Use of bladder volume measurement assessed with ultrasound to predict postoperative urinary retention

Nilgun Kavrut Ozturk, Ali Sait Kavakli

Department of Anesthesiology and Reanimation, Antalya Training and Research Hospital, Antalya, Turkey

ABSTRACT

OBJECTIVE: Postoperative urinary retention (POUR) is a common complication after spinal anesthesia. Ultrasound (US) is a simple, non-invasive method to estimate bladder volume before and after surgery. Primary aim of the present study was to investigate utility of bladder volume measured before and after surgery in prediction of POUR risk. Secondary aim was to investigate necessity of urethral catheter use and risk of urethral catheter-related infections.

METHODS: Eighty patients who received spinal anesthesia for arthroscopic knee surgery were included in the study. Level and duration of sensory and motor block; bladder volume measured preoperatively, in post-anesthetic care unit (PACU), and when discharged from PACU; use of urethral catheter; and incidence of urinary tract infection data were recorded.

RESULTS: POUR was observed in 28.7% of patients. Length of time for sensory block regression was significantly shorter in patients without POUR (p=0.012). Spontaneous urination was not observed in 3 of 23 patients with POUR, although bladder volume was less than 600 mL. Bladder volume over 600 mL without urination was recorded in 20 patients. There was no statistical difference in preoperative bladder volume between patients who did or did not develop POUR. Bladder volume on admission to PACU was higher in patients with POUR (p=0.023). Urgency and dysuria were observed in 5 patients who required urethral catheterization during postoperative period. Urinary tract infection developed in 1 patient. There was no statistical difference in development of urinary tract infection between patient groups who did and did not undergo urethral catheterization.

CONCLUSION: Assessment of patient bladder volume with US before arthroscopic knee surgery may be used to foresee development of POUR. Avoiding elective urinary catheterization may reduce urinary infections.

Keywords: Bladder volume; postoperative urinary retention; spinal anesthesia; ultrasound.

Postoperative urinary retention (POUR) is a frequent complication encountered following spinal anesthesia. In the literature, incidence of POUR has been reported within a broad spectrum, ranging between 5% and 52% [1, 2].

Risk increases in women, and population aged over 50 years. Factors such as type of surgery, neurological disease, diabetes mellitus, drugs used

during perioperative period (e.g., anticholinergics, beta-blockers, sympathomimetics), quantity of intravenous fluid used, duration of surgery, analgesics and anesthetics, and anesthesia technique play role in development of POUR [3].

Various studies have revealed correlation between spinal anesthesia and development of POUR. In 30 to 60 seconds following intrathecal injection of local anesthetic, feeling of urgency to micturate disappears; however, feeling of distension caused by full bladder continues. Analgesia of the bladder is achieved with blockade of conduction of stimuli via afferent nerve fibers traveling from the bladder to miction center in the brain. Blockade of the detrusor muscle begins to take effect 2 to 5 minutes after injection of anesthetic agent. Sensory block regresses to level of sacral spine segment S3 7 to 8 hours after intrathecal injection of bupivacaine. When the detrusor strength is returned, the level of analgesia is at or caudal to L5 [4].

Relationship between long-acting local anesthetics and POUR has been reported. Use of short-acting local anesthetics is associated with lower incidence of bladder distension and risk of POUR [5].

US is noninvasive method that can easily be used to calculate bladder volume before anesthesia and during postoperative period, as well as to estimate post-void residual volume.

Aim of the present study was to evaluate use of bladder volume measured with US before application of spinal anesthesia and during postoperative period to predict development of POUR and need for urethral catheterization.

MATERIALS AND METHODS

This study was conducted in compliance with the principles of Declaration of Helsinki, and it was approved by the ethics committee of Antalya Training and Research Hospital (decision no: 22/14, dated: 04.07.2013). Written informed consent of all patients was obtained.

