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Preoperative and Postoperative Residual Urine in 796 Men Older than 65 Years Undergoing Elective Orthopaedic Surgery in Denmark

A Single-Center Cohort Study

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Investigation performed at: Elective Surgery Center, Regional Hospital Silkeborg, Denmark

Background: Postvoid residual urine (PVR) can be an unknown chronic disorder, or it can occur after surgery. A pilot study led to development of a flowchart suggesting performing preoperative and postoperative bladder scans and recommending men with PVR further diagnostic work-up. This study aimed to determine the prevalence of preoperative and postoperative PVR in men older than 65 years undergoing major elective orthopaedic surgery and also to determine risk factors and possibility of prediction.

Methods: This was a single-center cohort study. The patients were consecutively included for 1 year from April 2022. Data were extracted from the electronic patient files: age, lower urinary tract symptoms (LUTS), comorbidity, type of surgery and anesthesia, opioid use, and preoperative and postoperative PVR which was defined as ≥150 ml.

Results: A total of 796 men were eligible for inclusion: 316 knee, 276 hip, and 26 shoulder arthroplasties and 178 lower back spinal surgeries. Preoperative bladder scans were acquired in 95% of the eligible patients, and PVR was found in 15% (confidence interval [CI] 12-18). There was a higher risk of preoperative PVR in men reporting LUTS, OR 1.97 (1.28-3.03); neurological disease, OR 3.09 (1.41-6.74); and the risk increased with higher age, OR 1.08 per year (1.04-1.12). PVR was found in 9% of the men without risk factors. A postoperative bladder scan was performed in 72% of the men. Among men without preoperative PVR, 15% (CI 12-19) had postoperative PVR de novo. The highest risk for PVR postoperative was PVR preoperatively.

Conclusions: Preoperatively, 15% had PVR. Neurological disease, LUTS, and higher age were identified as risk factors, but PVR was found in 9% of the men without risk factors. In men without preoperative PVR, 15% had postoperative PVR de novo. It is not possible to conclude whether PVR is transient or chronic, and it is unclear whether a PVR of 150 ml is associated with complications or if the threshold should be higher. This study highlights the importance of awareness regarding voiding issues before and after surgery.

Level of Evidence: Level III. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Postoperative urinary retention (POUR) is a lack of ability to void or an increased volume of postvoid residual urine (PVR). POUR is a common complication following orthopaedic surgery[1-6], and the risk of POUR increases if the patient has PVR before surgery[5-7]. However, a preoperative bladder scan of these patients is only a routine in some settings[3]. At the study site, elderly male patients undergoing lumbar spine surgery were routinely bladder scanned for PVR preoperatively. However, there were no routine for postoperative bladder scans for PVR and no existing routine for preoperative bladder scans in patients undergoing other major orthopaedic surgeries such as

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hip, knee, or shoulder arthroplasty. Consequently, when POUR is detected, whether it is a new problem or an unknown chronic urinary retention (CUR) is unclear. CUR can be an unknown medical disorder and is defined as a nonpainful bladder with urinary retention. There is no evidence-based defined minimum threshold volume for significant PVR or CUR in the literature[8,9].

Urinary retention can be caused by several pathological conditions such as neurological diseases, diabetes, cancer, urinary obstruction (e.g., enlarged prostates), reduced detrusor function, side effects of medicine, e.g., opioids, and spinal anesthesia[10,11], or it can be idiopathic. The risk of urinary retention increases with age and is most frequent in men caused by enlarged prostates[4,12]. Left untreated, urinary retention can cause cystitis, bladder stones, urosepsis, and permanent damage to the bladder or kidney[13-18]. Patients with a high amount of urinary retention or a damaged bladder will need either an indwelling catheter or clean intermittent catheterization (CIC) to empty the bladder. This may lead to an increased risk of urinary tract infections[16] and affect quality of life[16]. For these reasons, POUR and CUR must be identified in connection with admission.

This study focuses on PVR prevalences and determining whether PVR is a new problem or CUR, thereby being a preexisting condition that has not developed due to surgery. This distinction is important to choose the best treatment. Identifying predictors to determine specific subgroups of patients who either require scanning or can be safely excluded from it could be time-saving in clinical practice.

Aim

The aim of this study was to determine the prevalence of preoperative and postoperative PVR in men older than 65 years undergoing common major elective orthopaedic surgeries such as hip, knee, and shoulder arthroplasty and lumbar spine surgery, and also to determine risk factors and possibility of prediction.

