Arthroplasty Today 13 (2022) 181–187

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original research

Preoperative Factors to Assess Risk for Postoperative Urinary Retention in Total Joint Arthroplasty: A Retrospective Analysis

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ARTICLE INFO

Article history:
Received 3 June 2021
Received in revised form
21 September 2021
Accepted 11 October 2021

Keywords:
Post-operative urinary retention
Total joint arthroplasty
Catheterization
Risk factors
Post void residual
Bladder ultrasonography

ABSTRACT

Background: Postoperative urinary retention (POUR) is a significant problem in total joint arthroplasty (TJA). Although risk factors for POUR have been well documented, they are ubiquitous in an aging total joint population, which makes risk stratification difficult. The purpose of this study was to determine if a high preoperative post-void bladder scan identifies patients at risk for POUR.
Methods: A retrospective analysis was conducted on all TJAs performed at a high-volume orthopedic center between December 2019 and February 2020. A total of 585 elective TJA patients received post-void bladder scans before surgery. Bladder scan volumes were correlated with catheterization via Chi-squared tests.
Results: A high post-void residual volume (PVRV > 50 ml) was associated with an increased risk of catheterization (23% vs 34%, chi-squared statistic = 6.2638, *P* value = .013), as was intravenous fluid volume (>1000 ml in knee, >2000 ml in hip). Catheterization rates were higher among total knee arthroplasty patients younger than 60 years (37% vs 24%, chi-squared statistic = 4.284, *P* value = .0385) and total hip arthroplasty (THA) patients older than 65 years (30% vs 18%, chi-squared statistic = 3.292, *P* value = .0695). Multiple risk factors were additive.
Conclusions: Higher PVRV and intravenous fluids were independently associated with catheterization after TJA. Younger age was associated with greater risk in total knee arthroplasty, while older age increased risk in THA. We propose that a preoperative bladder scan to detect a high PVRV may provide clinical utility to identify patients likely to develop POUR.

Introduction

Postoperative urinary retention (POUR), defined as the inability to void despite a large bladder volume, is common after total joint arthroplasty (TJA) [1,2]. The diagnosis of POUR can be confirmed using specialized bladder ultrasonography, which is also commonly used as a noninvasive screening tool to detect residual bladder volumes and, thus, signs of incomplete bladder emptying [3-6]. The mainstay for the treatment of POUR has been and continues to be catheterization, despite conflicting evidence regarding the efficacy of pharmacologic agents such as alpha-adrenergic antagonists and muscarinic agonists [7,8]. The bladder has a normal capacity of 400-600 ml, with the first signal of micturition occurring at 150 ml and a sensation of fullness occurring at approximately 300 ml. Urinary retention may be classified into obstructive and non-obstructive pathologies, with postoperative patients commonly falling into the latter category; often exhibiting transient signs and symptoms suggesting that most cases are iatrogenic [9].

The exact incidence of urinary retention after a major orthopedic surgery is unclear, with rates ranging between 5% and 84% [2,10]. Despite this wide variability, which is diagnostic criteria dependent, POUR is a significant concern for patients and healthcare providers. Not only is an overdistended bladder and

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.artd.2021.10.009.

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https://doi.org/10.1016/j.artd.2021.10.009

subsequent catheterization uncomfortable for the patient, but it may also increase the risk of urinary tract infections (UTIs) and delay mobilization [11,12], both of which may impede same-day discharge, leading to increased health-care costs. In the postoperative orthopedic setting, UTIs may undergo hematogenous seeding [13], which can lead to periprosthetic joint infections. Therefore, despite it being a relatively common and benign postsurgical complaint, the risk of significant morbidity makes it important to determine the risk factors that lead to POUR to reduce the overall incidence, alleviate the financial burden of urinary and orthopedic complications, and improve outcomes after TJA.

