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# Global Incidence and Risk Factors Associated With Postoperative Urinary Retention Following Elective Inguinal Hernia Repair

## The Retention of Urine After Inguinal Hernia Elective Repair (RETAINER I) Study

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**IMPORTANCE** Postoperative urinary retention (POUR) is a well-recognized complication of inguinal hernia repair (IHR). A variable incidence of POUR has previously been reported in this context, and contradictory evidence surrounds potential risk factors.

**OBJECTIVE** To ascertain the incidence of, explore risk factors for, and determine the health service outcomes of POUR following elective IHR.

**DESIGN, SETTING, AND PARTICIPANTS** The Retention of Urine After Inguinal Hernia Elective Repair (RETAINER I) study, an international, prospective cohort study, recruited participants between March 1 and October 31, 2021. This study was conducted across 209 centers in 32 countries in a consecutive sample of adult patients undergoing elective IHR.

**EXPOSURE** Open or minimally invasive IHR by any surgical technique, under local, neuraxial regional, or general anesthesia.

**MAIN OUTCOMES AND MEASURES** The primary outcome was the incidence of POUR following elective IHR. Secondary outcomes were perioperative risk factors, management, clinical consequences, and health service outcomes of POUR. A preoperative International Prostate Symptom Score was measured in male patients.

**RESULTS** In total, 4151 patients (3882 male and 269 female; median [IQR] age, 56 [43-68] years) were studied. Inguinal hernia repair was commenced via an open surgical approach in 82.2% of patients (n = 3414) and minimally invasive surgery in 17.8% (n = 737). The primary form of anesthesia was general in 40.9% of patients (n = 1696), neuraxial regional in 45.8% (n = 1902), and local in 10.7% (n = 446). Postoperative urinary retention occurred in 5.8% of male patients (n = 224), 2.97% of female patients (n = 8), and 9.5% (119 of 1252) of male patients aged 65 years or older. Risk factors for POUR after adjusted analyses included increasing age, anticholinergic medication, history of urinary retention, constipation, out-of-hours surgery, involvement of urinary bladder within the hernia, temporary intraoperative urethral catheterization, and increasing operative duration. Postoperative urinary retention was the primary reason for 27.8% of unplanned day-case surgery admissions (n = 74) and 51.8% of 30-day readmissions (n = 72).

**CONCLUSIONS** The findings of this cohort study suggest that 1 in 17 male patients, 1 in 11 male patients aged 65 years or older, and 1 in 34 female patients may develop POUR following IHR. These findings could inform preoperative patient counseling. In addition, awareness of modifiable risk factors may help to identify patients at increased risk of POUR who may benefit from perioperative risk mitigation strategies.

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 Invited Commentary

 Supplemental content

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**Group Information:** A complete list of the members of the RETAINER I Study Group of the Irish Surgical Research Collaborative appears in Supplement 2.

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Inguinal hernia repair (IHR) is one of the most frequently performed surgical procedures worldwide, with approximately 27% of men and 3% of women undergoing IHR in a lifetime.<sup>1</sup> Postoperative urinary retention (POUR) is a well-recognized complication of IHR.<sup>2</sup> Published literature has described a highly variable incidence (0.4%-41.6%) of POUR following IHR, without a clear correlation with surgical technique or other variables.<sup>2-20</sup> Sequelae of POUR may include pain, autonomic dysregulation, urinary tract infection (UTI), and bladder overdistension or long-term voiding dysfunction.<sup>21,22</sup> Urethral catheterization may lead to patient distress, urethral trauma, UTI or bacteremia, impaired mobility, delirium, prolongation of hospital stay, and urethral stricture development.<sup>22-25</sup> In addition, IHR-POUR poses significant financial and logistical burdens to health care services. Postoperative urinary retention may cause 20% to 25% of unplanned admissions following ambulatory general surgical procedures.<sup>26,27</sup> Furthermore, POUR may present following discharge, requiring emergency department attendance, and frequently requires short-interval follow-up with specialist services.