Materials and Method

This was a single-center cohort study with continuous retrospective collection of prospectively acquired data. Because of the lack of evidence-based recommendations on how to examine for and treat PVR in an orthopaedic setting, a collaboration with 2 urological departments was established to improve the quality of treatment and patient safety. This resulted in a flowchart with recommended preoperative and postoperative bladder scans for PVR, catheterization if the PVR volume exceeds 300 ml[19], and postoperative follow-up. If postoperative PVR is ≥150 ml, follow-up by a general practitioner is recommended, and if PVR is >300 ml, both preoperatively and postoperatively, referral to a urologist is recommended[9]. PVR ≥150 ml is set as the threshold for significant PVR[1,20].

The flowchart and procedure for PVR registration were implemented as a standard in April 2022, and data were registered in the electronic patient files. Data were consecutively collected from April 25, 2022, to April 24, 2023, and stored in an online secured REDCap database. Data include age, American Society of Anesthesiologists (ASA) classification, lower urinary tract symptoms (LUTS), comorbidity (diabetes or neurological disease), type of surgery, type of anesthesia, opioid use, and results of preoperative and postoperative bladder scans for PVR.

Participants

The participants were men older than 65 years undergoing hip, knee, or shoulder arthroplasty or lumbar spine surgery. Men with preexisting urinary disease treated with either intermittent or permanent catheterization were excluded.

Setting

This study was conducted in Elective Surgery Centre, Silkeborg Regional Hospital, an elective orthopaedic department specializing in elective surgery in Denmark.

The first bladder scan was performed on the day of admission, after voiding, and before the planned surgical procedure. The second bladder scan for PVR was performed postoperatively when the man was able to void again. Some men were discharged on the day of surgery, while others stayed longer, and it was possible to repeat bladder scans for PVR if the amount was high (Fig. 1). Bladder scans for POUR were performed in adherence to a local guideline. All bladder scans were performed using a Biocon-700 Bladder scanner (MRC-700N, Mcube Technology Co, Ltd, Republic of Korea).

Study Size

All men following the inclusion criteria were planned to be bladder scanned. Based on an estimate, about 25% of the expected 3,000 to 3,500 annual patients undergoing the predetermined types of surgeries would be eligible for inclusion. Data from our pilot study indicated that 13% had PVR ≥150 ml. Assuming a true prevalence of 13%, a sample size of 700 men was sufficient to achieve a 95% confidence interval (CI) for the true prevalence of width approximately 5 percentage points. This resulted in a preplanned 1-year timeframe for study inclusion.

Statistics

Data are reported as numbers and proportions (%), normally distributed data as means with standard deviations (SD), 95% CI, and ranges, and nonnormally distributed data as medians with interquartile ranges (IQR) and ranges where appropriate. Associations between the risk of PVR and multiple risk factors were quantified by odds ratios (OR) using logistic regression. Groupwise comparisons of risks were made by the Fisher exact test with a level of significance of $p < 0.05$.

Data management and statistical analysis were performed in STATA, version 18.5.

Statistical analysis and interpretation aided by biostatistician, co-author A.R.P.

Ethics

The study was approved by the head of the department and the hospital direction as a quality improvement study. Ethical approval and informed consent were not required according to the study design. All data were handled according to the law of processing personal data and the Danish Health Act, and data

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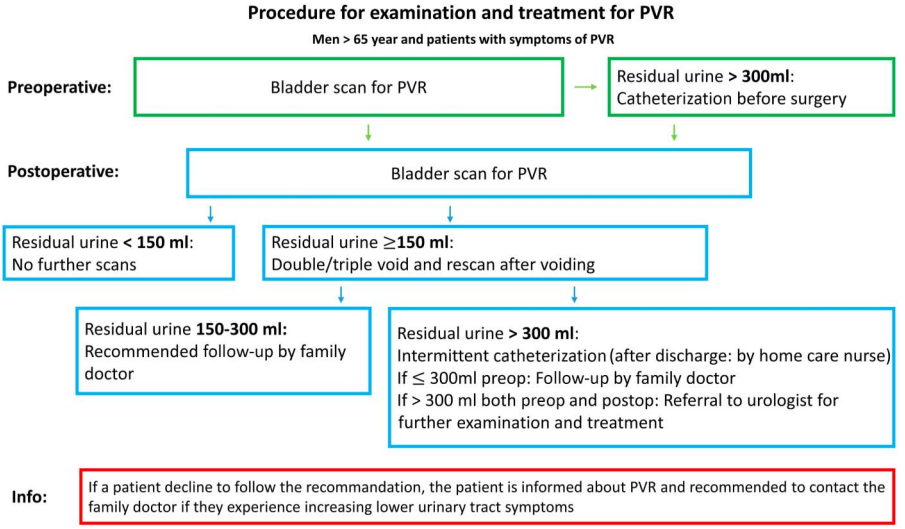

Fig. 1

Flowchart for residual urine bladder scan and follow-up. Procedure for the bladder scan for PVR and recommendation for treatment during hospital stay and follow-up or further examination after hospital discharge. PVR = postvoid residual urine.

