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Postoperative urinary retention after oblique lumbar interbody fusion under the systematic management protocol

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Oblique lumbar interbody fusion (OLIF) is a minimally invasive lateral lumbar fusion technique and patients are discharged 1–2 days after surgery. Because OLIF utilizes a retroperitoneal approach close to the superior hypogastric plexus, postoperative urinary retention (POUR) may not be an uncommon problem. The purpose of this study was to present the incidence and outcomes of POUR with a systematic care protocol. The records of 102 consecutive patients (M:F = 34:68; mean age, 68.0 ± 8.4 years) were retrospectively reviewed. After OLIF, the indwelling urinary catheter was immediately removed, and every patient was encouraged to void within 6 h. The POUR care protocol, following a clinical pathway, was based on residual urine (RU), which was monitored with an ultrasound bladder scan after each voiding or every 6 h for 48 h. The incidence rate of POUR was 44% (45/102) at 24 h, 17% (17/102) at 48 h, and 2% (2/102) at 1 month. Preoperative urological symptoms (odds ratio [OR] 3.2) and violation of the protocol (OR 28.3) were risk factors at 24 h. At 48 h, violation of the protocol was the only risk factor (OR 9.6). Identifying risk factors and a preemptive care protocol may reduce permanent POUR.

Keywords Algorithm, Arthrodesis, Enhanced recovery after surgery, Lumbar vertebra, Protocol, Spine, Surgery, Urinary retention

Lumbar spinal fusion surgery is a common surgical procedure for the management of lumbar degenerative diseases such as spinal stenosis and spondylolisthesis[1–7]. Oblique lumbar interbody fusion (OLIF) via a retroperitoneal approach is a minimally invasive surgical technique for lumbar spinal fusion surgery[8–13]. Traditionally, attention has been given to clinical and radiological outcomes and well-known complications during the perioperative period[6,13,14]. Currently, a systematic approach toward the care of patients is emphasized to improve patients' overall outcomes[15]. The well-known complications of OLIF include postoperative neurological deficit, vascular injury, ureter injury, bowel injury, and paralytic ileus[9,12–14,16–20]. Postoperative urinary retention (POUR) is a common complication after lumbar spinal surgery and has been reported in 25% of patients[21–24]. POUR that occurs after OLIF can have multiple pathophysiological causes. Lee et al. and Oh et al. each reported about ureter injury as a complication after OLIF[25,26]. Zeng et al. reported about sympathetic chain injury after OLIF as another possible cause[27]. Pan et al. focused on differences in temperature sensation between both lower extremities after

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OLIF caused by lumbar sympathetic trunk injuries[28]. Although Pan et al. focused on temperature sensations, lumbar sympathetic trunk injuries can lead to POUR because the lower urinary tract is innervated by 3 sets of peripheral nerves including lumbar sympathetic nerves[29]. These studies collectively highlight that both ureteral and sympathetic nerve injuries, which may occur during OLIF, can contribute to the development of POUR. However, POUR after OLIF has not been previously studied, despite the proximity of the superior hypogastric plexus and sympathetic chain in the surgical trajectory. This lack of attention may be explained by the relatively short hospital length of stay (1–2 days for this type of minimally invasive spine surgery[30,31]), which may result in patients being discharged from the hospital with undetected POUR. Although POUR is usually transient, preemptive and systematic monitoring and care of POUR would reduce the discomfort of patients, the length of hospital stays, hospital costs, re-admission rates, and the incidence of permanent POUR, and would improve the management of nursing facilities[18–20,24,32,33].

The primary objective of this study was to investigate the incidence and outcomes of POUR in patients undergoing OLIF surgery with a systematic care protocol. Secondary objective is to identify risk factors of temporary POUR, and 1-month outcomes of POUR after OLIF.

Materials and methods

A systematic protocol for the care and monitoring of POUR has been applied to all patients undergoing spinal surgery in the clinical pathway since 2010[18]. We reviewed data from 111 consecutive patients with lumbar spondylolisthesis and stenosis who underwent single-level OLIF at L4–5 or L5–S1 between September 2016 and September 2022. We excluded 6 patients with previous spinal fusion surgery and 3 patients with incomplete data. In total, 102 patients were included in the analysis. Seoul National University Hospital Institutional Review Board approved the retrospective review and analysis of the data (2210-081-1368) and the need for informed consent was waived by Seoul National University Hospital Institutional Review Board. All methods were carried out in accordance with relevant guidelines and regulations.