A number of potential risk factors have been both proposed and refuted in the development of POUR following IHR, including choice of a minimally invasive surgical approach,<sup>3,7,10</sup> performance of bilateral synchronous IHR,<sup>3-5</sup> use of spinal anesthesia,<sup>3,28,29</sup> administration of narcotic analgesia,<sup>5</sup> infusion of higher volumes of intravenous fluid perioperatively,<sup>5,21</sup> and a preexisting diagnosis of benign prostatic hyperplasia.<sup>3,5</sup> In addition, perioperative  $\alpha$ -blockade has been both supported and disputed as exerting a protective role against IHR-POUR.<sup>15,30</sup> Much evidence has arisen from single-center studies, many of which were retrospective in design, and the contradictory nature of these findings means that uncertainty prevails. The Retention of Urine After Inguinal Hernia Elective Repair (RETAINER I) study aimed to definitively determine the incidence of IHR-POUR in a large, international, multicenter cohort to identify risk factors for its evolution and to evaluate the outcomes of POUR associated with health care services.

## Methods

### Study Design

The RETAINER I study was an international, multicenter, prospective cohort study, with a published protocol.<sup>31</sup> The full collaborative structure is described in eMethods 1 in [Supplement 1](#). This cohort study was approved by the ethics review board of the index center (University Hospital Limerick) and reviewed or waived by the boards of subsequently enrolled centers in accordance with local requirements. Verbal and/or written patient consent was sought in compliance with requirements of each participating center. This study complied with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.<sup>32</sup>

### Inclusion and Exclusion Criteria

All patients aged 18 years or older undergoing elective IHR were eligible for inclusion. Patients undergoing emergency IHR, those with an indwelling urinary catheter or urinary diver-

## Key Points

**Question** What is the incidence of postoperative urinary retention (POUR) following elective inguinal hernia repair (IHR), and what risk factors are associated with POUR?

**Findings** In this cohort study of 4151 adult patients across 32 countries, the incidence of POUR after IHR was 5.8% in men, 2.97% in women, and 9.5% in men 65 years or older. Significant risk factors were patient age, anticholinergic medication, history of urinary retention, constipation, out-of-hours surgery, involvement of urinary bladder within the hernia, temporary intraoperative urethral catheterization, and operative duration.

**Meaning** The incidence of POUR following elective IHR was high in this study, with a number of potentially modifiable risk factors, which could help to identify patients at increased risk of POUR who may benefit from perioperative risk mitigation strategies.

sion, and those routinely performing self-catheterization were excluded.

### Outcome Measures

The primary end point was the incidence of POUR following elective IHR. Secondary outcomes were associations of perioperative variables with POUR and the management, clinical consequences, and health service outcomes of IHR-POUR. Thirty-day follow-up was completed.

### Study Definitions

In the absence of a universally accepted definition,<sup>21</sup> the multispecialty trial management committee agreed on a POUR definition as the inability to void, with the patient needing bladder decompression by catheterization as determined by the treating clinician within 1 week of IHR. Definitions of POUR complications are listed in eMethods 2 in [Supplement 1](#).

### Data Collection Methods

Standardized data collection templates were used. The International Prostate Symptom Score (IPSS), a validated self-administered questionnaire assessing male lower urinary tract symptoms,<sup>33,34</sup> was requested from male patients (translations via PROVIDE; Mapi Research Trust). A preoperative postvoid residual urine volume was recorded where feasible. Anonymized data were collated centrally using REDCap software (Vanderbilt University), centrally supported by the Royal College of Surgeons in Ireland.

### Sample Size, Statistical Power, Missing Data, and Pilot Study

Using anesthetic technique (spinal vs general) as the hypothesized major risk factor and estimating a 5% to 10% incidence of POUR, with a 5% difference between groups ( $\alpha = .05$ ; power, 90%), we estimated a required sample size of 1162 patients and set target enrollment at greater than 1500. Given the need to maintain equal participation opportunities for all enrolled centers, alongside the possibility of a lower incidence of POUR and multiple potential risk factors, we decided that recruitment would not be terminated before the formal study completion date.

In the instance of loss to follow-up, or where data regarding the primary outcome (POUR) were unavailable, patients were excluded from all analyses (Figure 1). Where data relating to descriptive secondary outcomes were absent for a particular patient, this was reported as not recorded. A 3-week pilot study was conducted in a single center in advance of study launch and confirmed the feasibility of recruitment and study methodology.

### Adaptations Due to the COVID-19 Pandemic

The first wave of the SARS-CoV-2 pandemic in 2020 severely affected health care systems immediately prior to the intended launch of RETAINER I, with IHR deprioritized in many centers.<sup>35</sup> Accordingly, 2 postponements of the launch date occurred until March 2021, and a pragmatic approach was applied, with site leaders permitted to select the most feasible data collection block (minimum, 4 weeks; aim, 12 weeks) for their center over a 6-month period.