TABLE I Patient Demographics of the Full Cohort and the Groups of Patients with Preoperative and Postoperative PVR

	Full Cohort N = 796 n (%)	Preoperative PVR ≥150 ml N = 112 n (%)	Postoperative PVR ≥150 ml N = 133 n (%)
Age			
66-75	480 (60)	54 (48)	69 (52)
76-80	196 (25)	32 (29)	37 (28)
81-85	94 (12)	17 (15)	22 (16)
>85	26 (3)	9 (8)	5 (4)
Type of surgery			
Knee arthroplasty	316 (40)	35 (31)	46 (34)
Hip arthroplasty	276 (35)	47 (42)	57 (43)
Lumbar spine	178 (22)	26 (23)	29 (22)
Shoulder arthroplasty	26 (3)	4 (4)	1 (1)
ASA			
1	71 (9)	15 (13)	17 (13)
2	462 (58)	60 (54)	81 (61)
>2	263 (33)	37 (33)	35 (26)
Diabetes	119 (15)	20	22
Neurological disease	36 (5)	11	5
Anesthesia		-	
Spinal	579 (73)	-	101
General	217 (27)	-	32
Postop opioid		-	
Morphine	168 (21)	-	25
Oxycodone	608 (76)	-	103

ASA = American Society of Anesthesiologists, and PVR = postvoid residual urine.

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TABLE II Preoperative and Postoperative PVR

	Preoperative Bladder Scan Total N = 755 n (%)	Postoperative Bladder Scan Total N = 569 n (%)
<150 ml	643 (85)	436 (77)
150-300	89 (12)	97 (17)
>300 ml	23 (3)	36 (6)

Distribution of patients with preoperative and postoperative PVR. PVR = postvoid residual urine.

collection and storage was registered by the Danish Data Protection Agency. Data are presented anonymized. The authors declare no conflicts of interest.

Results

Participants

There were 796 men eligible for inclusion, encompassing 316 knee, 276 hip, and 26 shoulder arthroplasties and 178 lower back spinal surgeries. The mean age was 75 years, with a range of 66 to 91; the majority was ASA 2; and 73% of the men underwent spinal anesthesia. Diabetes occurred in 15% and neurological disease in 5% (Table I).

Preoperative PVR Prevalence

Preoperatively, 755 of 796 (95%) men were bladder scanned for PVR, 12% had 150-300 ml and 3% had >300 ml (Table II). The number of patients with >300 ml is too small for statistical analysis. Consequently, the 2 groups were merged to "≥150 ml," i.e., at least 150 ml for analysis. The proportion of men with at least 150 ml was 15% (CI 12-18). Preoperative PVR for all the participants was median 44 ml, IQR 10 to 97, range 0 to 6,200.

Before surgery, 301 (39%) reported LUTS, and of those, 21% (CI 16-26) had at least 150 ml PVR preoperatively. The prevalence of preoperative PVR in men without reported LUTS was 11% (CI 8-14) (Fig. 2), which was significant ($p < 0.001$).

Predictors for PVR

There was a higher risk for PVR in men with LUTS, OR 1.97 (CI 1.28-3.03), or neurological disease, OR 3.09 (CI 1.4-6.7), and the risk increased with age, OR 1.08 per year (CI 1.04-1.12). The most significant risk factor for PVR was neurological disease, OR 3.09 (CI 1.4-6.7). A higher ASA correlated with a lower risk for PVR. Higher ASA correlates with lower age in our population because both high age and high ASA correlate with a higher risk in relation to surgery. Therefore, the association between ASA and PVR is presumed to be bound to our population. The type of surgery and diabetes were not statistically significantly associated with an increased risk of PVR before surgery (Table III).