A significant literature and study review was conducted by Agrawal et al. in June 2018, which detailed numerous risk factors for urinary retention in the postoperative period [11]. Nonmodifiable risk factors include gender, age, and a variety of preexisting conditions and comorbidities. One of the most consistent risk factors identified in the literature is gender, with male patients 2-3 times more likely to develop POUR, likely due to anatomical differences such as urethral mechanical obstruction [2,6,14]. Increased age is also a risk factor, but this may be due, in part, to an increasing incidence of age-related progressive neuronal degeneration, as well as comorbidities such as renal failure, diabetes, or, in men, benign prostatic hyperplasia (BPH) [2,6,10]. Other pre-existing conditions associated with an increased risk of POUR include a prior history of urinary retention and neurological abnormalities such as stroke, cerebral palsy, multiple sclerosis, as well as diabetic or alcohol-related neuropathies [4]. Iatrogenic and modifiable risk factors include type of anesthesia, intraoperative and postoperative opioid use, and administration of large amounts of intraoperative intravenous (IV) fluids. Intraoperative fluid volume exceeding 2 L is highly correlated with the development of POUR, irrespective of other risk factors [15]. Patients who received spinal/epidural anesthesia are at a higher risk of POUR than those receiving general anesthesia [11].

Orthopedic surgery itself is a known risk factor for POUR. Patients undergoing lower joint arthroplasty have a rate of POUR up to 84% [10], which is 20 times greater than that in the general surgery population [2]. Some exacerbating conditions that put arthroplasty patients at increased risk include spinal/epidural anesthesia, intraoperative opioids or anticholinergics, and higher postoperative fluid administration. In the case of spinal anesthesia, complete detrusor block is established 2-5 minutes after the injection, and the time to recovery depends on the duration of sensory block but averages around 7 to 8 hours when using isobaric and hyperbaric bupivacaine [4]. Complete normalization of detrusor strength occurs 1 to 3.5 hours after ambulation [16], suggesting that early mobilization may actually be protective for POUR. Meanwhile, intraoperative opioids decrease the urge sensation and detrusor contraction, increasing the bladder capacity and residual volume [17]. The use of intraoperative opioids as a significant risk factor was further demonstrated in a 2019 study which found a relatively low incidence (9.3%) of POUR in an opioid-free regional anesthesia protocol in a TJA cohort [13]. In addition, the use of anticholinergics, such as glycopyrrolate, to reverse the effects of anesthesia in fast-track TJA patients discharged on day 0 or day 1 increased the likelihood of developing POUR by 5.9 times [14]. Previous research has also extensively documented the association between higher intraoperative IV fluid volume and the development of POUR. It is hypothesized that excessive fluid administration can lead to bladder overdistention and the inhibition of the normal micturition reflex. This is further supported by the finding that postoperative bladder volumes greater than 270 ml are independently associated with POUR [18].

In individuals who develop urinary retention, bladder emptying requires either intermittent catheterization or the placement of an indwelling (Foley) catheter. Repeated intermittent catheterization can predispose patients to UTIs, which is a concern when patients have orthopedic implants. Similarly, each day an indwelling urinary catheter remains in place, the risk of UTI increases 5%-7% [2], which likewise increases the risk of periprosthetic infections [2,6,19] and may increase length of stay [15]. A 2020 study of 9123 total knee arthroplasties (TKAs) performed across a large health system in the United States found indwelling catheter use, as opposed to intermittent catheterization, to be significantly associated with periprosthetic joint infections [20]. In addition, a recent systematic review of 6397 TJA patients concluded that indwelling catheters should only be used in cases of persistent POUR despite repeated intermittent catheterization. If an indwelling catheter was inevitably used, it should be removed within 48 hours [21]. While the evidence suggests that indwelling catheters pose significant risks to TJA patients, little has been done to stratify risk for urinary catheterization based on a patient's preoperative profile. These findings suggest the preference for a protocol in which patients are screened preoperatively and undergo early ultrasound bladder scanning and intermittent catheterization to detect and treat POUR after lower TJA before a need arises for indwelling catheterization. Ultimately, it is imperative to identify the patients most at risk for POUR and carefully monitor these patients so as to lower the incidence of urinary retention and with it the rate of periprosthetic infection.

Few studies, outside of those involving urological surgery, have looked at preoperative post-void residual volume (PVRV) and its relationship with POUR. Shadle et al. did not find a correlation between preoperative PVRV and POUR when looking at abdominal and neck surgeries [22]. A study by Valsalan and Chandran looking at orthopedic fracture cases found that preoperative PVRV did not correlate with the development of POUR, nor did postoperative residual volume, but anesthesia type heavily factored in POUR development [23]. There is some debate in the literature about what constitutes inadequate bladder emptying. Ballstaedt and Woodbury indicated that a PVRV below 50 ml indicated adequate bladder emptying, whereas a value over 200 ml was considered abnormal [24]. The Agency for Health Care Policy and Research (AHCPR) guidelines reiterate these values, also stating that a PVRV above 50 ml is abnormal [25]. Scholten et al., however, reported that in a TJA population, a preoperative PVRV greater than 150 ml was associated with POUR [26] but concluded that preoperative monitoring only identified pre-existing voiding issues. This conclusion is confounded by the fact that at their institution, patients are catheterized once urine volume is 150 ml.