### Statistical Analysis

Statistical analysis was performed using Stata, version 16 software (StataCorp LLC). Descriptive statistics were used for basic demographic characteristics and incidence of POUR. Univariable analysis was applied to postulated risk factors for the development of POUR in male and female patient cohorts using 2-sample *t* tests, the  $\chi^2$  test of association, and odds ratios (ORs). Clinically expected and significant risk factors on univariable analysis in male patients were examined in a multivariable logistic regression. A 2-sided *P* < .05 was considered statistically significant. Multivariable regression analysis was not applied to the female patient cohort given the low incidence of POUR.

## Results

### Geographic Enrollment and Patient Characteristics

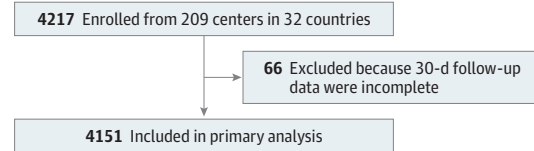
From March 1 to October 31, 2021, 4217 patients were enrolled in RETAINER I, with complete 30-day follow-up data received on 98.4% (*n* = 4151) from 209 centers located in 32 countries (Figure 1). Participating centers were geographically distributed across all major continents (eTable 1 and eFigure 1 in Supplement 1). As stratified by country income category,<sup>36</sup> 43.7% of patients (*n* = 1815) were recruited from high-income countries, 44.4% (*n* = 1843) from lower- to upper-middle-income countries, and 10.3% (*n* = 426) from low-income countries.

Patient characteristics are presented in Table 1. The cohort comprised 3882 men and 269 women (median [IQR] age, 56 [43-68] years), and most patients had an American Society of Anesthesiologists (ASA) score of 1 or 2. Median body mass index (measured by weight in kilograms divided by height in meters squared) was 25 (IQR, 23-28).

### Surgical and Anesthetic Practice

Surgical and anesthetic variables are outlined in Table 1. Inguinal hernia repair was commenced via an open surgical approach in 82.2% of patients (*n* = 3414) and minimally inva-

Figure 1. Flow Diagram of Patients Enrolled in the Retention of Urine After Inguinal Hernia Elective Repair (RETAINER I) Study



Shown are numbers included in the final analysis and their representation of country income and sex categories.

sive surgery in 17.8% (*n* = 737). Inguinal hernia repair was performed via an open approach in 82.5% of male patients (*n* = 3201) and 79.2% of female patients (*n* = 213), without significant differences between sexes. Of 737 minimally invasive cases, 96.4% (*n* = 697) were completed laparoscopically and 3.5% (*n* = 26) with robotic assistance, with open conversion in 1.9% (*n* = 14). Mesh was used in the majority of patients (92.5% [*n* = 3838]). Primary anesthesia was general in 40.9% (*n* = 1696), neuraxial regional (NRA) in 45.8% (*n* = 1902), and local in 10.7% (*n* = 446). Female sex was associated with general anesthesia (OR, 1.4; 95% CI, 1.1-1.9; *P* = .004).

### Incidence, Diagnosis, and Management of POUR

The primary outcome, POUR, occurred in 5.8% of male patients (*n* = 224) and 2.97% of female patients (*n* = 8), with an incidence of 9.5% (*n* = 119) in male patients older than 65 years (eFigures 1 and 2 in Supplement 1). Postoperative urinary retention was diagnosed on the day of surgery in 68.4% of patients (*n* = 154) and on postoperative day 1 in 12.9% (*n* = 29). Timing of diagnosis did not differ between sexes or among male patients of any age. A diagnosis of POUR was most commonly based on failure to void and suprapubic discomfort (Table 2). Of patients catheterized on the day of surgery having not voided postoperatively (*n* = 140), the timing of urinary catheter insertion from procedure completion time was less than 4 hours in 20.0% (*n* = 28), 4 to 7 hours in 55.0% (*n* = 77), and 8 hours or longer in 25.0% (*n* = 35). The proportion of patients catheterized within 4 hours was not associated with the time of day at which surgery was performed. Management of POUR was described in 93.1% (216 of 232) of patients, with indwelling urethral catheterization in 95.4% (*n* = 206), intermittent catheterization in 2.8% (*n* = 6), and suprapubic catheterization in 1.9% (*n* = 4) (Table 2).