Primary objective of the study was to investigate the utility of pre- and postoperatively measured bladder volume to predict postoperative urinary retention. Secondary objective was to investigate necessity for catheterization and risk of urinary infection associated with urethral catheter.

Total of 80 patients of American Society of Anesthesiologists classification I through III and aged 19 to 65 years, who were scheduled for elective unilateral arthroscopic surgery were included in the study. Patients with known prostatic disease; history of difficulty voiding, urinary incontinence, urological surgery; contraindication for spinal anesthesia (e.g., coagulopathy, serious valvular disease); neurological dysfunction; or who unable to cooperate.

Patients were permitted to urinate before they were brought to operating room for induction of anesthesia. In the operating room, pulse oximetry, electrocardiographic examination, and standard anesthetic monitoring, which included noninvasive blood pressure measurement, were performed. Peripheral venous route was opened with 18-G cannula, and 0.9% sodium chloride infusion was initiated at a rate of 6 mL/kg/hr. The patients also received intravenous midazolam at dose of 0.05 mg/kg.

Bladder volume of the patients was measured and calculated with US device (DC-T6 Diagnostic Ultrasound System; Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China) with 5 Mhz convex probe. All measurements were performed by 2 anesthesiologists. US probe was placed approximately 2 cm over transverse and longitudinal planes, and transverse, anteroposterior, and superoinferior diameters of the bladder were measured. Bladder volume was calculated automatically (Figure 1).

Patients were placed in lateral decubitus position, and 27-G pencil point spinal needle (Egemen Tibbi Teknik Sanayi ve Dis Ticaret Ltd. Sti., Izmir, Turkey) was inserted at L4-5 interspace to deliver 7.5 mg 0.5% hyperbaric bupivacaine to subarachnoid space. Patients were left in lateral decubitus position for 10 minutes, then turned to supine position and placed in 20° Trendelenburg position. Following application of spinal anesthesia, level of sensory and motor blocks was evaluated using pinprick test and Bromage scale, respectively.

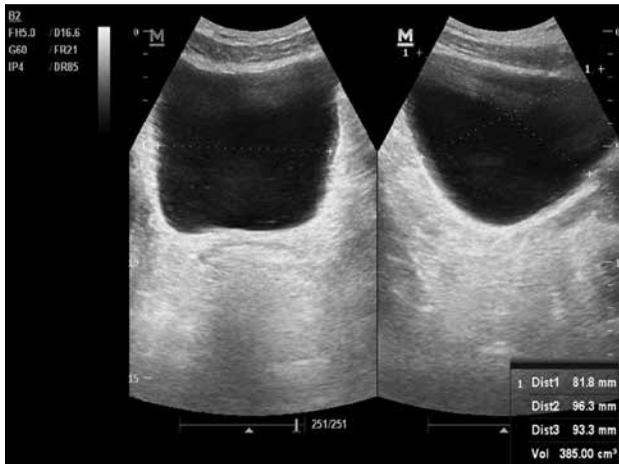Time elapsed for sensory block to reach T12

FIGURE 1. Ultrasonographic view of the bladder in 2 different images. The image on the left was obtained by placing the probe in transverse plane. Dashed lines indicate the longest transverse diameter of the bladder. The image on the right was obtained by placing the probe in longitudinal plane. Dashed lines demonstrate anteroposterior and supero-inferior diameters of the bladder.

thoracic vertebra, maximum level of sensory block, time needed for sensory block to reach maximum level on both sides, maximum sensory block, time to reach maximum block, quantity of fluid given during perioperative period, and volume of blood loss were recorded.

Patients were brought to postoperative recovery room after procedure and monitored until motor and sensory blocks had completely receded. Time elapsed from application of spinal anesthesia until loss of motor block (Bromage=0), and time interval until regression of sensory block to L2 level were recorded.

In recovery room, intravenous paracetamol at dose of 1 g was administered.