The primary purpose of this study is to determine whether the risk factors associated with POUR identified in the literature are those for patients in this TJA cohort. Some of these risk factors identified include age, gender, anesthesia type, surgery type, IV fluids received, and bladder scan volumes before and after surgery. We hypothesize that hip arthroplasty patients will undergo catheterization more frequently than knee arthroplasty patients based on the increased IV fluid volume that is typical during total hip arthroplasty (THA). We also hypothesize that there will be significantly more IV fluid administered to patients who receive intermittent catheterization vs those who do not, irrespective of surgery type. Based on the literature, we hypothesize that patients who undergo catheterization will be significantly older than patients who do not receive a urinary catheter.

The secondary purpose of this study is to evaluate whether PVRV measured preoperatively is an independent predictor of POUR. We hypothesize that patients with a high preoperative PVRV (>50 ml) will be more likely to require intermittent catheterization than patients with a preoperative PVRV below 50 ml, based on the AHCPR guidelines.

Table 1
Demographic information for the entire population assessed, further divided by surgery type.

POUR demographic information						
	Number of patients	Average age	% Female	Number catheterized	% Catheterized	Main anesthesia
All TJA	447	67	54%	118	26%	Spinal
TKA	288	67	55%	79	27%	Spinal
THA	159	66	51%	39	25%	Spinal

Material and methods

Approval from the institutional review board was obtained to perform this study (HHC-2020-0184). This study was a retrospective, nonrandomized, single-center observational study comparing risk factors for urinary catheterization in patients undergoing TJA. This retrospective review of 585 patient records was conducted for patients undergoing total joint replacement surgery between December 1, 2019, and February 28, 2020.

Patients were included in the study if they were between the ages of 18 and 89 years and had an elective unilateral THA or TKA. Patients were excluded from the study if they underwent a nonelective TJA, had a pre-existing indwelling catheter, urostomy, or could not urinate on their own before the surgery. Patients were also excluded if they were on medications for urinary issues, such as tamsulosin.

All patients also received a single post-void residual bladder scan before the initiation of their surgery taken 5-10 minutes after voiding. All patients received the same spinal anesthesia induction protocol. After surgery, patients received a bladder scan every 4-6 hours. Scans were continued until the patient was able to void on their own. If the scan showed a bladder volume above 500 ml, the patient was urged to urinate, and if unable, they underwent single intermittent catheterization and regular monitoring until they could void on their own. If volumes again reached 500 ml, patients would undergo a second catheterization and consultation for postoperative Foley catheter placement. Preoperative and postoperative bladder scan volumes were recorded and correlated with catheterization rate via Chi-squared tests.

Chi-squared tests were used to compare the proportion of patients who received a catheter against those who did not for each hypothesized risk factor. This included but was not limited to preoperative post-void residual bladder volume >50 ml, surgery type, IV fluids administered, age, gender, and anesthesia type. All analyses were conducted using Microsoft Excel 2016. All results yielding $P < .10$ were deemed statistically significant.

Results

Of the 585 records accessed, 447 contained complete data sets and were included in the analysis. Demographics for the patient population are shown in Table 1. An initial analysis performed on the total population demonstrated that a preoperative PVRV over 50 ml was associated with a higher rate of catheterization (23% vs 34%, chi-squared statistic = 6.2638, P value = .013; Fig. 1a, statistical significance below 0.05 denoted with 2 stars). There was no difference in catheterization rate based on gender (27% male vs 26% female, chi-squared statistic = 0.104, P value = .747). There was no difference in length of stay based on catheterization (catheter = 1.22 days, no catheter = 1.26 days, P value = .602).