Surgical technique of OLIF

The standard surgical procedures were performed as follows:[9,12–14,17].

(1) After general anesthesia, the patient was placed in the left lateral decubitus position after an indwelling urinary catheter was inserted.
(2) The ventral disc space was approached along the retroperitoneal trajectory, under the guidance of fluoroscopy or surgical navigation.
(3) The disc space was cleaned with a Cobb elevator and curette, and an interbody cage was inserted.
(4) Next, a posterior percutaneous pedicle screw and rod system was applied to fix the operational segment.

Postoperatively, the indwelling urinary catheter was immediately removed from patients upon arrival to the general ward. Patients were encouraged to ambulate and scheduled to be discharged at 3–4 days, postoperatively.

A systematic POUR care protocol

While management protocols for POUR after other spinal surgeries have been discussed in literature, to the best of our knowledge, there is no standardized protocol specifically for OLIF. The main objective of the POUR care protocol is to detect and systematically manage postoperative urinary retention. In addition, the secondary objective is to prevent secondary complications and delayed discharge that may arise from POUR. The systematic POUR care protocol was established by the Department of Urology and modified by the Department of Neurosurgery in [blind for review][34,35], and the protocol has been being applid to all patients with spinal surgery since 2010 (Fig. 1)[18]. The care protocol was based on the residual urine volume in the bladder (RU) after each void. Every patient was encouraged to void within 6 h after surgery and every 4–6 h thereafter for 48 h. After each voiding, RU was measured by an ultrasound bladder scan (MRC-700, Mcube Technology Co., Ltd., ROK). POUR was first assessed after 24 h, and confirmed if RU did not decrease to less than 100 mL, RU exceeded 400 mL twice or more, or the patient failed to urinate twice or more. POUR was ruled out if, within the first 24 h, RU measured less than 100 mL two consecutive or non-consecutive times, or decreased to less than 100 mL If either RU exceeded 400 mL or patients could not urinate, the bladder was emptied using clean intermittent catheterization (CIC) by a doctor or nurse. If POUR was not ruled out within the first 24 h, the same protocol was repeated for the next 24 h. If POUR could not be ruled out after 48 h, a parasympathomimetic choline carbamate (bethanechol) and an alpha-blocker (tamsulosin hydrochloride) were started, and a consult was sent to a urologist. After medication, if RU measured less than 100 mL twice consecutively, the patients were discharged without CIC, and an outpatient clinic appointment with a urologist was arranged for 4 weeks later. If RU measured greater than 100 mL or CIC was required twice consecutively, the patient was educated on self-CIC, discharged with CIC, and attended an outpatient clinic with a urologist 2 weeks later.

Variables

The POUR statuses of patients were categorized as Group 1, 2, 3, or 4. Patients in Groups 1 and 2 had no POUR, and those in Group 3 and 4 had POUR (Fig. 1). Group 1 showed an RU less than 100 mL two consecutive or non-consecutive times during three voidings, and Group 2 showed an RU less than 100 mL two non-consecutive times during 24 h or decreasing RU less than 100 mL at 24 h. Group 3 showed an RU of 100–400 mL after 24 h, and Group 4 showed an RU greater than 400 mL or no self-voiding twice or more. Patients in Group 1 and 2 had no POUR, and those in Groups 3 and 4 had POUR. The risk factors for POUR were analyzed at 24 h, 48 h, and 1 month postoperatively. The following patient-related variables were considered: age, sex, body mass index (BMI, kg/m^2), Diabetes mellitus (DM), smoking, preoperative urologic symptoms (hesitancy, urgency,

