyme inhibitor, ARB: angiotensin II receptor blocker.

Table 3. The logistic regression analysis of risk factors for high-grade postoperative urinary retention.

Variables	High-grade POUR Odds ratio (95% CI)	*P*-value
Univariable analysis		
Female sex	2.986 (1.813-4.919)	<0.001
Age (yr/10)	1.704 (1.405-2.068)	<0.001
Height	0.952 (0.980-0.975)	<0.001
Weight	0.978 (0.959-0.998)	0.03
ASA classification		<0.001
I	Reference	
II	2.442 (1.184-5.039)	0.016
III	12.090 (5.440-26.873)	<0.001
Hypertension	2.842 (1.829-4.416)	<0.001
Diabetes mellitus	2.848 (1.700-4.771)	<0.001
Cerebrovascular disease	5.722 (2.963-11.048)	<0.001
Chronic kidney disease	3.887 (1.796-8.413)	0.001
Pelvic surgery history	1.954 (1.101-3.470)	0.022
α blocker/β blocker	1.903 (1.023-3.541)	0.042
ACEi/ARB	1.949 (1.241-3.062)	0.004
Statin	2.210 (1.372-3.561)	0.001
NSAIDs	1.799 (1.110-2.916)	0.017
HbA1c	1.331 (1.037-1.707)	0.025
Estimated blood loss	1.000 (1.000-1.001)	0.074
Multivariable analysis		
Female sex	2.118 (1.113-4.029)	0.022
Age (yr/10)	1.499 (1.138-1.974)	0.004
ASA classification		<0.001
I	Reference	
II	1.381 (0.506-3.773)	0.529
III	6.741 (2.237-20.310)	0.001
NSAIDs	1.847 (0.954-3.578)	0.069
Estimated blood loss	1.001 (1.000-1.001)	0.068

The whole cohort was dichotomized into high-grade POUR group vs. low-grade POUR plus non-POUR group. The age variable was converted to age/10 for the statistical analysis. The odds ratio of high-grade POUR

according to each ASA classification was calculated based on ASA classification Ⅰ as a reference.

Although ASA classification was included in the final multivariable model, only ASA classification III had significantly increased odds of high-grade POUR, compared with ASA classification I. NSAIDs and estimated blood loss were excluded from the final multivariable model.

POUR: postoperative urinary retention, CI: confidence interval, ASA: American Society of Anesthesiologists physical status, ACEi: angiotensin-converting-enzyme inhibitor, ARB: angiotensin II receptor blocker, NSAIDs: nonsteroidal anti-inflammatory drugs.

Table 4. The effect of postoperative urinary retention on clinical outcomes.

	Non-POUR (n = 670)	POUR (n = 211)		Odds ratio (95% CI)	*P*-value
		Low-grade (n = 119)	High-grade (n = 92)		
Reinsertion, n	1 (0.1%)	6 (2.8%)		19.6 (2.3-163.6)	0.006
	N.A.	1 (0.8%)	5 (5.4%)	6.8 (0.8-59.1)	0.083
Medication, n	1 (0.1%)	105 (49.8%)		663 (92-4799)	<0.001
	N.A.	33 (27.7%)	72 (78.3%)	9.4 (5.0-17.7)	<0.001
Consultation, n	1 (0.1%)	28 (13.3%)		102 (14-757)	<0.001
	N.A.	3 (2.5%)	25 (27.2%)	14.4 (4.2-49.6)	<0.001
UTI, n	2 (0.3%)	5 (2.4%)		8.1 (1.6-42.1)	0.013
	N.A.	1 (0.8%)	4 (4.3%)	5.4 (0.6-48.8)	0.136
DOS, day	9 (8-10)	10 (9-11)		N.A	0.099
	N.A.	9 (8-10)	10 (8.5-11.5)	N.A.	0.018

Values are number (percentage) or median (interquartile range). DOS did not show a normal distribution.

The five clinical outcomes were compared between the POUR group and non-POUR group (upper part of solid line). The odds ratio of Foley catheter reinsertion, medication use for urinary problem, urology consultation, and UTI were calculated. DOS was compared using Mann Whitney *U* test. Then, each comparison was repeated between the high-grade and low-grade POUR groups (lower part of solid line).

The POUR group was associated with significantly higher odds of UTI incidence than the non-POUR group was. The high-grade POUR group was

associated with significantly higher odds of medication use for urinary problem and urology consultation than the low-grade POUR group was.
There was no significant difference in the DOS between the POUR group and non-POUR group. However, the DOS was significantly longer in high-grade POUR group than low-grade POUR group.
POUR: postoperative urinary retention, CI: confidence interval, UTI: urinary tract infections, DOS: duration of hospital stay.