In order to elucidate the differences between hip and knee surgeries, patients were further striated based on the surgery performed. Demographics are shown in Table 1 for each group. In THA patients, 21% of the those with a preoperative bladder volume below 50 ml received a catheter compared to 34% of those with a volume above 50 ml (21% vs 34%, chi-squared statistic = 3.2627, P = .078; Figure 1a, orange bars, statistical significance below 0.1 denoted with 1 star). In TKA patients, 24% of the those with a preoperative bladder volume below 50 ml received a catheter compared to 34% of those with a volume above 50 ml (24% vs 34%, chi-squared statistic = 2.876, P = .0899; Fig. 1b, green bars, statistical significance below 0.1 denoted with 1 star).

High volumes of IV fluids were also a risk factor for catheterization. In THA patients, volumes totaling over 2000 ml administered perioperatively and in the 24-hour postsurgical period increased the rate of catheterization from 22% to 40% (chi-squared statistic = 3.836, P = .0502; Fig. 2a, orange bars, statistical significance below 0.1 denoted with 1 star). This is consistent with values

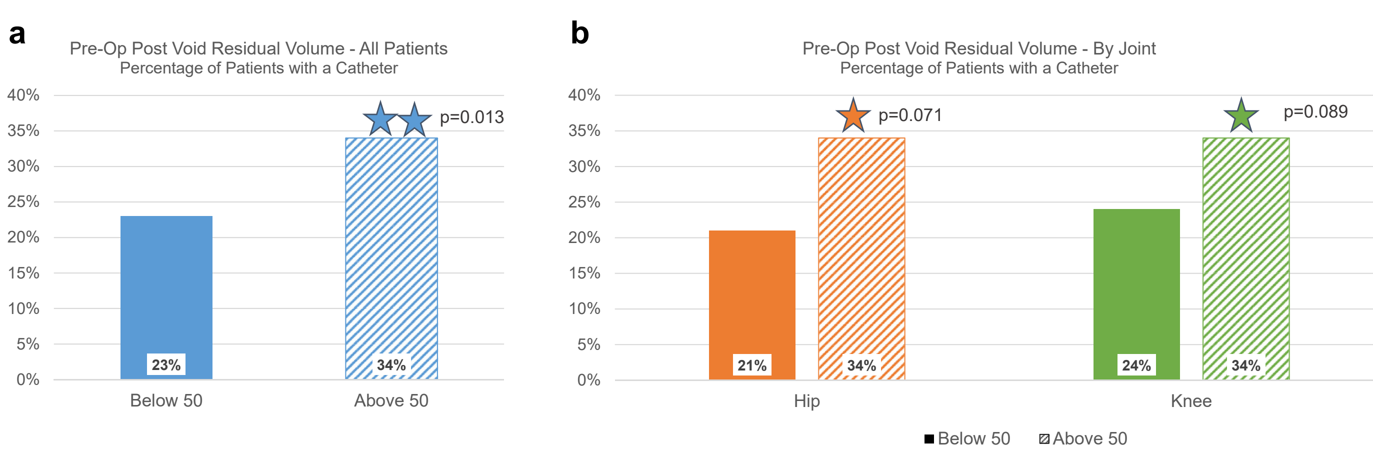

Figure 1. Patient demographics and preoperative post-void residual volume. (a) Catheterization rate for all TJA patients dependent on post-void residual volume less than 50 ml or greater than 50 ml. (b) Catheterization rate for patients shown on the Y axis. Orange bars represent total hip patients. Green bars represent total knee patients. Solid bars represent patients with a post void residual volume less than 50 ml. Hatched bars represent patients with a post-void residual volume greater than 50 ml. For all figures, two stars indicate a P value ≤ .05, and one star indicates a P value ≤ .10.