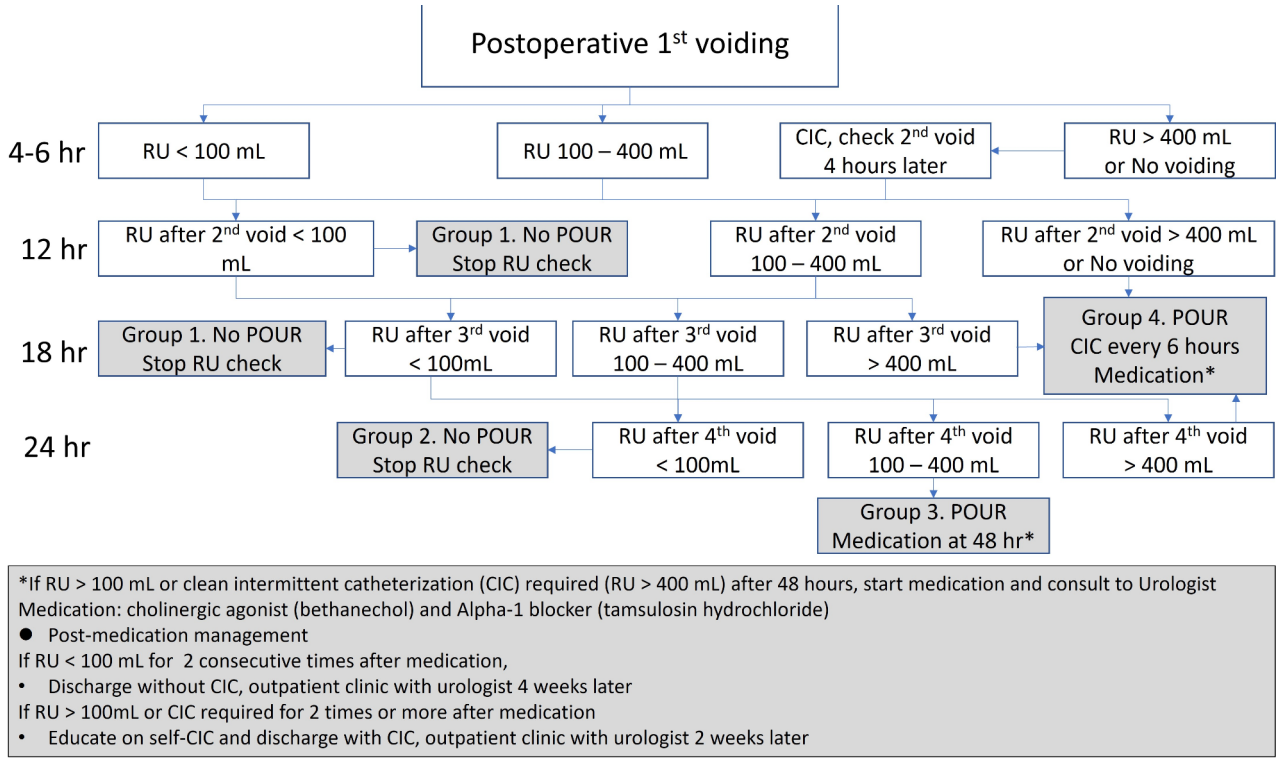

Fig. 1. Voiding care protocol. The protocol was based on residual urine in the bladder measured by non-invasive ultrasound after each void. The POUR statuses of patients were categorized as Groups 1, 2, 3, and 4. Group 1 showed an RU less than 100 mL two consecutive or non-consecutive times during three voidings, and Group 2 showed an RU less than 100 mL two non-consecutive times during 24 h or a decreasing RU less than 100 mL at 24 h. Group 3 showed an RU of 100–400 mL after 24 h, and Group 4 showed an RU greater than 400 mL or no self-voiding twice or more. Patients in Group 1 and 2 had no POUR, and those in Groups 3 and 4 had POUR.

frequency, sense of residual urine), preoperative neurological problems (weakness in leg, decreased sensation), preoperative Oswestry Disability Index (ODI), numeric rating score of back pain (NRS-B) and leg pain (NRS-L). Additionally, surgery-related factors were considered, including intraoperative bleeding, infused fluid, urine output, net fluid intake and output, surgery level, spondylolisthesis (Meyerding grade I vs. II, III, and IV) and surgery time[12]. Although the voiding care protocol was noted in the clinical pathway for every patient, several patients opted to wait and see without CIC. Therefore, violations of the protocol included a first RU check more than 6 h after surgery, opted to wait and see without CIC, or an interval of more than 6 h between RU checks.

