

## Original Article

# The incidence and risk factors for postoperative urinary retention in neurosurgical patients

Mohammed Alsaidi, Joanne Guanio, Azam Basheer, Lonni Schultz, Muwaffak Abdulhak, David Nerenz, Mokbel Chedid, Donald Seyfried

Department of Neurosurgery, Henry Ford Health System, 2799 W Grand Blvd, Detroit, MI 48202

E-mail: Mohammed Alsaidi - [malsaid1@hfhs.org](mailto:malsaid1@hfhs.org); Joanne Guanio - [jguanio9@hfhs.org](mailto:jguanio9@hfhs.org); Azam Basheer - [abashee1@hfhs.org](mailto:abashee1@hfhs.org); Lonni Schultz - [lschult1@hfhs.org](mailto:lschult1@hfhs.org); Muwaffak Abdulhak - [mabdulh1@hfhs.org](mailto:mabdulh1@hfhs.org); David Nerenz - [dnerenz1@hfhs.org](mailto:dnerenz1@hfhs.org); Mokbel Chedid - [mchedid1@hfhs.org](mailto:mchedid1@hfhs.org); \*Donald Seyfried - [dseyfri1@hfhs.org](mailto:dseyfri1@hfhs.org)

\*Corresponding author

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## Abstract

**Background:** Postoperative urinary retention (POUR) is a common problem in adult neurosurgical patients. The incidence of POUR is unknown and the etiology has not been well established. POUR can lead to urogenital damage, prolonged hospital stay, higher cost, and infection. This study elucidates several risk factors that contribute to POUR in a variety of neurosurgical patients in one institution.

**Methods:** A total of 137 neurosurgical patients were prospectively followed up for the development of POUR, which we defined as initial postvoid residual (PVR1) >250 ml 6 hours after removal of an indwelling urinary catheter (IUC). For patients with PVR >250 ml on the third check, IUCs were reinserted and kept in for 5-7 days.

**Results:** Of the 137 patients, 68 (50%) were male, 41% (56/137) were 60 years or older, 86% (118/137) underwent spinal surgery, and 54% (74/137) had anesthesia over 200 minutes. Overall incidence of clinical POUR was 39.4% (54/137). Significantly higher rates of PVR1 >250 were noted in males, patients older than 60 years, and those who underwent spine surgery. When considering all patient characteristics (except selective alpha blockers), only gender, surgery time, and surgery type remained significant. In addition, PVR1 >250 was positively associated with longer length of stay. Of all patients, 24 (18%) had IUCs reinserted postoperatively or should have had one (5 refused and 2 had a third PVR). The association of IUC reinsertion with male gender was significant.

**Conclusion:** Male gender, time of anesthesia >200 minutes, older age, and spinal surgery are the most significant risk factors associated with POUR in neurosurgical patients.

**Key Words:** Indwelling urinary catheter, neurosurgery, postoperative urinary retention, risk factor

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## INTRODUCTION

Postoperative urinary retention (POUR) is a common problem across many surgical specialties.<sup>[1]</sup> Some may

regard it as a minor complication; however, it can lead to significant pain, anxiety, and cost, as well as prolonged hospital stay for many patients.<sup>[4,5,16,19,21,24]</sup> In the elderly population POUR and its standard treatment by straight

catheterization can lead to urethral strictures, trauma, infection, and possibly delirium.<sup>[4]</sup> It has been reported that a single significant episode of bladder distention can lead to the weakening of bladder collagen fibers resulting in chronic impairment of bladder emptying capacity or even atony.<sup>[1,4]</sup> Nationwide health quality improvement efforts are currently underway to address complications such as deep venous thrombosis (DVT) or urinary tract infections (UTIs). Although POUR is not identified among such complications, it is a potential source of UTI and bacteremia.<sup>[1,4,25]</sup>

The incidence of POUR has been reported in the range of 5-75% of all surgical procedures.<sup>[1,4,10]</sup> Urologic, colorectal, and certain orthopedic procedures are known to carry a higher risk of POUR.<sup>[4,21,12]</sup> The wide variation in reported incidence is related to factors that include differences in patient characteristics, lack of a uniform definition, and conflicting clinical trials.<sup>[4,10,12]</sup> A few risk factors such as old age, male gender, and preexisting urologic symptoms have been associated with development of POUR in some studies.<sup>[1,10,12,25]</sup> Other risk factors such as net balance of intraoperative intravenous fluid (NBIOIVF), length and type of anesthesia, body mass index (BMI), preexisting diabetes mellitus (DM), as well as the amount, type, and mode of delivery of postoperative pain medication may have a role in the development of POUR.<sup>[1,4,25]</sup> Certain medications, such as beta blockers and anticholinergic agents, are also thought to play a role in the development of POUR.<sup>[10,12,16]</sup>