In the group of men with 1 or more predictors, the risk of ≥150 ml preoperative PVR was 19% (CI 15-23). In the group of men with no predictors, the risk of ≥150 ml preoperative PVR was 9% (CI 6-13). If only men with 1 or more predictors were bladder scanned, 25% of the men with ≥150 ml would not have been identified (27/110) (Table IV).

Postoperative PVR

Postoperatively, 71% had a bladder scan for PVR, and 29% had no postoperative scan for PVR. The proportion of patients without postoperative scans is largest in the groups without a

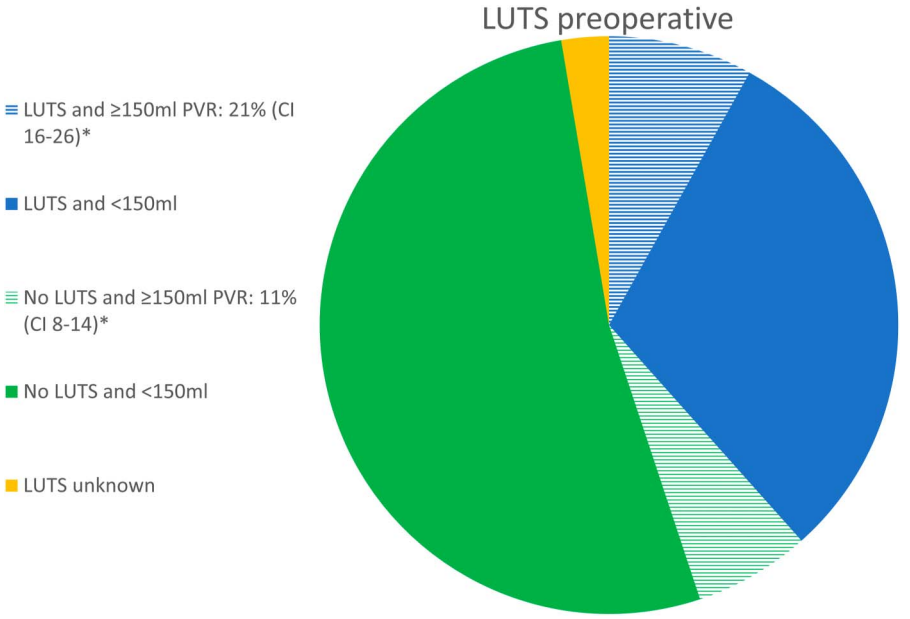

Fig. 2

Reported lower urinary tract symptoms and correlation with preoperative PVR. In N = 301, men reporting LUTS preoperatively. *$p < 0.001$. LUTS = lower urinary tract symptoms, and PVR = postvoid residual urine.

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TABLE III Predictors for Preoperative PVR

Predictors	OR (CI)	p
Age		
Per year	1.08 (1.04-1.12)	p < 0.001
Type of surgery		
Knee arthroplasty	1 (ref)	p = 0.346
Hip arthroplasty	1.54 (0.94-2.53)	
Lumbar spine surgery	1.24 (0.70-2.21)	
Shoulder arthroplasty	1.86 (0.56-6.23)	
ASA		
	1 (ref)	p = 0.008
2 vs 1	0.38 (0.19-0.75)	p = 0.005
>2 vs 1	0.31 (0.15-0.66)	p = 0.002
Diabetes		
No	1 (ref)	p = 0.099
Yes	1.63 (0.91-2.90)	
Neurological disease		
No	1 (ref)	p = 0.005
Yes	3.09 (1.41-6.74)	
LUTS		
No	1 (ref)	p = 0.002
Yes	1.97 (1.28-3.03)	

N = 735 (755 with performed bladder scan for PVR preoperative, -20 with unknown LUTS). Predictors: predictors of PVR. ASA = American Society of Anesthesiologists, PVR = postvoid residual urine, LUTS = lower urinary tract symptoms, and OR = odds ratio.

preoperative scan or a preoperative scan showing less than 150 ml PVR (Table V). Of men with 150-300 ml PVR preoperatively, 54% had at least 150 ml PVR postoperatively. In patients with preoperative PVR >300 ml, 95% had a remaining problem of at least 150 ml PVR at the postoperative scan during the hospital stay (Table VI). Postoperative PVR for all the participants with postoperative scans was median 79 ml, with the range of 0 to 896.

Postoperatively, 15% (CI 12-19) of the men had de novo PVR of at least 150 ml. Postoperatively, 11 men had >300 ml and were recommended an intermittent or indwelling catheter until further diagnosis was initiated regarding recommendations in the flowchart (Fig. 1).