Statistical analysis

The means (standard deviations) were used to summarize continuous variables, and either Student t-test or Yuen-Welch t-test with a 10% trim percentage at each tail was applied to compare the differences between two groups depending on the normality. The normality assumption was checked using Shapiro–Wilk test ($p < 0.05$) and the normal probability plots. The chi-square test (or Fisher's exact test) was used for categorical variables. Variables that were significant at the 20% level in the above tests were included in the multivariable logistic regression model. The linearity assumption of the continuous variables with log (odds) was checked using restricted cubic spline. Binary logistic regression with backward stepwise regression was used for a multivariable analysis. All statistical tests were two-sided, and a p-value < 0.05 was considered to indicate statistical significance. All statistical analyses were conducted with SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA), and SAS (version 9.4, SAS Institute).

Results

This study included 102 patients (male:female, 34:68; mean age, 68.0 ± 8.4 years) (Table 1) of whom 82.4% (84/102) underwent L4–5 and 17.6% (18/102) underwent L5–S1 surgery. The incidence rates of POUR were 44.1% (45/102) at 24 h, 16.7% (17/102) at 48 h and 2% (2/102) at 1 month (Tables 1 and 2, and Fig. 2). Table 1 shows the incidence rates of POUR according to patients' baseline characteristics. Preoperative urologic symptoms and preoperative neurological problems were reported in 21.6% (22/102) and 4.9%(5/102) of patients, respectively. In a univariate analysis on the significance of each variable according to POUR at 24 and 48 h, age, BMI, diabetes, neurological problems, urologic symptoms, duration of surgery, and violation of the protocol had a p-value of less than 0.2. These variables were included in the multivariable logistic regression model. Based

Variable	Total	24-hr POUR		p-value	48-hr POUR		p-value
		Yes	No		Yes	No	
Patient no. (%)	102	45 (44.1)	57 (55.9)		17 (16.7)	85 (83.3)	
Sex							
Male	34 (33.3)	17 (37.8)	17 (29.8)	0.40	6 (35.3)	28 (32.9)	0.85
Female	68 (66.7)	28 (62.2)	40 (7.02)		11 (64.7)	57 (67.1)	
Age (year)	68.0 (8.4)	69.6 (7.1)	66.7 (9.1)	0.08	70.4 (7.6)	67.5 (8.5)	0.19
Body mass index (kg/m^2)*	25.0 (3.8)	25.5 (1.8)	24.3 (2.4)	0.06	25.6 (2.7)	24.7 (2.1)	0.31
Diabetes mellitus	25 (24.5)	14 (31.1)	11 (19.3)	0.17	7 (41.2)	18 (21.2)	0.12
Smoking	8 (7.8)	5 (11.1)	3 (5.3)	0.30	1 (5.9)	7 (8.2)	1.00
Urologic symptoms	22 (21.6)	13 (28.9)	9 (15.8)	0.11	6 (35.3)	16 (18.8)	0.19
Neurological problems	5 (4.9)	4 (8.9)	1 (1.8)	0.17	1 (5.9)	4 (4.7)	1.00
Spondylolisthesis grade II, III and IV	22 (21.6)	7 (15.6)	15 (26.3)	0.23	3 (17.6)	19 (22.4)	0.76
Surgical level L4–L5	84 (82.4)	39 (86.7)	45 (78.9)	0.31	16 (94.1)	68 (80.0)	0.29
L5–S1	18 (17.6)	6 (13.3)	12 (21.1)		1 (5.9)	17 (20.0)	
Duration of surgery (min)	273.0 (65.4)	262.9 (44.5)	271.2 (40.3)	0.51	252.3 (32.5)	270.9 (43.3)	0.14
Urine output (mL)	476.8 (227.3)	438.5 (221.0)	449.9(243.7)	0.86	420.3 (212.4)	447.3 (233.2)	0.72
Intraoperative bleeding (mL)	164.3 (112.4)	163.2 (78.1)	146.8 (84.9)	0.48	160 (104.1)	153.5 (79.1)	0.85
Infused fluid (mL)	1452.3 (597.6)	1360 (342.3)	1432.6 (378.5)	0.49	1311.3 (306.6)	1420 (372.9)	0.34
Net fluid intake and output (mL)	813.0 (578.6)	768.6 (313.7)	783.8 (329.7)	0.88	778.3 (281.1)	775.9 (327.7)	0.98
Oswestry Disability Index (%)	24.3 (7.8)	23.5 (5.5)	24.1 (6)	0.62	23.5 (8)	24.1 (5.5)	0.79
NRS-B (/10)	7.0 (2.6)	7 (1.8)	7 (1.8)	0.89	6.4 (2.1)	7.1 (1.7)	0.32
NRS-L (/10)	7.0 (2.7)	7.6 (1.7)	7.1 (2)	0.32	7.6 (1.7)	7.3 (1.8)	0.83
Number of protocol violations	29 (28.4)	26 (57.8)	3 (5.3)	< 0.01	12 (70.6)	17 (20.0)	< 0.01