The risk of POUR in neurosurgical patients has not been studied extensively. Boulis *et al.*<sup>[3]</sup> reported a 39.1% incidence in 503 spine patients. McLain *et al.*<sup>[14]</sup> and Jellish *et al.*<sup>[8]</sup> reported a 23% and 22.9% incidence of POUR, respectively, in their lumbar spine patients who had general anesthesia. Neurosurgical pathologies, whether in the central or peripheral nervous systems, add complexity to the etiology of POUR. We attempt here to elucidate some of the risk factors that contribute to the incidence of POUR in different neurosurgical patients.

## MATERIALS AND METHODS

From May 2010 to June 2011, 137 neurosurgical patients in our hospital were followed prospectively for the development of POUR. This study was approved by the Henry Ford Hospital Institutional Review Board (IRB # 6893). POUR, per hospital protocol, was defined as an initial postvoid residual (PVR1) greater than 250 ml using bladder ultrasonography (BVI 3000, Verathon) 6 hours after the removal of indwelling urinary catheters (IUCs) that were inserted during the time of surgery. Straight catheterization was performed for patients with any PVR greater than 250 ml every 6 hours. For patients with the third PVR greater than 250 ml, IUCs were reinserted. Patients were then discharged and instructed to return to the urology clinic in 5-7 days for follow-up. Subsequently,

patients' records were reviewed for age, gender, BMI, length of anesthesia, type of surgery (cervical, thoracic, lumbar, and cranial), preoperative diagnosis of DM, usage of selective alpha blockers, beta blockers, anticholinergic agents, T2 signal on cervical, and thoracic magnetic resonance imaging (MRI), NBIOIVF, and length of hospital stay. There were two patients who underwent thoraco-lumbar surgeries that were included in the thoracic group. Due to the small number of thoracic patients, cervical and thoracic patients are grouped into the cervico-thoracic group.

Nonparametric methods such as Wilcoxon two sample tests, Kruskal-Wallis test, and Spearman's correlation coefficients were used to assess the associations between PVR1 and demographic, medical, and surgical information. These methods were used instead of standard parametric methods because of the wide distribution of values for PVR1 which ranged from 0 to 1000. Regression methods using stepwise procedures were utilized to determine which combination of factors were most associated with PVR1 for all patients, males only and females only. Chi-square tests were done to assess the relationship between patient characteristics and IUCs for the categorical variables and Wilcoxon nonparametric two sample tests for the continuous variables (PVR1 and NBIOIVF). In addition, sensitivity, specificity, and positive and negative predictive values for IUC reinsertion based on specific cutpoints of PVR1 were computed. The testing alpha level was set at 0.05. All statistical analyses were done using SAS (Cary, NC, USA) version 9.2.

## RESULTS

Of the 137 patients, 68 (50%) were male and the mean age was 57.5 years (SD = 14, range 26-95 years). The remainder of the patient characteristics is shown in Table 1. One patient had missing information for the first PVR (PVR1). The incidence of POUR in overall patients based on our definition of PVR1 greater than 250 ml was 39% (54/137). The associations between gender, age (<60 vs ≥60), and surgery type (cranial vs spine) and PVR1 were significant [Figure 1]. In addition, the difference between cranial and cervico-thoracic surgery types was significant. Positive trends were also seen for duration of anesthesia (≤200 vs >200 minutes), lumbar vs cervico-thoracic and lumbar vs cranial, and beta blockers. Twenty-three patients had a diagnosis of DM with an average PVR1 of 363 ml compared with nondiabetic patients with a PVR1 of 245 ml ( $P = 0.10$ ) [Figure 1]. This difference was not statistically significant, however, it showed a positive trend. A positive trend was also seen with NBIOIVF measurement ( $r = 0.156$ ,  $P = 0.072$ ) [Figure 2]. There was no difference in PVR1 between patients with BMI greater than 30, being on selective alpha blockers (males only), or anticholinergic as home medication [Figure 1]. Furthermore, PVR1 was positively associated with length of stay ( $r = 0.176$ ,  $P = 0.04$ ) [Figure 3].