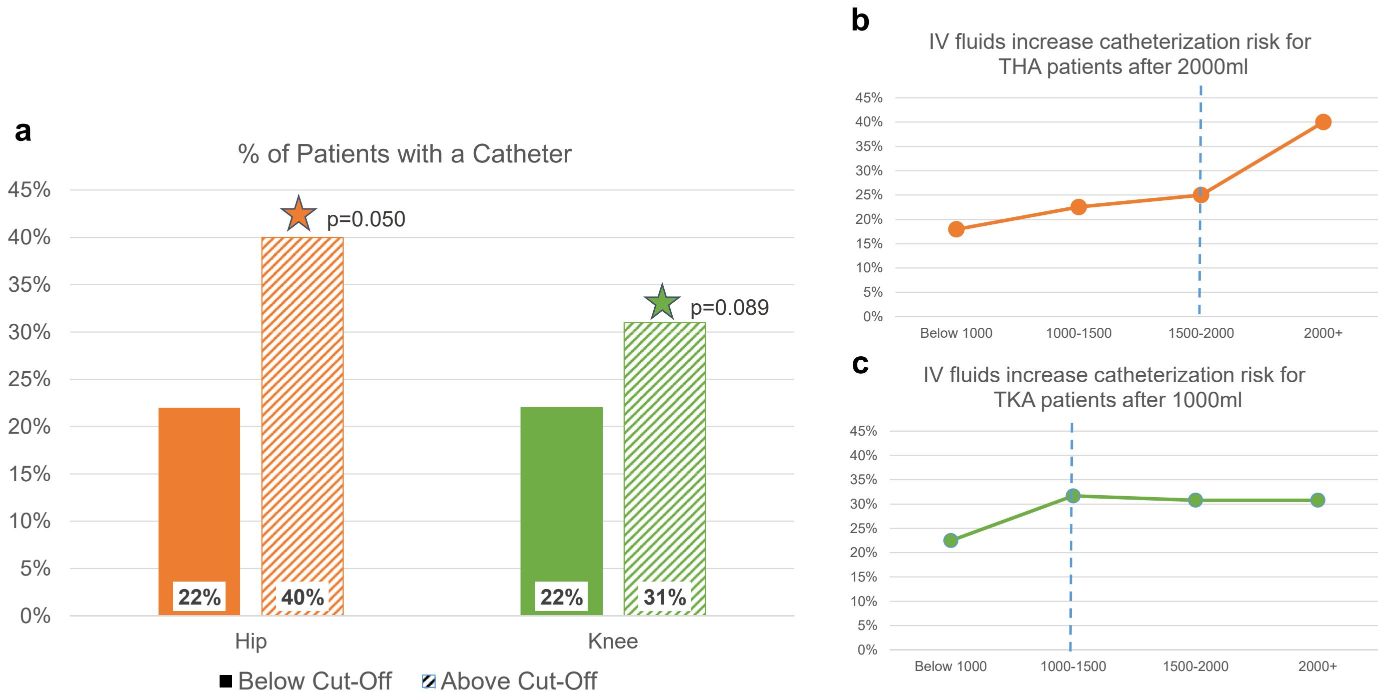

Figure 2. High fluid volumes increase catheterization risk. (a) Percentage of patients catheterized who received high fluid volumes separated by surgery type. Orange bars represent total hip patients. Green bars represent total knee patients. Solid bars represent patients who received lower fluid volumes 24 hours after surgery. Hatched bars represent patients who received higher fluid volumes 24 hours after surgery. For hip patients, the cutoff for higher fluid volume is 2000 ml. For knee patients, the cutoff for higher fluid volume is 1000 ml. (b) Catheterization rate for THA patients increases when patients receive more than 1500 ml of fluid. (c) Catheterization rate for TKA increases when patients receive more than 1000 ml of IV fluid and remains elevated. For all figures, two stars indicate a P value $\leq$ .05, and one star indicates a P value $\leq$ .10.

reported in the literature. Knee arthroplasty patients rarely received this much fluid during the same period. Above intraoperative fluid volumes of 1000 ml in TKA cases, the catheterization rate rose sharply from 22% to 32% (chi-squared statistic = 2.876, $P =$ .089). For THA and TKA populations, respectively, there is a significant increase in catheterization once 2000 ml (hips, Fig. 2b, orange line) or 1000 ml (knees, Fig. 2c, green line) is reached.

When analyzing the THA and TKA cohorts together, it was found that patients younger than 60 years had a catheterization rate of 29% while those older than 60 years were catheterized 25% of the time (chi-squared statistic = 0.924, P value = .336). Hip and knee patients, however, differed greatly in how age affected catheterization rate. For TKA patients, catheterization rates were significantly increased in those younger than 60 years (24% vs 37%, chi-squared statistic = 4.284, $P =$ .0385, Fig. 3a). For THA patients, the opposite was true, with catheterization rates beginning to increase after the age of 60 years and increasing further after 65 years (18% vs 30%, chi-squared statistic = 3.292, $P =$ .0695, Fig. 3b).