DISCUSSION

In this retrospective study, the incidence rate of POUR after THRA under neuraxial anesthesia was 24%. Identified independent risk factors for POUR were female sex, older age, diabetes mellitus, and the intraoperative use of dexmedetomidine. Furthermore, POUR was significantly associated with increased odds of UTI incidence.

A previous cohort study reported that THRA itself was a risk factor for POUR following lower joint arthroplasty.[13] According to a recent study that included only male patients undergoing THRA, POUR was significantly associated with age, spinal anesthesia, and patient-controlled analgesia.[14] Charles et al. [24] identified a history of urinary retention and receiving high intraoperative fluid volume as risk factors for POUR following THRA under spinal anesthesia. However, both studies were based on relatively small patient groups and did not consider post-void residual urine volume as a diagnostic criterion for POUR. In contrast, the current study analyzed the medical records of 881 patients who underwent THRA under neuraxial anesthesia and considered post-void residual urine volume.

We have introduced objective diagnostic criteria for POUR by applying systematic protocol for postoperative bladder volume management. This protocol is largely analogous to the strategy suggested by Stephen et al.[23] Both of them consider not only the ability to void but also the post-void residual urine volume that would be important to define POUR.

Unlike the strategy presented by Stephen et al., which involved the use of ultrasonography for the measurement of the

post-void residual urine volume, CIC was used in the current study. CIC is still known as the gold standard for the measurement of post-void residual urine volume. However, this direct and invasive method causes discomfort to patients, and consequently, indirect methods such as ultrasound bladder scanning have been used more widely.[25] However, CIC is superior to ultrasonography in terms of accuracy, because the accuracy of ultrasonography in the measurement of the urinary bladder volume can be affected by body weight as well as the bladder volume.[26]

Determining thresholds to define acceptable post-void residuals was a concern, because it was poorly defined previously. A volume of 50-100 ml as the upper threshold to define the normal post-void residual urine volume has been widely accepted by most urologists.[16] Accordingly, it would be reasonable to include a cut-off value of 100 ml as a diagnostic criterion for POUR in this protocol.

The time of POUR assessment was also a concern, because the incidence rate might vary depending this. In a previous retrospective study, POUR was assessed 6-8 h after THRA, and the incidence rate was 40%.[14] However, in the current study, the assessment of POUR was started on POD 2, when the influence of neuraxial anesthesia on urinary retention had completely disappeared, and therefore, the incidence rate was 24%.

It has long been believed that male sex is the risk factor for POUR.[4,13,27] However, some recent studies have identified female sex as a risk factor for POUR.[22,28] Similarly, our analysis showed that female sex is an independent risk factor for urinary retention. According to Kreutziger et al.,[28] urinary retention

frequently occurred in women after surgery, possibly because immobilization with splints made it harder for women to urinate than for men and because men might be more willing to have spontaneous voiding because of enhanced feeling of pain from CIC.

Previously, older age has been known to increase the risk of POUR,[4,27,28] which is also confirmed by our study. The mechanism of micturition is regulated by the sympathetic and parasympathetic systems.[1] The significant association between age and POUR may be attributed to the inadequate regulation of micturition by autonomic nervous systems, which is caused by aging.

It is well known that diabetes mellitus is a serious disease, which gradually damages multiple organs leading, for instance, to neuropathy, retinopathy, and nephropathy.[29] Most importantly, close association of diabetic bladder dysfunction with diabetic neuropathy is known to affect almost half of all diabetic patients and to possibly impair bladder filling sensation and contractility, which would inevitably increase post-void residual urine volume.[30,31] Accordingly, some studies have indeed identified diabetes as a risk factor for urinary retention.[22,32,33] Similarly, we have also found that diabetes is an independent risk factor for POUR.

Dexmedetomidine, a selective $\alpha-2$ adrenoreceptor agonist used for intravenous sedation, is known to have facilitatory effects on the duration of spinal anesthesia.[34] However, Takizuka et al. [35] noted that dexmedetomidine inhibits the function of M_3 receptor, which is the key component involved in the intestinal and detrusor smooth muscle contraction, in Xenopus oocytes.

Furthermore, stimulation of $\alpha-2$ adrenoreceptor via dexmedetomidine significantly decreased the rhabdosphincter electrical activity and maximum bladder pressure as well as increased the volume of residual urine, in a previous animal study.[36] The result of the current study also supported the influence of dexmedetomidine on the lower urinary tracts. However, further clinical research is needed to confirm the precise association between POUR and the use of dexmedetomidine.