Table 1. Incidence of POUR according to baseline characteristics. *POUR* postoperative urinary retention, *NRS-B* numerical rating score of back pain, *NRS-L* numerical rating score of leg pain. The values are presented as number (%) for non-continuous values and mean (standard deviation) for continuous values. The means and standard deviations of the trimmed data for each group are presented.

	24 h	48 h	1 month
Group 1	32	77	100
Group 2	25	8	
Group 3	11	4	2
Group 4	34	13	
Total number	102	102	102

Table 2. Incidence of POUR (number) by group. *POUR* postoperative urinary retention.

on this multivariable analysis, urological symptoms ($p = 0.05$; odds ratio [OR] 3.2; 95% confidence interval [CI] 1.02–9.88) and violation of the protocol ($p < 0.01$; OR 28.3; 95% CI 7.4–107.8) were risk factors for POUR at 24 h (Table 3). At 48 h, violation of the protocol was the only risk factor ($p < 0.01$; OR 9.6; 95% CI 2.98–30.96).

Discussion

The primary objective of this study was to investigate the incidence and outcomes of POUR in patients undergoing OLIF surgery with a systematic care protocol. Secondary objective is to identify risk factors of temporary POUR, and 1-month outcomes of POUR after OLIF. The incidence rates of POUR were 44.1% (45/102) at 24 h, 16.7% (17/102) at 48 h, and 2% (2/102) at 1 month. Urological symptoms and violation of the protocol were risk factors for POUR at 24 h. At 48 h, violation of the protocol was the only risk factor.

Comparison with literature data

The incidence of POUR at 48 h was lower than a previously reported incidence rate of 25%, but the incidence at 24 h was much higher than the previously reported rates after single-level OLIF[22,24,36–38]. The high incidence rate at 24 h may be explained by the retroperitoneal trajectory, early assessment of POUR, and definition of POUR. The retroperitoneal approach used in OLIF, which traverses the superior hypogastric plexus and/or sympathetic chain, may transiently or permanently influence the sympathetic and parasympathetic nervous systems[16,39,40]. However, the high incidence of POUR discovered in this study cannot be accounted for by the retroperitoneal