When multiple risk factors are combined, they appear to have an additive effect. For example, TKA patients younger than 60 years, who received more than 1000 ml of IV fluids and had a preoperative PVRV above 50 ml, had a catheterization rate of 54% (Fig. 4a, solid orange bar). For a patient older than 60 years, who received less than 1000 ml of fluid and had a PVRV under 50 ml, the catheterization rate was 14% (Fig. 4a, dotted orange bar).

For THA patients, preoperative bladder scan values over 50 ml and increased age seem to have the most effect on catheterization rate. A patient younger than 65 years and undergoing THA had a PVRV under 50 ml, and those who received less than 1500 ml of fluids had a 13% rate of catheterization (Fig. 4b, green dotted bar). In contrast, a patient older than 65 years, with a bladder scan over 50 ml, who also received more than 1500 ml of fluid, had a 50% rate (Fig. 4b, solid green bar). For both groups, gender was not found to be predictive of catheterization.

If postoperative bladder ultrasonography detected a volume above 500 ml, the patient was urged to urinate before manual decompression was performed with a straight catheter. Although some of these patients were able to void, it is interesting to note that those who received a catheter had a higher average PVRV (64 ml) than those that did not receive a catheter (49 ml). Of these patients, approximately 38% could void on their own when challenged.

Discussion

There remains controversy over the risk factors for POUR in THA and TKA. Because the incidence ranges widely and the etiology is poorly understood, it is necessary to further elucidate risk factors for POUR to improve patient outcomes and reduce health-care costs.

In addition to previously described risk factors such as age, gender, and IV fluid volume, this study aimed to investigate whether preoperative post-void residual bladder volumes were associated with POUR after lower limb TJA. Our study defines a high preoperative post-void residual bladder volume as that greater than 50 ml. In an observational cohort study, Kolman et al. found that men with a PVRV greater than 50 ml at baseline were about 3 times as likely to have subsequent acute urinary retention with catheterization during 3 to 4 years of follow-up [27]. The AHCPR states that in adults, PVRV < 50 ml is normal while PVRV > 200 ml is abnormal [25]. This gap suggests that PVRV volumes less than 200 ml and greater than 50 ml be further investigated to find if a smaller PVRV has comparable sensitivity to detect urinary retention. In completing our analysis, we did not find a difference when using a 200 ml threshold. It is worth noting that the definition of an abnormal PVRV being >200 ml is normally used in the diagnosis of urinary retention in the general population. In our study, a preoperative PVRV > 50 ml does not diagnose urinary retention but

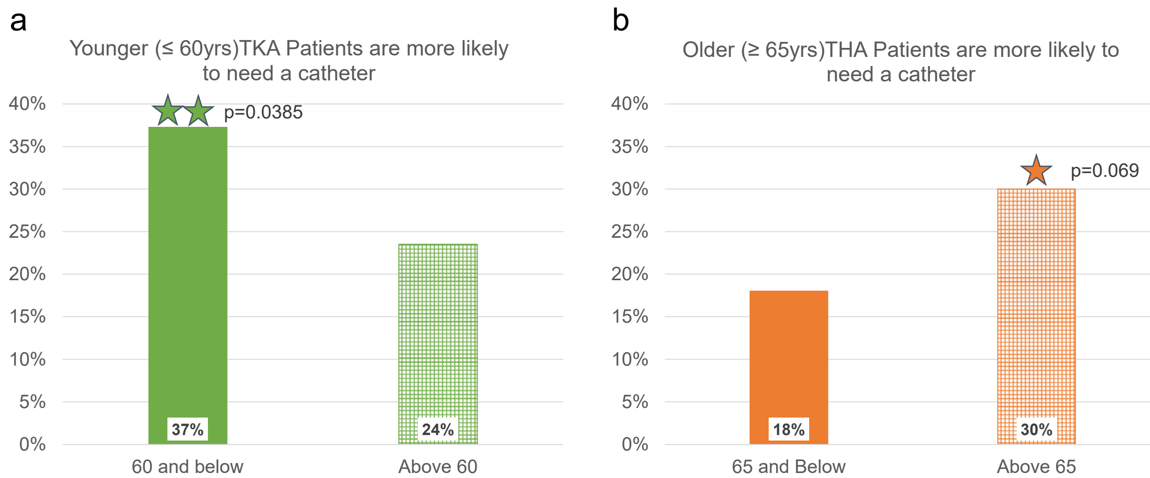

Figure 3. Age as a risk factor is surgery type dependent. (a) Younger patients (age 60 years and below) who receive a TKA are at significantly higher risk of catheterization. Solid green bars represent those in the younger age group. Hatched green bars represent those in the older age group. (b) For THA patients, those older than 65 years are at the greatest risk of catheterization. Solid orange bars represent those in the younger age group. Hatched orange bars represent those in the older age group. For all figures, two stars indicate a *P* value $\leq$ .05, and one star indicates a *P* value $\leq$ .10.