When considering all patient characteristics (except selective alpha blockers), the three variables that remained significant in the multivariable regression analysis were gender, duration of anesthesia, and surgery type (spine vs cranial) [Table 2]. In female patients, the variables of duration of anesthesia over 200 minutes and spine vs cranial surgery remained significant [Table 2]. However, in males, neither duration of anesthesia nor surgery type was significant in predicting PVR1.

Of all patients, 24 (18%) had IUCs reinserted postoperatively or should have had one (5 refused and 2 had a third PVR). The association of IUC reinsertion with gender was significant, with males having higher rates of reinsertion than females (28% vs 7%,  $P = 0.001$ ). A trend was seen with patients older than 60 compared with younger patients having higher reinsertion rates (25% vs 12%,  $P = 0.055$ ), and longer duration of anesthesia (>200 minutes) vs shorter ( $\leq 200$  minutes) being associated with higher reinsertion rates (23% vs 11%,  $P = 0.069$ ). Surgery location, DM, beta blockers, BMI, and anticholinergic agents were not significantly associated with IUC reinsertion [Table 3]. The differences between patients with and without IUC reinsertion were significant for PVR1 and NBIOIVF, with patients with IUC reinsertion having higher values compared with patients without IUC reinsertion for both variables [Table 4].

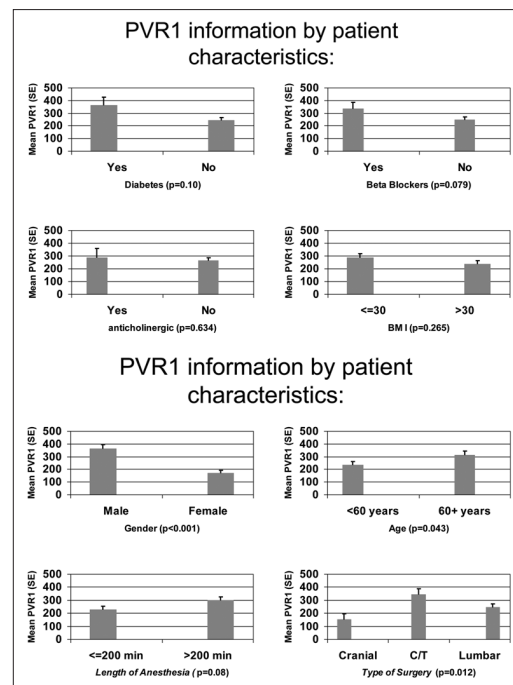
96% of the patients with IUC reinsertion had a PVR1 greater than 250 ml, while 73% of the patients without a IUC reinsertion had a PVR1 less than 250 ml. Of the patients with a PVR1 over 250 ml, 42% had IUC reinsertion (positive predictive values [PPV]) and of the patients with a PVR1 <250 ml, only 1% had IUC

reinsertion (negative predictive values [NPV]). However, a cutpoint of 800 ml for PVR1 had a 86% NPV and 100% PPV [Table 5].

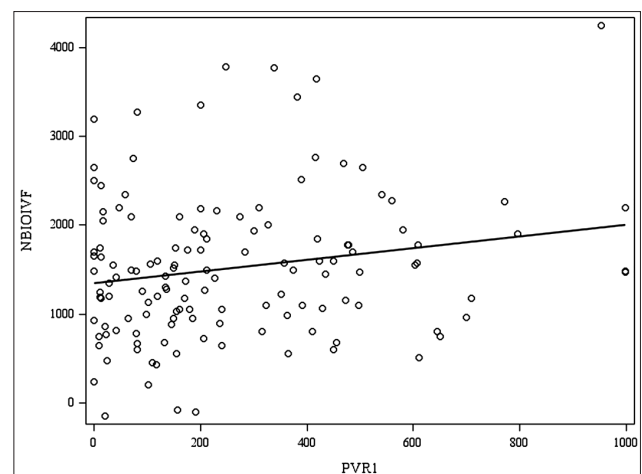
## DISCUSSION

### POUR: Gender, age

POUR is common among different neurosurgical patients and may be a major source of pain, infection, and increased cost. Although Boulis *et al.*<sup>[3]</sup> did not find a significant difference between males and females, our study shows male gender as a major



**Figure 1:** The association of initial postvoid residual with gender, age, length of anesthesia, type of surgery, presence of preoperative diagnosis of diabetes mellitus, body mass index, and being on beta blockers, or anticholinergic agents preoperatively