Bladder volume of patients who met criteria (fully conscious, stable vital signs, visual analog scale <5, absence of nausea and vomiting, loss of motor and sensory block) for transfer to ward was measured again in recovery room using the same method. Patients were also asked about need to urinate before they were sent to ward. Urethral catheterization was performed for patients whose bladder volume was ≥600 mL and could not urinate despite

presence of urgency. If the patient did not indicate any need to urinate, we waited for 30 minutes. If the patient could not urinate spontaneously, urethral catheterization was performed, and amount of residual urine was measured. Patients whose bladder volume was less than 600 mL, but who could not urinate within 1 hour were also catheterized and urine volume was recorded.

During monitoring of catheterized patients, urine cultures were obtained for patients who complained of fever (>38°C), dysuria, frequency, strangiuria, or suprapubic pain. Urinary infection was defined as presence of bacterial growth of more than 105/mL CFUs on culture media.

Statistical analysis

SPSS software, version 21 (IMB Corp., Armonk, NY, USA) was used to analyze statistical data. All data were expressed as number or percentage. Results were expressed as mean±standard deviation. Normal distribution was assessed using Shapiro-Wilk test. Student's t-test and chi-square test were used to compare numerical and nominal values, respectively. P<0.05 was accepted as level of statistical significance.

RESULTS

Total of 80 patients who underwent elective unilateral arthroscopic knee surgery under spinal anesthesia were included in the study. Demographic data of the patients are presented in Table 1.

Postoperative urinary retention developed in 23 (28.7%) study patients and was not seen in 57 (71.3%) patients.

Surgery of all patients was performed under spinal anesthesia. No patient displayed any indication of need to switch to general anesthesia or required additional intraoperative analgesia.

Time for sensory block to rise to level of T12 did not differ between patients who did or did not develop urinary retention. However, time until regression of sensory block to level of L2 was significantly shorter in patients who did not develop POUR (p=0.012). Significant intergroup difference was not detected in time to develop motor

Table 1. Demographic data

	Patients who developed urinary retention (n=23)		Patients who did not develop urinary retention (n=57)		p
	n	%	n	%	
Age (mean±SD)	52±11		54±9		0.775
Gender					
Male	14	60.9	36	63.2	0.322
Female	9	39.1	21	36.8	0.414
BMI kg/m^2 (mean±SD)	27.8±3.1		27.3±4.2		0.822
ASA score					
ASA I	10	43.5	23	40.4	0.212
ASA II	9	39.1	26	45.6	0.324
ASA III	4	17.4	8	14	0.243
Comorbidities					
Hypertension	3	13	6	10.5	0.466
Diabetes mellitus	2	8.7	4	7	0.439
Coronary artery disease	3	13	6	10.5	0.364

SD: Standard deviation; BMI: Body mass index; ASA: American Society of Anesthesiologists.

Table 2. Sensory and motor block data

	Patients who developed urinary retention (n=23)	Patients who did not develop urinary retention (n=57)	p
	Mean±SD	Mean±SD	
Time elapsed until sensory block reached T10 level, min	5±2	7±2	0.765
Time elapsed until sensory block regressed toL2 level, min	210±18	150±16	0.012*
Time until achievement of maximum motor block, min	12±4	11±3	0.818
Time until termination of motor block, min (Bromage scale=0)	226±32	198±21	0.226

SD: Standard deviation.

block. Although time until termination of motor block was shorter in group that did not develop urinary retention, intergroup difference was not statistically significant (Table 2).

No difference was found in preoperative bladder volume between groups that did or did not develop urinary retention. However, bladder volume was significantly higher at admission to postoperative recovery room in patients who developed urinary retention (p=0.023). Three (3.7%) of 23 patients who developed urinary retention had bladder volume below 600 mL and could not urinate spontaneously. In addition, 20 (25%) patients whose bladder volume was above 600 mL could not urinate spontaneously (Table 3).