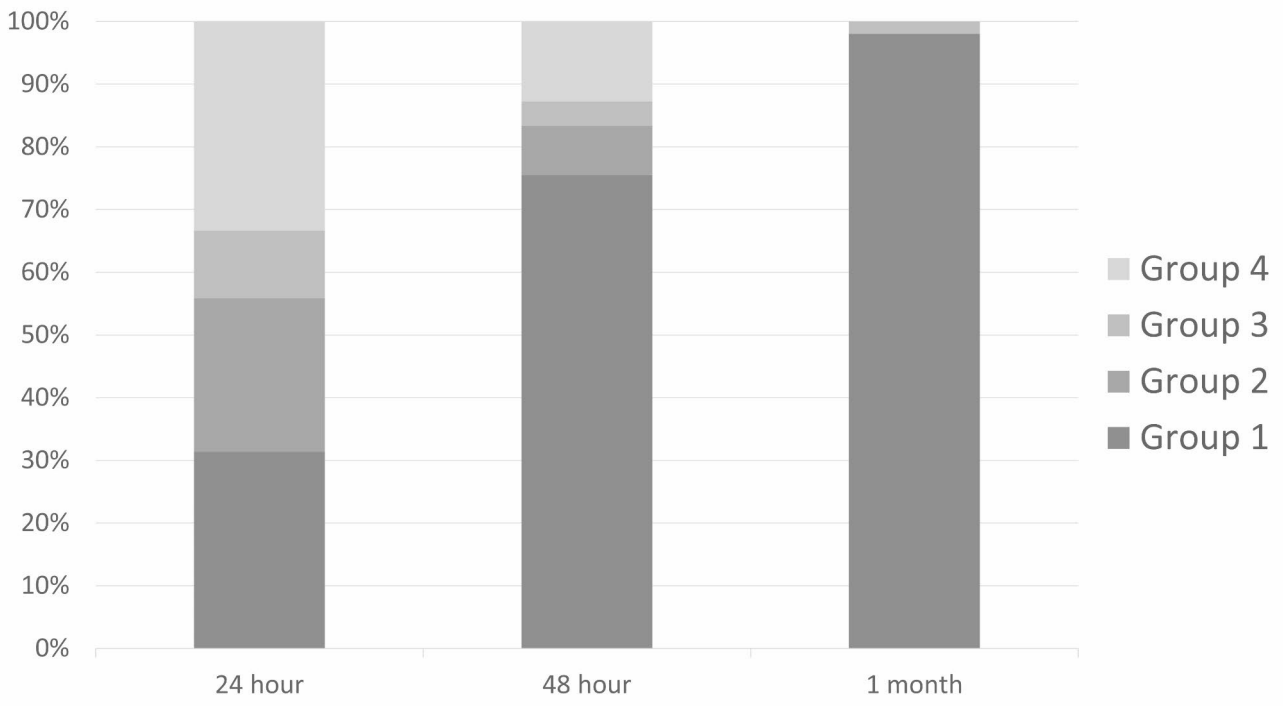

Fig. 2. Patients' POUR statuses by group. The POUR statuses of patients were categorized as Groups 1, 2, 3, and 4. Patients in Groups 1 and 2 had no POUR, and those in Groups 3 and 4 had POUR.

Variables	24 h (*p*-value)	OR (95% CI)	48 h (*p*-value)	OR (95% CI)
Age	0.51		0.44	
Diabetes	0.23		0.15	
Urologic symptom	0.05	3.2 (1.02–9.88)	0.08	
Neurological problem	0.26		0.96	
BMI	0.54		0.52	
Op time	0.51		0.71	
Protocol violation	< 0.01	28.3 (7.4–107.8)	< 0.01	9.6 (2.98–30.96)

Table 3. Multivariate analysis of factors influencing POUR. *CI* confidence interva, *OR* odds ratio, *POUR* postoperative urinary retention, *NRS-B* numerical rating score of back pain.

approach alone; it may also be explained by the definition of POUR in this study. Previous studies used an RU of 300–400 mL as the threshold to define POUR, while this study used 100 mL[22]. Moreover, the present POUR care protocol was more sensitive than previous ones[18,22,34,40–42]. Although this protocol may have been highly sensitive, the incidence of POUR at 1 month was 2%, which suggests the potentially favorable outcomes of utilizing a systematic care protocol.

In addition to a systematic care protocol, the identification of risk factors was important in the effective application of the care protocol. Brant et al. showed that a delayed postoperative void after 4 h was associated with prolongation of the hospital stay by more than 24 h. 23 Patients who developed POUR had longer hospital stays than patients who did not develop POUR (3.94 days versus 2.34 days; $p = 0.005$)[38]. This finding is an important consideration when a day surgery or outpatient surgery is being planned for single-level OLIF. Identifying patients with risk factors would be an important preoperative assessment. Several studies have been conducted to identify risk factors for POUR after spinal surgery. Reported risk factors were age, sex, BMI, preoperative urologic symptoms, diabetes, volume of infused fluid, duration of surgery, and extent of surgery[18,22–24,38,41,42]. Preoperative urologic symptoms were present in 22% of patients in this study and were associated with 24-hour POUR. Brant et al. showed that nearly half of the patients had preoperative urinary symptoms and that the urinary symptoms should be inquired about in the preoperative patient evaluations[23]. There were other important risk factors that this study did not identify. Age was frequently mentioned as a significant risk factor for POUR in previous studies[18,41,43,44]. With age, the contractility of bladder muscles is weakened, and the pathways of neurons involved in the urination process, such as bladder filling, urine storage, and volatility, degenerate[43,45]. In addition, the prostate is enlarged in males[43,45]. DM is related to increased bladder capacity,

impairment in bladder sensation, and decreased detrusor muscle contractility[42]. These facts could explain the correlation between DM and POUR.