Of the 453 men who had a postoperative bladder scan and had less than 150 ml PVR preoperatively, 444 were treated with opioids postoperatively. There was no significant difference in the incidence of men with at least 150 ml PVR as a new problem related to the type of opioid, type of anesthesia, or spine surgery versus other surgery (Table VII).

There are a correlation between spine or shoulder surgery and general anesthesia, and spinal anesthesia and hip or knee arthroplasty. In men undergoing hip or knee arthroplasty, 97 to 98% were anesthetized with spinal anesthesia, and spine and shoulder surgery is similar to general anesthesia (Table VII).

The highest risk for at least 150 ml PVR postoperative is in men with at least 150 ml preoperatively (OR 8.32 [4.98-13.9] [p < 0.001]).

Analysis of Missing Postoperative Bladder Scans

Postoperatively, 29% of the men were not scanned for residual urine. The largest proportion (84%) of men with missing postoperative scans was in men with less than 150 ml in the preoperative bladder scan (Table V).

Based on our data, we estimate that 15% (CI 12-19) of the men develop a new problem postoperatively with PVR ≥150 ml (Table VI). However, there is uncertainty regarding whether a proportion of patients without a problem previously have an unknown problem postoperatively due to the missing scans. Nevertheless, we assume that drop-out in bladder scans is equally distributed and that this estimated incidence of PVR as a new problem after surgery may be considered representative of the full cohort, despite the relatively large proportion of missing postoperative bladder scans.

Discussion

Our results show a 15% (CI 12-18) prevalence of significant PVR before surgery. A bladder scan before surgery can differentiate chronic PVR from PVR as a new problem related to surgery. We set PVR ≥150 ml as the threshold for significant PVR and >300 ml as the threshold for catheterization before surgery and for referral to a urologist. Other studies use different thresholds between 50 ml PVR[5] and 200 ml[21]. It is a limitation that the correct threshold is uncertain, and it is

TABLE IV Correlation Between Risk Factors and Preoperative PVR

Risk for PVR	<150 ml n (%)	150-300 ml	>300 ml	Total	≥150 ml p < 0.001	>300 ml p = 0.083
Yes	354 (81)	65 (15)	18 (4)	437	19% CI 15-23	4% CI 2.5-6.4
No	271 (91)	22 (7)	5 (2)	298	9% CI 6.1-13	1.7% CI 0.5-3.9

LUTS = lower urinary tract symptoms, and PVR = postvoid residual urine. Risk for PVR: LUTS, diabetes, spine surgery, and neurological disease.

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TABLE V Distribution of Patients Receiving or Missing Postoperative Bladder Scans Versus Preoperative PVR Distribution

Preoperative	No Postop Scan n (%)	Postop Scan n (%)
Unknown	21 (9)	20 (3.5)
<150 ml	190 (84)	453 (80)
150-300	13 (6)	76 (13)
>300 ml	3 (1)	20 (3.5)
Total	227	569

Postop = postoperative, and unknown = no preoperative scan.

unclear whether a PVR of 150 ml is associated with complications or if the threshold should be higher. Future studies could help in deciding the cutoff value of PVR, guiding decisions on when to treat to avoid complications from residual urine and when not to treat to prevent complications due to catheterization. Joelsson-Alm et al. found that 14% of patients undergoing general orthopaedic surgery had a bladder volume >300 ml immediately before surgery, and their results support that a bladder scan before surgery is essential to prevent an overdistended bladder[17]. We only found >300 ml in 3% of our study population, but some of this difference may be because their study population included elderly patients with a higher level of comorbidities undergoing acute surgeries.

We included men older than 65 years in line with Halawi, who describes 60 years as the cutoff for higher risk for POUR[22]. Our results show that OR for PVR increases with age by OR 1.08 per year.

Determining predictors for the risk of PVR would be beneficial and time-saving, but in our study, 9% of the men with significant PVR had no predictors. Therefore, it is not possible to provide a viable prediction model based on this study.

Surprisingly, only 21% of men with LUTS had significant PVR, and diabetes and spine surgery could not be used as individual predictors for significant PVR. Spine injuries below the sacral micturition center located in S2-S4 will result in high PVR, and the patients undergoing spinal surgery in our study are primarily men with lumbar spine issues. There may be patients who underwent knee, shoulder, or hip surgery and also suffer from spine disease; this is unknown, and it is a limitation of this study. Regarding diabetes, peripheral neuropathy is a possible complication and can result in diabetic cytopathy, which subsequently will lead to PVR[23]. Our data are from the orthopaedic medical file, and we have no information about glycemic control and the severity of diabetes. Patients with minimal disease and no risk of cytopathy will, therefore, be included in the group.