### Risk Factors for POUR

Associations between the development of POUR and perioperative variables in both male and female patients on univariable analysis are presented in eTable 2 in Supplement 1. An apparent, possibly confounded, association was observed between  $\alpha$ -blocker and 5 $\alpha$ -reductase inhibitor use and POUR on univariable analysis. On adjusted multivariable analysis in male patients (Table 3; Figure 2; eFigure 1 in Supplement 1), significant associations with POUR were seen with increasing patient age (adjusted OR, 1.02; 95% CI, 1.01-1.03; *P* = .003), use of anticholinergic medication (adjusted OR, 2.38; 95% CI,

**Table 1. Demographic, Clinical, and Operative Characteristics of Patients Who Underwent Inguinal Hernia Repair**

Characteristic	% (No.)			P value
	All patients (n = 4151)	Male sex (n = 3882)	Female sex (n = 269)	
Age, median (IQR), y	56 (43-68)	57 (43-68)	53 (43-67)	.23
BMI, median (IQR)	25 (23-28)	25 (23-28)	25 (23-29)	.80
ASA score				
I	44.0 (1825)	43.6 (1693)	49.1 (132)	.08
II	42.8 (1778)	43.1 (1672)	39.4 (106)	.24
III	11.7 (486)	11.3 (455)	11.5 (31)	.92
>III	1.5 (60)	1.6 (60)	NA	NA
Surgical approach				
Open	82.2 (3414)	82.5 (3201)	79.2 (213)	.18
Laparoscopic	16.8 (697)	16.6 (643)	20.1 (54)	.13
Robotic	0.6 (26)	0.6 (24)	0.7 (2)	
MIS converted	0.3 (14)	0.4 (14)	NA	NA
Laterality				
Right	49.0 (2034)	49.1 (1904)	48.3 (130)	.76
Left	38.7 (1605)	38.8 (1505)	37.2 (100)	.60
Bilateral	12.3 (510)	12.1 (471)	14.5 (39)	.25
Primary anesthetic				
General	40.9 (1696)	40.3 (1564)	49.1 (132)	.005
Neuraxial regional	45.8 (1902)	46.3 (1799)	38.3 (103)	.01
Local	10.7 (446)	10.8 (419)	10.1 (27)	.70
Unknown	2.6 (107)	2.6 (100)	2.6 (7)	NA
Mesh repair	92.5 (3838)	92.7 (3598)	89.2 (240)	.04

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (as measured by weight in kilograms divided by height in meters squared); MIS, minimally invasive surgery; NA, not available.

1.02-5.52;  $P = .04$ ), a history of urinary retention (adjusted OR, 3.71; 95% CI, 2.51-5.47;  $P < .001$ ), constipation (bowels not opened for >2 days preoperatively) (adjusted OR, 3.13; 95% CI, 1.31-7.48;  $P = .01$ ), IHR performed after 5:00 PM (adjusted OR, 2.21; 95% CI, 1.42-3.47;  $P = .001$ ), involvement of urinary bladder within hernia sac (adjusted OR, 3.24; 95% CI, 1.76-5.98;  $P < .001$ ), temporary intraoperative urethral catheterization (adjusted OR, 1.96; 95% CI, 1.37-2.81;  $P < .001$ ), and increasing operative duration (60-120 vs <30 minutes: adjusted OR, 3.26; 95% CI, 1.19-8.92;  $P = .021$ ). Neuraxial regional anesthesia (spinal or epidural) was associated with decreased POUR vs general anesthesia (adjusted OR, 0.70; 95% CI, 0.50-0.997;  $P = .048$ ); local anesthesia showed reduced POUR vs general anesthesia but without statistical significance on multivariable analysis. On univariable analysis of NRA, the use of short-acting opioids (eg, fentanyl, sufentanil) was associated with increased POUR compared with nonopioid administrations (eg, bupivacaine, levobupivacaine) alone (adjusted OR, 1.73; 95% CI, 1.12-2.67;  $P = .01$ ). Short-acting opioids were used in 555 of 1839 patients with NRA recorded (30.2%).

Regarding application of nonroutine preoperative assessments, a linear increase in POUR was seen among mild, moderate, and severe IPSS categories on univariable analysis (POUR occurrence with severe vs mild scores: OR, 2.96; 95% CI, 1.9-4.7;  $P < .001$ ) (eTable 2 in Supplement 1). A preoperative postvoid residual bladder volume was available for 442 patients; a value of greater than 150 mL showed a significant association with POUR (OR, 2.96; 95% CI, 1.8-5.1;  $P < .001$ )

but was not included in the multivariable regression analysis due to a low number of observations vs other variables.