TABLE 3. Comparison of data of the patients who did and did not develop urinary retention

	Patients who developed urinary retention (n=23)			Patients who did not develop urinary retention (n=57)			p
	n	%	Mean±SD	n	%	Mean±SD	
Operating time, min			69±11	4		3±14	0.028*
Quantity of fluid given during surgery, mL			1050±226			725±115	0.033*
Quantity of fluid given during postoperative period, mL			950±214			860±195	0.590
Preoperative bladder volume, mL			180±40			160±37	0.840
Bladder volume at admission to recovery room, mL			520±52			220±45	0.023*
Bladder volume before leaving recovery room, mL			652±54			345±67	0.012*
Bladder volume >600 mL	20	25		6	7.5		0.042*
Bladder volume <600 mL	3	3.8		51	63.7		0.015*
Development of urinary tract infection	1	4.3		0	0		0.778
Length of hospital stay, d	6			5			0.277
Complications							
Bradycardia	3	13		5	8.7		0.175
Hypotension	2	8.7		4	7		0.766

SD: Standard deviation.

Statistically significant difference was not found between measurement of urine volume using US evaluation and volume estimated with urethral catheterization (Figure 2).

During postoperative monitoring, 5 patients who underwent urinary catheterization complained of frequency and dysuria. Bacterial growth was detected on urine culture of 1 of these patients and he was diagnosed with urinary infection. Rate of urinary infection did not differ between patients who developed urinary retention and required urethral catheterization and those did not undergo urethral catheterization. No patient required urethral catheterization for more than 24 hours.

Paresthesia was not detected in any patient. Intraoperatively, in 8 (10%) patients, bradycardia developed, and hypotension was observed in 6 (7.5%) cases. No other complication related to spinal anesthesia was observed.
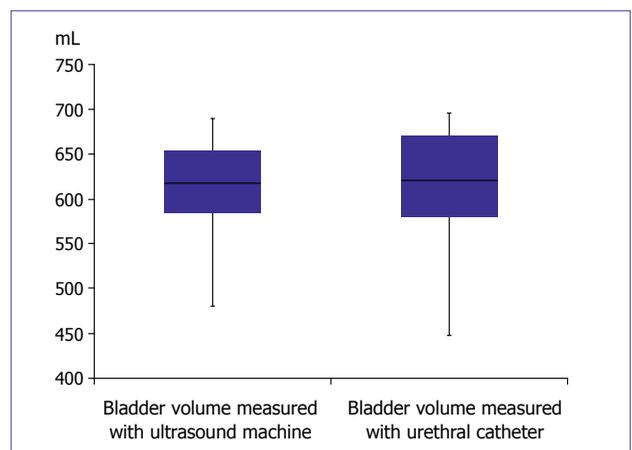

FIGURE 2. Comparison of bladder volume values obtained using ultrasound and urethral catheter.

DISCUSSION

Present study has demonstrated that measurement of bladder volume in postoperative recovery room

following spinal anesthesia may predict development of POUR.

Spinal anesthesia may affect vesicle function, thereby leading to POUR. Association of use of long-acting analgesics for spinal anesthesia [6] and bilateral spinal anesthesia with development of POUR has been reported in relevant studies [7]. In study conducted by Keita et al., authors reported close relationship between bladder volume greater than 270 mL at admission to postoperative recovery room and development of POUR [8]. In the same study, age of more than 50 years, intraoperative fluid requirement greater than 750 mL, operating time longer than 60 minutes, and anesthesia lasting longer than 80 minutes were associated with development of POUR. In the current study, mean bladder volume of the patients who did and did not develop urinary retention at admission to recovery room was 460±52 mL and 220±45 mL, respectively. Similarly, in present study, operating time was found to be associated with development of POUR.