Men with larger PVR >300 ml preoperatively also had >300 ml postoperatively in 85% of the cases. PVR >300 ml may be better investigated and treated before surgery due to increased risk of infection when treated with catheterization. Further studies are required to address the possible implications of performing surgery despite the newfound high amount of PVR and if catheterization has consequences for the result of the orthopaedic procedure. However, national registry data do not indicate an increase in total joint infections during the study period[24,25]. Although these data are not directly linked to individual cases in our study, they may help address concerns regarding infection risk. Data concerning urinary tract infections were not collected in this study.

The proportion of men identified with PVR de novo after surgery can be biased because only 69% of the men with <150 ml preoperatively were rescanned for PVR postoperatively. Analysis of patients with missing postoperative bladder scans shows that a larger proportion of the men who underwent spine surgery or men with at least 150 ml PVR preoperative were bladder scanned postoperatively. This means that there is a selection bias due to the results of postoperative scans.

There may be several reasons for the missing scans postoperatively. Some men may have declined further scans, or the staff may have missed the postoperative scan due to other focus points before discharge when the patient reports habitual voiding. During the study period, implementing strategies increased the proportion of men where bladder scans were performed as planned both preoperatively and postoperatively.

We estimated that 15% (CI 12-19) of the men had significant PVR de novo after surgery. Analyses show that if none of the men with missing scans had de novo PVR, the prevalence would be 11% (CI 9-14), which means that the true prevalence in our study population is at least 11%.

It is not possible to conclude if PVR is transient or chronic because some of the men had a bladder scan on the day of surgery, with the potential of anesthesia still affecting the

TABLE VI Postoperative Bladder Scan Volume Distributions Versus Preoperative PVR Distributions

Preoperative PVR	Postoperative PVR <150 ml n (%)	Postoperative PVR 150-300 ml n (%)	Postoperative PVR >300 ml n (%)	Postoperative PVR ≥150 ml n (%)
<150 ml	383 (85)	59 (13)	11 (2)	70 (15%, CI 12-19)
150-300 ml	35 (46)	33 (43)	8 (11)	41 (54)
>300 ml	1 (5)	2 (10)	17 (85)	19 (95)

N = 549 men with performed bladder scan both preoperative and postoperative. Postoperative ≥150 ml is the merged groups of 150 to 300 and >300 ml. PVR = postvoid residual urine.

TABLE VII Predictors for PVR Postoperative

Predictor	New Problem with PVR n (%)	<150 ml Pre and Post n (%)	p
Oxycodone	52 (16)	278 (84)	p = 0.884
Morphine	16 (14)	98 (86)	p = 0.765
No opioid	2	7	
Type of anesthesia			p = 0.392
Spinal anesthesia	53 (16)	269 (84)	
General anesthesia	17 (13)	114 (87)	
Type of surgery			p = 0.656
Spine surgery	16 (14)	100 (86)	
Other surgery	54 (16)	283 (84)	

N = 453: <150 ml preoperative PVR and were bladder scanned postoperatively. <150 ml pre and post: <150 ml PVR preoperative and postoperative. PVR = postvoid residual urine.

voiding. We did not collect data on whether the men were discharged on the day of surgery or later, but the overall mean hospitalization was 1.7 days in 2022. In our center, patients were discharged despite PVR, and follow-up was recommended as prescribed by the flowchart (Fig. 1).

Conclusion

The prevalence of preoperative PVR was 15% (CI 12-18). Neurological disease was the most severe risk factor (31%), and secondary reported LUTS in the outpatient clinic before surgery (21%). As expected, the risk increased with age. No predictors were noted in 9% (CI 6-13) of the men with PVR preoperatively.

A postoperative bladder scan was performed in 72% of the men. Among men without preoperative PVR, 15% (CI 12-19) had postoperative PVR de novo. It is not possible to conclude whether PVR is transient or chronic, but further studies are ongoing. The highest risk for PVR postoperative was PVR preoperatively. It is unclear whether a PVR of 150 ml is associated with complications, or the threshold should be higher. This study highlights the importance of awareness regarding voiding issues before and after surgery. ■

Note: The authors appreciate the enthusiasm from the collective nursing staff performing the bladder scans and registering data and the surgeons adhering to the new guideline and recommendations.

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