Some studies have identified a history of pelvic surgery and BPH to be risk factors associated with POUR.[6,37] In our cohort, however, a history of pelvic surgery and BPH were not identified as risk factors for POUR. The term pelvic surgery is so broad that it covers a variety of surgeries, and this prevented a history of pelvic surgery from becoming an independent risk factor for POUR. Elkhodir et al. [38] reported that there was a significant correlation between the International Prostate Symptom Score and the possibility of urinary retention following major joint arthroplasty. Most patients who had a history of BPH in this study have used medication prescribed for obstructive symptom, which possibly made the patients urinate adequately in the perioperative period.

While Breebaart et al. [39] have divided urinary retention into five subgroups, in the current study, we quantified the severity of POUR by using objective numbers such as the total number of CICs. Considering that the total number of CICs were equivalent to the total number of voiding assessments performed and the voiding assessment was performed at least every 6 h until two consecutive adequate voidings were confirmed, the total number

of CICs can be adopted as a reliable surrogate measure to quantify the severity of POUR. Our trial, which aimed to determine the risk factors depending on the severity, showed that high-grade POUR was significantly associated with ASA classification III than with ASA classification I. Although sufficient number of studies did not investigate whether ASA classification is a risk factor for POUR, a recent study has shown that a high ASA classification was an independent risk factor for POUR.[40]

There are several limitations to this study. First, this is a retrospective study that relies only on previously recorded data. Second, the quantity of intravenous fluid infused as well as the use of opioids that may potentially affect POUR [1,6] were not included in the analysis. Third, because we have excluded the patients who had been treated with Foley catheter prior to anesthesia, the risk factors for POUR in such patients were not investigated. Lastly, the incidence rate of UTI was relatively low; therefore, we found no significant difference in the incidence of UTI between patients with high- and low-grade POUR. More data are needed to verify the influence of severity of POUR on UTI.

In conclusion, female sex, older age, diabetes mellitus, and the intraoperative use of dexmedetomidine have been identified as independent risk factors for POUR after THRA under neuraxial anesthesia. The patients with POUR showed a greater risk of UTI than those without POUR. Patients who have any risk factor for POUR need a more careful postoperative bladder management to avoid complications caused by urinary retention.

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초록

신경축 마취하에 고관절전치환술을 받은 환자에서 수술 후 요폐의 위험인자

배경: 수술 후 요폐는 신경축 마취하에 고관절전치환술을 받은 환자에서 흔한 합병증 중 하나이다. 수술 후 요폐는 요로계 감염을 일으킬 수 있으며, 이는 수술 후 예후와 관련이 있다. 임상적 중요성에도 불구하고 수술 후 요폐의 진단기준은 다양하며 일관되지 않다. 본 연구에서는 객관적이고 정확한 진단기준을 도입하여 신경축 마취하에 고관절전치환술을 받은 환자의 수술 후 요폐의 위험인자에 대해서 밝혀보고자 한다.

방법: 신경축 마취하에 고관절전치환술을 받은 881명의 환자의 의무기록을 후향적으로 분석하였다. 수술 후 2일 째에 폴리 도뇨관을 제거한 이후, 6시간마다 한번 씩 배뇨평가를 시행하여 자발 배뇨 여부와 잔뇨량을 평가하였다. 자발 배뇨에 실패 하거나, 혹은 청결 간헐 도뇨를 통해 측정한 잔뇨량이 100 ml 이상인 경우가 적어도 한번 있는 환자를 수술 후 요폐로 진단하였다. 단변수 및 다변수 로지스틱 회귀 분석을 통해 수술 후 요폐의 잠재적 위험인자에 대해서 평가하였다.

결과: 211/881명 (24%)의 환자에서 수술 후 요폐가 발생하였다. 수술 후 요폐는 여성 (조정된 오즈비: 1.699, 95% 신뢰구간 1.122−2.573, *p*값 0.012), 연령/10 (조정된 오즈비: 1.256, 95% 신뢰구간 1.054−1.497, *p*값 0.011), 당뇨 병력 (조정된 오즈비: 1.767, 95% 신뢰구간 1.103−5.293, *p*값 0.025), 그리고 수술 중 덱스메데토미딘 사용 (조정된 오즈비: 2.417, 95% 신뢰구간 1.103−5.293, *p*값 0.027)과 유의한 연관성이 있었다. 수술 후 요폐로 진단 받은 환자군의 요로감

염의 위험이 정상 환자군에 비해 유의하게 높았다 (오즈비: 8.107, 95% 신뢰구간 1.561–42.096, *p*값 0.013). 그러나 두 군의 병원재원 기간에는 유의미한 차이가 없었다 (*p*값 0.099).
결론: 여성, 고령, 당뇨, 수술 중 덱스메데토미딘 사용이 수술 후 요폐의 독립적인 위험인자로 확인되었다.

주요어: 수술 후 요폐, 신경축 마취, 여성, 고령, 당뇨, 덱스메데토미딘
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