### Acute Clinical and Health Service Outcomes of POUR

Postoperative urinary retention was associated with suspected UTI in 28.4% of patients ( $n = 66$ ) and acute kidney injury (AKI) in 3% ( $n = 7$ ) (Table 2). No difference was observed in UTI diagnosis between male and female patients, among male age categories, or in AKI diagnosis between these subgroups. Traumatic catheterization occurred in 19.0% of patients ( $n = 44$ ), with male patients aged 65 years or older being the most vulnerable. Bladder spasm due to the presence of a catheter was reported in 33.2% of patients ( $n = 77$ ).

Of the entire cohort, unplanned overnight admission from day-case surgery pathways occurred in 6.41% of patients ( $n = 266$ ), and 30-day hospital readmission occurred in 3.3% ( $n = 139$ ) (Table 2). Postoperative urinary retention was the primary reason for unplanned day-case surgery admission in 27.8% of patients ( $n = 74$ ) overall and 44.6% of male patients aged 65 years or older ( $n = 37$ ). Postoperative urinary retention was the primary cause of 30-day readmission in 51.8% of patients ( $n = 72$ ) overall and 60.3% of male patients 65 years or older ( $n = 38$ ).

### Outcomes of POUR

Voiding outcomes following POUR are outlined in Table 2. At 30-day follow-up, 66.8% of patients with data (149 of 223) had resumed normal voiding. First trial of voiding (TOV) was

Table 2. Postoperative Urinary Retention (POUR) in Patients Following Inguinal Hernia Repair

Variable	% (No. of total No. with available data)		
	Male		Female (n = 269)
	Aged <65 y (n = 2628)	Aged ≥65 y (n = 1252)	
Incidence of POUR	4.0 (105 of 2628)	9.5 (119 of 1252)	3.0 (8 of 269)
Diagnostic criteria (multiple permitted)			
Failure to void	82.9 (87 of 105)	83.2 (99 of 119)	62.5 (5 of 8)
Suprapubic discomfort	45.7 (48 of 105)	52.1 (62 of 119)	37.5 (3 of 8)
Palpable bladder	31.4 (33 of 105)	25.2 (30 of 119)	25 (2 of 8)
Bladder scan reading	5.7 (6 of 105)	13.4 (16 of 119)	12.5 (1 of 6)
Timing			
Day of surgery	70.6 (72 of 102)	66.4 (77 of 116)	71.4 (5 of 7)
Postoperative day 1	10.8 (11 of 102)	15.5 (18 of 116)	0
Postoperative days 2-3	7.8 (8 of 102)	12 (14 of 116)	14.3 (1 of 7)
Postoperative days 4-7	10.8 (11 of 102)	6 (7 of 116)	14.3 (1 of 7)
Not recorded	2.86 (3 of 105)	2.6 (3 of 119)	12.5 (1 of 8)
Management			
Indwelling catheter (urethral)	96.8 (92 of 95)	93.8 (107 of 114)	100 (7 of 7)
Indwelling catheter (suprapubic)	2.1 (2 of 95)	1.8 (2 of 114)	0
Intermittent catheterization	1.1 (1 of 95)	4.4 (5 of 114)	0
Not recorded	9.5 (10 of 105)	4.4 (5 of 114)	12.5 (1 of 8)
Associated complications			
Acute kidney injury	2.9 (3 of 105)	2.6 (3 of 114)	16.7 (1 of 6)
Urinary tract infection	24.5 (25 of 102)	34.8 (40 of 115)	14.3 (1 of 7)
Bladder spasm	38.6 (39 of 101)	31.6 (36 of 114)	28.6 (2 of 7)
Traumatic catheterization	8.6 (9 of 105)	28.6 (34 of 119)	12.5 (1 of 8)
Catheter dislodgment	0	5.9 (7 of 119)	0
Hematuria	11.4 (12 of 105)	14.3 (17 of 119)	0
Delirium	0	2.5 (3 of 119)	0
Impaired mobility	17.1 (18 of 105)	8.4 (10 of 119)	12.5 (1 of 8)
Unplanned overnight admission			
All cause, entire cohort	6.2 (164)	6.6 (83)	7.1 (19 of 269)
Due to POUR	1.2 (31 of 2628) of cohort; 18.9 of unplanned admissions (31 of 164)	3.0 (37 of 1252) of cohort; 44.6 of unplanned admissions (37 of 83)	2.2 (6 of 269) of cohort; 31.6 of unplanned admissions (6 of 19)
Readmission			
All cause, entire cohort	2.4 (64 of 2628)	5.0 (63 of 1252)	4.5 (12 of 269)
Due to POUR	1.1 (29 of 2628) of cohort; 45.3 of readmissions (29 of 64)	3.0 (38 of 1252) of cohort; 60.3 of readmissions (38 of 63)	1.9 (5 of 269) of cohort; 41.7 of readmissions (5 of 12)
Discharged with indwelling catheter following admission	12.4 (13 of 105)	26.9 (32 of 119)	0
Successful trial without catheter (by 30-d follow-up, without requirement for intermittent self-catheterization)	65.3 (66 of 101)	68.1 (79 of 116)	66.7 (4 of 6)
≥2 Catheter removal attempts (where indwelling catheter inserted and removal attempted)	25.8 (23 of 89)	31.9 (37 of 116)	14.3 (1 of 7)