In addition to the reported factors, this study showed that violation of the voiding care protocol was a risk factor for POUR at 24 h and 48 h. A strict application of the protocol to every patient was not a simple task for the nursing team and patients, and violations of the protocol occurred in 28% of patients. In this study, we defined Profile Violation based on the management protocol during the first 48 h after surgery, and analyzed the differences between the POUR group and the non-POUR group.

POUR group (Group 3, 4):

1. Within the first 6 h: Many patients in this group had failed attempts to void or did not perform CIC despite RU exceeding 400 mL within the first 6 h after surgery. These early protocol violations had a significant impact on the occurrence of POUR.
2. Between 6 and 24 h: A protocol violation was considered if RU continued to exceed 400 mL or if there were two or more failed attempts to void but CIC was not applied. Patients with persistent violations during this time period were at high risk for POUR.
3. Between 24 and 48 h: Patients whose protocol violations were not resolved within the first 24 h had worsening POUR, and after 48 h, residual urine volume did not normalize or CIC was persistently required.

No POUR group (Group 1, 2):

1. Within the first 6 h: Some patients had violations in the first 6 h, such as not attempting to void or delayed residual urine volume measurement. However, most patients had violations resolved promptly by prompt compliance with the protocol.
2. Between 6 and 24 h: Violations also occurred during this time period, but POUR occurrence was prevented by appropriate implementation of CIC or rapid residual urine volume measurement and management.
3. Between 24 and 48 h: After 24 h, most patients had normal voiding function, and protocol violations were rare at this time point.

In conclusion, the POUR group primarily violated the protocol during the first 6 to 24 h, and these violations had a decisive impact on the occurrence of POUR. In contrast, the non-POUR group quickly corrected violations even when they occurred, preventing POUR. Although it was not associated with POUR at 1 month, the incidence of transient POUR may be reduced by strictly following the protocol. However, a causal relationship could not be verified in this retrospective study.

Limitations

There were several limitations in this study. Firstly, the results were obtained from a small number of patients at a single institution. In addition, the criteria of POUR may have been highly sensitive to a degree that inflated the incidence of POUR. Secondly, strict application of the protocol was not simple considering various clinical situations, and violations of the protocol occurred in 28% of patients. A simple and easy-to-follow protocol would be better for applying in clinical practice and should be devised considering the various circumstances of each medical institution. Thirdly, the cost-effectiveness of the care protocol needs to be considered. This protocol required bladder scans and CICs, which necessitated additional use of medical resources. Moreover, this protocol may delay the discharge of patients due to overreactions to a non-harmful and self-limiting problem. The effects of the protocol need to be confirmed in a further prospective study. Nonetheless, we showed that the incidence of POUR after OLIF was not uncommon, and that a systematic care protocol may reduce permanent POUR. Applying systematic care may improve patient care.

Recommendations

Although the protocol has been systemically applied since 2010, it has not been globally standardized and lacks generalizability. We hope the present protocol would be helpful for readers in devising their own protocols[18]. In devising a protocol, the use of a non-invasive ultrasound scanner to check RU would be useful. Measuring RU may reduce unnecessary CIC, patient discomfort, and iatrogenic injury or irritation to the urethra, and it could improve the detection of asymptomatic bladder distention[32]. Relying upon patient-reported symptoms would not be accurate because 54% of patients with bladder distention of more than 500 mL had no symptoms of bladder distension and failed to void within 30 min in the post-anesthesia care unit[32].

Conclusion

The incidence of transient POUR after OLIF was high, and POUR could be managed with a systematic care protocol. Identifying risk factors for POUR and applying a preemptive care protocol may reduce the incidence of permanent POUR.

Data availability

All data generated or analyzed during this study are included in this published article and its supplementary information file in excel spreadsheet form.

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Author contributions

CHK, JL and JL mainly designed this study. JL, JL SC and TK performed acquisition, analysis and interpretation of data. JL, JL and SC analyzed the results. JL, JL, CKC, STY and CHK wrote and revised the main manuscript text. JL, JL, AK, CKC, STY, KK and CHK substantively revised manuscript. All authors reviewed the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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