rather it represents one of multiple risk factors that may predispose patients to POUR.

Our hypothesis that both higher volumes of IV fluids and higher preoperative PVRVs were associated with POUR was shown to be true for all TJA patients. For patients undergoing THA, IV fluids greater than 1500 ml were significantly associated with POUR while IV volumes greater than 1000 ml were associated with POUR in TKA. In this study, THA patients received additional IV fluids during surgery to maintain hemodynamic stability, which explains the discrepancy in total IV fluid volume between these cohorts.

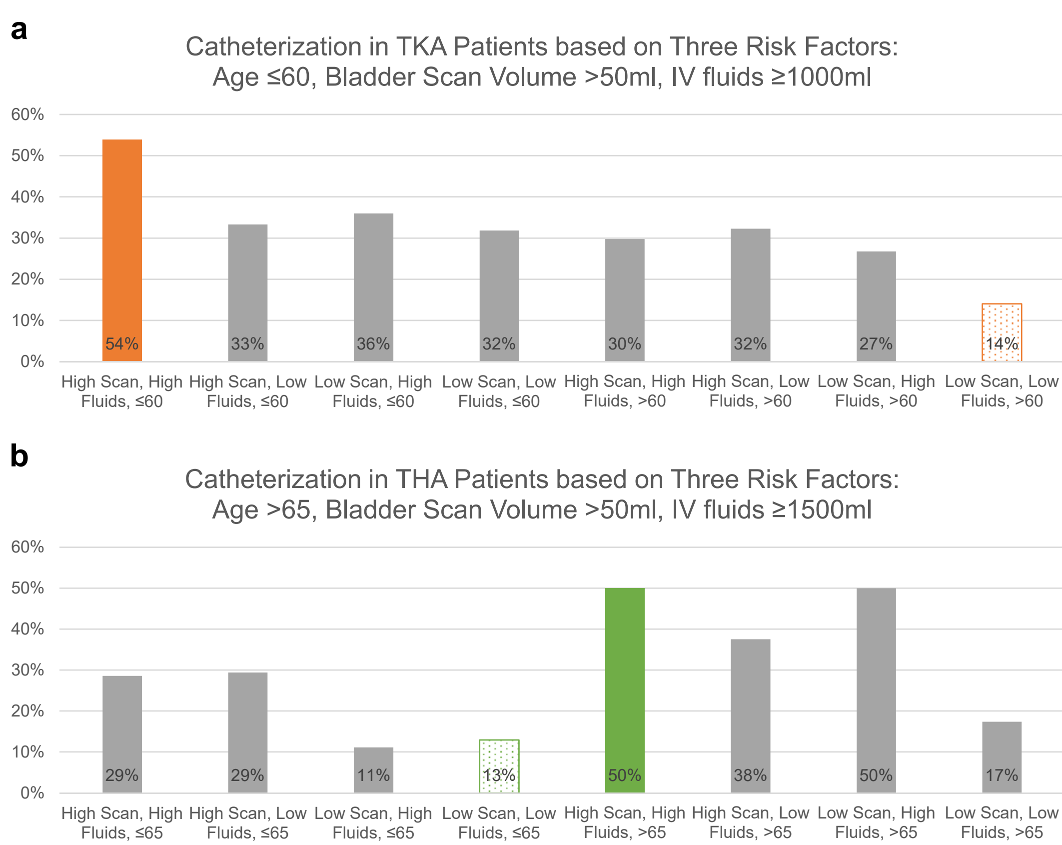

Figure 4. Catheterization risk profiles. Rates of catheterization vary depending on the type of joint surgery being performed, age, post-void residual volume, and amount of IV fluids received. (a) For TKA, younger patients (age 60 and below) who have a bladder scan volume over 50 ml, and who received more than 1000 ml fluids (solid orange bar) had a much higher catheterization rate than those patients who were over 60, had a normal bladder scan volume and who received less than 1000 ml IV fluids (hatched orange bar). (b) For THA patients, those older than 65 years are at the greatest risk of catheterization. Fluid volumes over 1500 ml and bladder scan volumes over 50 ml both appeared to increase the rate of catheterization equally. For patients without any of these factors, (green hatched bar) catheterization rates were very low.