successful in 40.9% of cases (95 of 232). The likelihood of a successful first TOV did not differ among male patients of any age, between male and female patients, or when first TOV was performed on the first postoperative day as opposed to a deferred date.

## Discussion

The RETAINER I study identified an incidence of POUR of 4.0% in male patients younger than 65 years, 9.5% in males 65 years

**Table 3. Multivariable Logistic Regression of Risk Factors for Postoperative Urinary Retention Following Inguinal Hernia Repair in Male Patients**

Variable	OR (95% CI)		P value
	Unadjusted	Adjusted	
Increasing patient age	1.03 (1.02-1.04)	1.02 (1.01-1.03)	.003
Taking vs not taking anticholinergic medication	5.13 (2.50-10.55)	2.38 (1.02-5.52)	.04
Benign prostatic enlargement, diagnosed vs surgically treated or never diagnosed	2.44 (1.79-3.33)	1.14 (0.78-1.69)	.50
Previous urinary retention, yes vs no	6.79 (4.97-9.26)	3.71 (2.51-5.47)	<.001
Increasing IPSS score (numeric)	1.06 (1.04-1.08)	1.02 (0.998-1.041)	.07
Constipation			
Bowels last opened: 2 d before vs 1 d before surgery	1.37 (0.79-2.36)	0.86 (0.44-1.67)	.66
Bowels last opened: >2 d before vs 1 d before surgery	3.32 (1.54-7.18)	3.13 (1.31-7.48)	.01
Time of surgery			
1:00 PM-5:00 PM vs 7:00 AM-1:00 PM	0.89 (0.64-1.24)	0.78 (0.54-1.14)	.20
After 5:00 PM vs 7:00 AM-1:00 PM	2.20 (1.48-3.27)	2.21 (1.42-3.47)	.001
Laterality, bilateral vs unilateral	1.52 (1.06-2.18)	1.12 (0.72-1.74)	.61
Minimally invasive vs open or converted surgical approach	0.89 (0.61-1.28)	0.64 (0.41-1.02)	.06
Bladder involved vs not involved in hernia	5.78 (3.42-9.76)	3.24 (1.76-5.98)	<.001
Primary anesthesia			
Neuraxial regional vs general	0.62 (0.46-0.82)	0.70 (0.50-0.997)	.048
Local vs general	0.35 (0.19-0.65)	0.55 (0.28-1.10)	.09
Temporary urethral catheterization inserted vs not inserted	3.60 (2.72-4.78)	1.96 (1.37-2.81)	<.001
Operative duration			
30-60 min vs <30 min	1.57 (0.68-3.62)	1.85 (0.68-5.04)	.23
60-120 min vs <30 min	2.98 (1.29-6.87)	3.26 (1.19-8.92)	.02
>120 min vs <30 min	3.40 (1.31-8.81)	3.44 (1.09-10.80)	.03
Drain used vs not used	1.75 (1.26-2.43)	1.13 (0.75-1.70)	.55

Abbreviations: IPSS, International Prostate Symptom Score; OR, odds ratio.

or older, and approximately 3% in female patients following IHR in a global cohort of more than 4000 patients. Clinical sequelae included UTI, AKI, bladder spasm, traumatic catheterization, and unsuccessful TOV. Additionally, POUR was found to be associated with a substantial need for and use of acute health care services. More than 1 in 4 unplanned day-case surgery admissions were attributable to POUR, exceeding even the quoted 20% to 25% for general ambulatory procedures.<sup>26,27</sup> One in two 30-day readmissions were attributable to POUR; as 7-day POUR was recorded exclusively, the relative contribution to 1-week readmissions may be greater still.