**Figure 2:** The association of initial postvoid residual and net balance of intraoperative intravenous fluid

**Table 1: Patient characteristics for all patients (n=137)**

Patient characteristics	
Age, mean (s.d.)	57.5 (14.1)
Median (range)	57 (28-95)
Over 60 years of age, n (%)	56 (41%)
Male, n (%)	68 (50%)
Duration of anesthesia in minutes, mean (s.d.)	225.4 (95.7)
Median (range)	205 (44-719)
Surgery with duration of anesthesia over 200 minutes, n (%)	74 (54%)
Surgery type, n (%)	
Cranial	19 (14%)
Cervical/thoracic	45 (33%)
Lumbar	73 (53%)
Diabetes, n (%)	23 (17%)
Beta blockers, n (%)	27 (20%)
Antichol, n (%)	14 (10%)
Flomax/hytrin (males only), n (%)	9 (13%)
BMI>30, n (%)	58 (42%)
PVR, Mean (s.d.)	265 (242.9)
Median (range)	195.5 (0-1000)

BMI: Body mass index; PVR: Postvoid residual

**Table 2: Regression results for PVR1**

Variable	All patients (n=137)			Females only (n=69)		
	Parameter estimate	Standard error	P value	Parameter estimate	Standard error	P value
Intercept	141.4	33.4	<0.001	120.6	31.5	<0.001
Male gender	193.4	37.1	<0.001			
Duration of anesthesia >200 minutes	91.2	37.7	0.017	125.9	43.1	0.004
Spine surgery (all spine vs cranial)	147.7	54.2	0.0073	135.8	60.9	0.029

**Table 3: IUC reinsertion rates by patient characteristics**

Variable	Response	N	IUC reinsertion (N=24) (%)	P value
Gender	Female	69	5 (7)	0.001
	Male	68	19 (28)	
Age	<60 years	81	10 (12)	0.055
	>=60 years	56	14 (25)	
Duration of anesthesia	<=200 minutes	63	7 (11)	0.069
	>200 minutes	74	17 (23)	
Surgery location	Cranial	19	1 (5)	0.315
	Cervical/thoracic	45	9 (20)	
	Lumbar	73	14 (19)	
Diabetes	No	114	18 (16)	0.236
	Yes	23	6 (26)	
Beta blockers	No	110	17 (15)	0.200
	Yes	27	7 (26)	
Anticholinergic medications	No	123	22 (18)	0.737
	Yes	14	2 (14)	
BMI	<=30	79	13 (16)	0.703
	>30	58	11 (19)	

BMI: Body mass index, IUC: Indwelling urinary catheter

**Table 5: Sensitivity, specificity, and positive and negative predictive values for IUC reinsertion (actual or intended) by cutpoints of PVR1**

PVR cutpoint	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
150	100 (23/23)	48 (54/113)	28 (23/82)	100 (54/54)
200	96 (22/23)	62 (70/113)	34 (22/65)	98 (70/71)
250	96 (22/23)	73 (82/113)	42 (22/53)	99 (82/83)
300	96 (22/23)	76 (86/113)	45 (22/49)	99 (86/87)
350	87 (20/23)	79 (89/113)	45 (20/44)	97 (89/92)
400	78 (18/23)	84 (95/113)	50 (18/36)	95 (95/100)
500	52 (12/23)	94 (106/113)	63 (12/19)	91 (106/117)
600	39 (9/23)	95 (107/113)	60 (9/15)	88 (107/121)
700	26 (6/23)	98 (111/113)	75 (6/8)	87 (111/128)
800	22 (5/23)	100 (113/113)	100 (5/5)	86 (113/131)

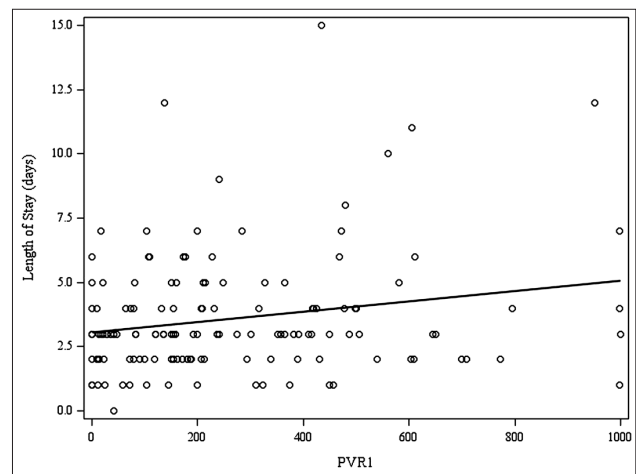
PVR: Postvoid residual; PPV: Positive predictive values; NPV: Negative predictive values