In study performed by Hollman et al., incidence of POUR was found to be 39.9% among 376 patients who had undergone implantation of total hip prosthesis. Authors also revealed age of 70 years or older, spinal anesthesia, and postoperative patient -controlled analgesia were independent risk factors for POUR [9]. Higher incidence of POUR when compared with our study might be related to difference in surgical procedure performed or use of morphine sulfate during postoperative period, rather than paracetamol. Unilateral spinal anesthesia with hyperbaric bupivacaine was associated with development of POUR in 30% of patients who had undergone knee arthroscopy, and no difference was found with regard to bilateral spinal anesthesia [10]. In the current study, development of POUR was detected in 21.7% of cases, smaller percentage than results reported by Voelckel et al. This difference might stem from differences in management of perioperative fluid therapy. In the study conducted by Voelckel et al., intraoperative fluid therapy was administered at rate of 7 mL/kg/hr, while in our study, fluid therapy was provided at rate of 6 mL/kg/hr.

In the literature, incidence of POUR varies between 7% and 52%. [11] Palpation alone is insufficient to demonstrate the presence of vesical globes, because about 61% of cases have urinary retention without pain [12]. US is simple and reliable tool to measure bladder volume [13]. US measurement of bladder volume of ≥100 cc has 97% sensitivity, 91% specificity, and 94% accuracy [8]. Pavlin et al., demonstrated only 15 mL difference between US measurement of intravesical urine volume and that measured after urethral catheterization [12, 14]. Present study also found consistency between measurements with US and bladder catheterization.

US measurement of the longest transverse diameter of the bladder has been reported to aid in management of patients with risk for POUR.[15] In the same study, it was reported that patients with longest transverse diameter of the bladder <9.7 cm can be discharged from postoperative recovery room without waiting for the patients to urinate. Need for catheterization was indicated in patients whose longest transverse diameter of the bladder was >10.7 cm [15]. In the current study, longest mean transverse diameter of the bladder in patients who developed POUR was 11.2±2.2 cm, which was consistent with results of cited study. We preferred to calculate bladder volume based on measurements of 3 different diameters to increase reliability of assessment.

Various formulas may be employed to calculate bladder volume using transabdominal US; superiority of one formula over another has not yet been demonstrated. Authors have reported that bladder volume calculated using formulas were nearly the same as those estimated using urethral catheterization, and it was concluded that transabdominal US is reliable method of measurement [16]. Specific automated bladder US devices developed to measure bladder volume may be also used. Watanabe et al. compared 3-dimensional US machine with transabdominal US machine, and found no significant difference between measurements of bladder volume [17].

Normal bladder capacity ranges between 400 and 600 mL [18]. For bladder volume >600 mL, urethral catheterization is recommended to prevent development of POUR [19]. However, that volume is somewhat high for adult patient group whose

maximum bladder volume is 400 to 500 mL and in present study, bladder volume of 600 mL was accepted as catheterization cut-off value.

Various studies have shown that routine catheterization during total hip prosthesis surgery increases hospital costs [20]. It is suggested that the urinary probe should not be routinely applied to speed up the recovery process of patients and to facilitate the mobilization of patients [21]. In a study performed with 4906 patients who had undergone orthopedic surgery, incidence of catheter-related urinary system infection was 8.5% [22]. Decrease in use of urethral catheter in postoperative period will decrease risk of infection and thereby shorten hospital stay. In present study, urinary infection developed in only 1 (4.3%) of 23 patients who had urethral catheter. Lower rate of urinary tract infection in our patients may be due to shorter (<24 hr) urethral catheterization period. Rate of urinary infection may increase when longer periods of urethral catheterization are needed.

POUR can lead to complications, such as infection, delirium, detrusor muscle damage, or even cardiac arrhythmia through activation of autonomic nervous system, and also may delay hospital discharge.

Conclusion

US measurement of bladder volume during postoperative period is simple and noninvasive. Likelihood of postoperative development of POUR due to spinal anesthesia can be predicted with US measurement of bladder volume in recovery room. Thus, routine and unnecessary catheterization may be prevented, which may reduce incidence of urinary infection, and thereby shorten hospital stay and reduce expenditures.

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