Unlike previous research which documented male gender as a risk factor for POUR [2,6,14], our study showed no differences in catheterization between genders. In addition, this study revealed a higher catheterization rate among younger TKA patients, a finding also contrary to the current literature. We believe these variations might be explained by the study design, which excluded patients who were taking medications for diagnosed urinary retention or BPH, including tamsulosin. As a result of this exclusion criteria, most, if not all, male patients with BPH were likely excluded. Because BPH is fairly common and more prevalent in older men, it is possible that this selection criteria alone could have contributed to the gender and age discrepancies seen in our study. However, owing to the retrospective nature of our study and the absence of information collected from each patient regarding their urinary symptoms and/or diagnoses, it is impossible to make this claim with certainty.

Owing to the number of POUR risk factors that are currently described in the literature, it may be worthwhile stratifying patients' risk based on the presence of multiple factors. This is the first study to show an association between a TJA-specific risk factor profile and POUR. When multiple risk factors are combined, they appear to have an additive effect on catheterization rate. The addition of any independent risk factor, including age, IV fluid volume, and PVRV, in either cohort appears to almost double the patient's risk of requiring catheterization.

Interestingly, catheterization had no effect on length of stay in our study. This finding may be confounded by the fact that patients undergoing TJA at our institution had a minimum required length of stay of 1 day, which corresponds to the average length of stay found in our cohort. Thus, without a more precise measurement, it is difficult to assess whether catheterization might have led to differences in length of stay. As the number of outpatient and same-day procedures increase, future studies should assess whether variations in patient selection and demographics affects the incidence and risk factors for POUR.

There are many limitations of this study. It was a retrospective review conducted at a single orthopedic hospital. In addition, the timing of bladder scans was not well controlled, and information about pre-existing urinary symptoms was not collected. Some prospective studies involving POUR use the International Prostate Symptom Score (IPSS) or equivalent survey to evaluate for pre-existing bladder dysfunction and predict POUR. Using such tools would have helped solidify the conclusions shown herein. The retrospective design of the study may, however, have offered the advantage of eliminating observer bias.

Conclusions

This is the first study performed on a TJA population showing that a preoperative post-void residual threshold of 50 ml is associated with POUR. Owing to our sample size and exclusion criteria, it is unlikely that the significant difference detected in our study was due to pre-existing urinary retention and, thus, represents a new risk factor that may be used to identify patients most at risk of POUR in the immediate preoperative setting. It is, however, plausible that the discrepancy is explained by undiagnosed and pre-existing urinary retention. Further research is warranted to investigate the prevalence and severity of pre-existing lower urinary tract symptoms in a TJA cohort and their effect on postsurgical outcomes. Our study confirms previous research demonstrating intraoperative IV fluid volume as a significant risk factor and also introduces a lower threshold for preoperative PVRV as an additional risk factor for POUR in TJA.

The authors recommend routine preoperative bladder ultrasonography to detect residual volumes, close monitoring of IV fluid volumes intraoperatively, and regular bladder scanning after surgery, as well as repeatedly encouraging patients to void, as part of a urinary protocol. The authors are currently evaluating whether risk stratification profiles such as IPSS can better identify those patients who may be most at risk of developing POUR after TJA. An ongoing prospective study at our institution is examining this scoring system to determine if POUR can be accurately predicted by the addition of the eight-question IPSS survey and preoperatively managed. Given the importance of minimizing complications, reducing length of stay, and improving patient outcomes in TJA, elucidating specific risk factors for POUR is warranted and highly beneficial.

Acknowledgment and funding sources

The authors wish to acknowledge Daniel Beaupre, RN, and Tracy Gonzalez, RN, for their assistance in bladder scanning and data collection. They would also like to thank Sherry Stohler, MSN, RN, for her incredible efforts in starting this project.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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