risk factor in developing POUR in the neurosurgical population, echoing previous findings reported in other surgical subspecialties.<sup>[1,4,17]</sup> The difference in urethral anatomy between males and females is hypothesized to contribute to this finding. Furthermore, diagnosed or undiagnosed benign prostatic hyperplasia (BPH) could be a contributing cause in relatively high-risk males. We

**Table 4: Association of IUC reinsertion with PVR and NBIOIVF**

Variable	IUC reinsertion (n=24)	No IUC reinsertion (n=113)	P value
<b>PVR</b>			
Mean (S.D.)	587.4 (251.7)	199.4 (181.6)	<0.001
Median (range)	505 (160-1000)	155 (0-772)	
<b>NBIOIVF</b>			
Mean (S.D.)	1844.8 (188.5)	1450.6 (804.7)	0.014
Median (range)	1775 (505-4250)	1400 (-150 to 3790)	

IUC: Indwelling urinary catheter; PVR: Postvoid residual; NBIOIVF: Net balance of intraoperative intravenous fluid



**Figure 3: The association of initial postvoid residual and length of stay**

found that older age correlated with increased risk of high PVR, as did several other studies.<sup>[1,3,10,12]</sup> Urodynamic studies have shown older age to be associated with many types of bladder dysfunction such as decreased capacity and urinary flow rate, and increased PVR urine volume.<sup>[20]</sup>

**POUR: Type of surgery**

Rectal procedures are associated with high rates of POUR, and many believe this is due to damage of the autonomic nerve, which sometimes occurs during total mesorectal excision.<sup>[7,11]</sup> The intricate control of the central and peripheral nervous system on the urogenital organs would imply that POUR may occur with higher incidences in subpopulations of neurosurgical patients similar to those patients undergoing rectal or urological surgeries. Higher rates of PVR1 were seen in patients who underwent cervical or thoracic surgeries as opposed

to cranial procedures. The trend of increased retention following cervico-thoracic surgeries compared with lumbar surgeries may be due to damaged spinal cord fibers. Interestingly there was no association observed between MRI T2 signal and increased PVRI (data not shown). Further urodynamic and clinical studies in such patients are needed to understand the pathophysiology of POUR in cervico-thoracic surgeries in particular and in neurosurgery patients generally. Of 104 patients with mean IUC time of 5 days (initially inserted after development of POUR), Lee *et al.*<sup>[12]</sup> found that patients who underwent spine surgery had much higher incidence of failure of Trial Without Catheter (TWOC) following the removal of the IUCs compared with nonspine surgery (86.7% vs 23.6%;  $P = 0.01$ ). This further highlights the possibility that POUR has a unique pathophysiology and its high incidence among spine patients occurs regardless of other perioperative risk factors.

### POUR: Anesthesia type and duration

Although all of our patients underwent general anesthesia, evidence suggests that techniques and length of anesthesia correlate well with increased incidence of POUR. Sedative agents affect the cortical micturition center leading to suppression of detrusor contraction and the micturition reflex.<sup>[1,4,10]</sup> McLain *et al.*<sup>[14]</sup> and Jellish *et al.*<sup>[8]</sup> reported only 8% and 14.8% incidence of POUR in patients who underwent spinal anesthesia, respectively. However, the incidence of POUR in patients undergoing general anesthesia in these studies was 23%<sup>[14]</sup> and 22.9%.<sup>[8]</sup> Although both studies reported similar incidence of POUR (23% and 22.9%), none elaborated on their criteria for POUR and how many patients required IUC reinsertion postoperatively. Boulis *et al.*<sup>[3]</sup> reported 39.1% incidence of POUR (POUR was defined as PVR >100 ml) among 503 cervical and lumbar spine surgery patients. The difference in incidence of POUR between these studies may be due to different definitions of POUR, age of patients, length of anesthesia, and the total number of cervical or thoracic surgeries [Table 6].