The incidence of POUR following IHR in other studies has varied substantially, with incidence rates of 1.4% to 22.2% reported after minimally invasive IHR<sup>3,5,7,9-11,14</sup>; 0.7% to 38% following open IHR<sup>7,10,37,38</sup>; and 0.8% to 13% in mixed cohorts.<sup>4,39</sup> This wide variation may reflect heterogeneity in both practice and data recording. Many studies have been retrospective or single center in design. The RETAINER I study is the largest in this area, with a prospective design and global distribution tailored to identify the true incidence of POUR in a diverse international population.

An understanding of factors associated with POUR is desirable for identification of susceptible patients and risk mitigation measures. Increasing patient age was associated with

a higher incidence of POUR, as previously reported.<sup>5,13,40</sup> The single most significant risk factor for POUR on multivariable analysis was a previous history of urinary retention, with an almost 4-fold increased odds. Although not well recorded in other hernia surgery studies, a previous history has been recognized as a significant variable in urinary retention in male populations.<sup>41,42</sup> While the preoperative IPSS category was associated with POUR on univariable analysis, significance was not confirmed on multivariable analysis, possibly limited by its application across a diverse age range, with young men experiencing high scores that may reflect overactive bladder as opposed to obstruction. A postvoid bladder volume of greater than 150 mL was associated with an increased risk of POUR. Due to disparities in access to bladder scanners, this data point was not mandatory and not included in the multivariable model; however, it bears consideration as a simple measure in institutions with the necessary resources. We observed that increasing operative duration was associated with increased POUR, as did Hudak et al,<sup>4</sup> who described an 11% increase in POUR for every 10-minute increase in surgical time.

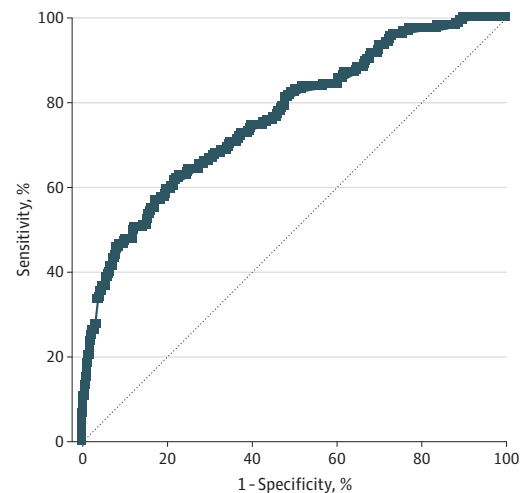
In addition, a number of modifiable risk factors for POUR emerged. Both anticholinergic medication use and constipation were associated with POUR on adjusted analyses. These risk factors for acute urinary retention in the general

population<sup>43,44</sup> have not been prospectively studied in a large IHR population, and they may be particularly noteworthy to address in preoperative optimization strategies. Intraoperatively, temporary urethral catheterization was associated with almost 2-fold increased odds of POUR, which has not been previously shown, although other recent studies have questioned the benefit of the practice.<sup>40,45</sup> Urologic instrumentation is a known risk factor for urinary retention.<sup>41</sup> Although an empty bladder is desirable prior to port placement for minimally invasive surgery, this may be achievable by preoperative voiding. Where catheterization is necessary, consideration of the indwelling catheter remaining overnight may be worthwhile, particularly if other POUR risk factors exist. Intravenous fluid volume exceeding 500 mL also emerged as a possible risk factor for POUR, possibly explained by bladder overdistension reducing detrusor muscle contractility.<sup>21</sup>

Regarding choice of anesthesia, the lowest incidence of POUR was seen among patients receiving local anesthesia alone, consistent with previous findings.<sup>40,46</sup> On multivariable analysis, NRA (spinal or epidural) was associated with a lower odds of POUR vs general anesthesia. Similar findings have been reported by other authors,<sup>37</sup> although a recent network meta-analysis found a higher POUR risk after NRA vs general anesthesia.<sup>46</sup> The global diversity of RETAINER I was associated with variance among anesthetic agents. Where a muscle relaxant is necessary to facilitate tracheal intubation for general anesthesia, reversal is required with the use of traditional anticholinergic agents or newer cyclodextrin agents, such as sugammadex. The antimuscarinic properties of the former are associated with urinary retention. The observed increased incidence of POUR following general anesthesia may be secondary to the use of anticholinergic agents, particularly in geographic regions with limited access to costly alternative agents. Among patients receiving NRA, a higher incidence of POUR was seen with the addition of short-acting opioids; however, their use was recorded in only a relatively small subset of patients receiving NRA. Practice variations in administration of a short-acting, opioid-containing NRA and use of older-generation general anesthesia agents could explain discrepancies in published data regarding associations between anesthetic choice and POUR.