### POUR: Diabetes mellitus, net balance of intraoperative IV Fluid

DM has been implicated in the impairment of bladder sensation, capacity, and decreased contractility, which would lead to higher incidence of POUR.<sup>[9,13,15]</sup> Although controversial, few studies in the literature have found a

positive association between increased perioperative fluid and POUR.<sup>[4]</sup> We found a positive trend in the association between PVRI and DM as well as between PVRI and NBIOIVF. Therefore, better control of diabetes, early mobilization and limiting excessive IV fluids could be used to decrease the incidence of POUR.

### POUR: Home medication of anticholinergic agents, beta blockers, and selective alpha blocker agents

Urinary retention is a known common side effect of anticholinergic agents. Such agents lead to impaired bladder contractility by working on the cholinergic receptors in the detrusor smooth muscle fibers. Although we failed to show a significant difference among our patients who were on home anticholinergic agents, the use of such agents intraoperatively has been hypothesized to increase the incidence of POUR.<sup>[4,17]</sup> The use of the beta blockers has been weakly associated with POUR in neurosurgical patients.<sup>[3]</sup> Our patients showed a higher PVRI if they were on beta blockers (not statistically significant,  $P = 0.079$ ). Such a trend may be due to the effect of beta receptors on the bladder neck, which led to decreased contractility. Males who were on selective alpha blockers (eight patients only) for BPH did not show lower volumes of PVRI. It is difficult to make any conclusive statements given the complicating factors of BPH as well as the small sample size. Such agents work primarily on the proximal urethral alpha receptors leading to decreased outflow obstruction.<sup>[1,7]</sup>

### POUR: Indwelling urinary catheter reinsertion

IUCs have been associated with increased risk of infection. Higher mortality rate has been shown in hospitalized patients with indwelling bladder catheters who developed UTI.<sup>[18]</sup> Even a single episode of catheterization can be a source of bacteraemia.<sup>[1,22]</sup> Some authors reported a bacteruria incidence of 3-10% per day with use of indwelling bladder catheters.<sup>[6,23]</sup> Lee *et al.*<sup>[12]</sup> reported a 19.2% incidence of pyuria in patients with IUCs for approximately 5 days. Early mobilization and removal of urinary catheters have been proven to decrease such complications.<sup>[1,4,10]</sup> Unfortunately, for those patients with prolonged impaired urinary voiding function postoperatively, reinsertion of urinary catheters is necessary to avoid worsening bladder function and kidney failure. The increasing use of hardware in spinal surgery makes for a stronger argument for eliminating all possible causes of infection.

**Table 6: Comparing studies**

	Total spine patients who underwent general anesthesia	Age	Length of anesthesia in minutes	Male/female	% of lumbar to % cervico-thoracic	% of POUR
McLain <i>et al.</i> <sup>[14]</sup>	200	47	195	55/45	100/0	23
Jellish <i>et al.</i> <sup>[8]</sup>	61	46	131.0	50/50	100/0	22.9
Boulis <i>et al.</i> <sup>[3]</sup>	503	50	Not provided	304/199	Not specified	38
Alsaidi <i>et al.</i> (submitted)	118	57	225.4	50/50	62/38	43

POUR: Postoperative urinary retention

Clinically, those patients with a very high PVR1 had much higher incidence of IUC insertion. Although IUCs have been associated with increased morbidity and mortality, in patients with a high PVR1 (>800 ml), early reinsertion of the IUC may not be unreasonable to avoid the dreadful consequences of distended bladder and potential renal failure, as well as to facilitate aggressive mobilization for a few days. Such early mobilization is paramount to reduce DVT and pulmonary embolism (PE) and, potentially, POUR.

### POUR: Length of stay

Boulis *et al.*<sup>[3]</sup> found POUR to be associated with longer hospital stay in 503 patients who underwent spine surgery ( $P < 0.01$ ). Among those with retention, the median difference between observed and expected stay was 1 day.<sup>[3]</sup> Balderi *et al.*<sup>[2]</sup> found that patients who developed POUR had a median length of stay of 7 days compared with 6 days only in patients who did not develop POUR ( $P = 0.007$ ). In our patients, PVR1 >250 was positively associated with length of stay.

## CONCLUSION

POUR is prevalent among neurosurgical patients, especially in males, those older than 60 years of age, and those with spinal pathologies. It may lead to high rates of infection, complication, cost, and longer hospital stay. Therefore, more studies are needed to understand the exact pathophysiology, risk factors, and potential point of intervention that would lead to the decreased incidence of POUR.

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