A minimally invasive surgical approach accounted for 17.8% of IHR in this global cohort, which is similar to the 13% to 18% rate reported by international surgeons in an earlier snapshot study by the RETAINER Collaborative Group, Irish Surgical Research Collaborative.<sup>35</sup> It is possible that the early stage of the COVID-19 pandemic was associated with some practice shifts toward open surgery and local and regional anesthesia and with a slightly lower minimally invasive surgical rate than might have been encountered at another time. Other studies reported conflicting findings regarding IHR surgical approach, with minimally invasive vs open surgery reported to both increase<sup>47</sup> and decrease<sup>39</sup> the risk of POUR. Results may be confounded by surgical duration, pain control, and preponderance of a general anesthetic approach in minimally invasive surgery. We did not find, on multivariable analysis, an association between IHR surgical approach and POUR.

Figure 2. Receiver Operating Characteristic Curve of the Multivariable Analysis of Risk Factors for Postoperative Urinary Retention (POUR) in Male Patients



Area under the receiver operating characteristic curve, 0.7587.

Several hypothesized risk factors did not emerge as significant. Systemic opioids did not appear to increase POUR, although correlations have been previously reported.<sup>5,14</sup> While opioids are known to impair detrusor contractility,<sup>21</sup> this is possibly offset by enhanced pain control. A diagnosis of benign prostatic hyperplasia has failed to confirm an association with POUR in some studies,<sup>5</sup> although an association would be expected.<sup>43</sup> In this analysis, we studied only benign prostatic enlargement never surgically treated to remove contamination by patients carrying a benign prostatic hyperplasia diagnosis who had previously undergone transurethral resection of the prostate. We observed a univariable association with POUR, not maintained on multivariable analysis. Benign prostatic enlargement remains challenging to study in this context due to being frequently undiagnosed, being variably recorded at surgical clerking, and covering a wide spectrum of severity,<sup>48</sup> and this apparent lack of association may not be significant.

Both  $\alpha$ -blocker and 5 $\alpha$ -reductase inhibitor use showed an association with POUR on univariable analysis, although the opposite would be expected from their mechanisms of action. We believe that this association may be confounded by a history of urinary retention or diagnosis of benign prostatic enlargement.

### Limitations

We acknowledge a number of limitations to this study. An objectively standardized definition of POUR does not exist, and clinical acumen underpins the diagnosis. In light of this limitation and the desire to capture generalizable data, we applied a pragmatic definition of POUR but acknowledge that catheterization thresholds may differ somewhat among clinicians. The timing of catheter insertion was analyzed in patients catheterized on the first postoperative day who did not void postoperatively. Twenty percent underwent catheter insertion within 4 hours postoperatively. While this interval

appears to be short, it is timed from procedure completion, and we should note that these patients may not have voided for a period preoperatively or been catheterized intraoperatively while receiving intravenous fluids, resulting in the development of full bladders in the early postoperative period. Reassuringly, the proportion of patients catheterized within 4 hours did not statistically differ among morning, afternoon, and out-of-hours periods, suggesting that clinical need rather than logistic pressures (eg, day wards approaching closing time) remained the dominant impetus to catheterize.

There is no consensus on when to label urinary retention as postoperative. We included urinary retention within 7 days of IHR to capture the potential association of peri- and early postoperative variables with POUR and to identify late-presenting cases. It is possible that cases occurring at the latter end of this period could have alternative precipitants to IHR; however, the majority of cases of POUR were recorded

within 2 to 3 days of surgery. Given the uncommon nature of both inguinal hernias and POUR in female patients, low case numbers were recorded, as anticipated. We therefore had inadequate numbers to perform a multivariable analysis on female POUR risk factors. Nonetheless, we recognize the importance of studying and reporting on conditions in all patients in whom they can occur.

## Conclusions

The findings of this cohort study indicate that POUR may be a common occurrence following IHR, occurring 1 in 17 male patients, 1 in 11 male patients aged 65 years or older, and 1 in 34 female patients. Awareness of risk factors may help to identify patients at increased risk and to inform risk mitigation strategies.

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