The Association of Postvoiding Residual Volume, Uroflowmetry Parameters and Bladder Sensation

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Purpose: To investigate whether postvoiding residual bladder volume (PVR) and uroflowmetry parameters associate with bladder sensation in male patients with bladder outlet obstruction (BOO) and to find out the reliable time of these examinations.

Materials and Methods: Sixty men with bladder outlet obstruction underwent transabdominal ultrasound in order to measure postvoiding residual volume and uroflowmetry. At the first day, PVR was measured while the patients had mild bladder sensation. Patients emptied their bladder during uroflowmetry. The next day, same patients underwent a second uroflowmetry and PVR measurement while the patients had severe bladder sensation. The first and next day PVR and uroflowmetry parameters were compared and their correlation with lower urinary tract symptoms (LUTS) were analysed.

Results: The mean age of the subjects was 69.7 ± 8.6 years. PVR measured at the first day while patients had mild bladder sensation was significantly lower than the next day PVR (mean ± SD: 80.79 ± 72.18 vs 158 ± 115.82, $P < 0.001$) and correlated with LUTS (rs =0.38, $P = 0.012$). In contrary, uroflowmetry parameters at severe sensation of bladder (mean ± SD: Qmax:13.53 ± 6.32; Qave:5.32 ± 2.31) showed correlation with LUTS (rs = -0.492, $P = 0.001$).

Conclusion: PVR measurement at mild bladder sensation correlates with LUTS and should be performed in the evaluation of male patients with BOO. However, uroflowmetry is advised to be performed when the patient has severe bladder sensation.

Keywords: Bladder sensation; Postvoiding residual volume; Bladder outlet obstruction; Uroflowmetry

INTRODUCTION

Men with lower urinary tract symptoms (LUTS) related to bladder outlet obstruction (BOO) including bening prostatic hyperplasia is a very prevalent disease constituting a great amount of patients evaluated in urology practice.[1] Uroflowmetry and postvoiding residual urine volume (PVR) measurement are recommended for both the initial evaluation and follow-up after medical or surgical treatment of male patients with LUTS.[2] These examinations are simple, non-invasive, widespread and have a prominent role in the management of the patients.[2-4]

Ultrasound is commonly used for the estimation of PVR and easy to perform and highly accurate.[5] In most radiology departments, patients are advised to drink a significant amount of fluid to measure PVR and also to image the urinary tract reliably.[6-8] In guidelines, uroflowmetry is recommended to be carried out with a voided volume of over 150 mL.[2] Consequently, PVR and urine flow rate are usually measured under severe sensation of bladder and this is quite incompatible with real life and does not represent the patient's daily voiding practice. It is reported that a residual volume over 100 ml after an increased oral fluid intake may acutely and temporarily decompensate the bladder and might lead to the selection of an inappropriate treatment modality.[8] Therefore, the accurate measurement of PVR and uroflowmetry in accordance to daily voiding practice is of clinical importance.

In our clinical practice, some male patients with BOO reported that they voided more troublesome prior to PVR measurement than their daily routine voiding activity. To the best our knowledge we noticed that in male patients with BOO association of PVR and uroflowmetry parameters with bladder sensation has not been thoroughly investigated. Therefore, we intended to investigate whether PVR and uroflowmetry parameters change according to bladder sensation at the first desire or strong desire to void and to find out the reliable time of these examinations.

MATERIAL AND METHODS

Male patients complaining of LUTS related to BOO were included in the study. BOO was assigned according to the evaluation of urinary symptoms, radiologic and laboratory examinations with the exclusion of other pelvic pathologies. All patients were subjected to a diagnostic work-up including medical history, and examined for urinary symptoms with International prostate symptom score (IPSS). Physical examination including digital rectal examination was done and serum levels of urea and creatinine were measured. Ultrasonography

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Table 1. Descriptive statistics

	Minimum	Maximum	Mean	SD
Age	53	86	69.7	8.6
IPSS total score	4	35	21.04	8.1
PSA (ng/dL)	0.21	15.95	4.12	3.83
Prostate volume (mL)	14	190	67.8	37.9
Serum Creatinine (mg/dL)	0.71	2.23	1.0	0.3
Testosterone	249.65	1078.08	554.08	192.89

Abbreviations: IPSS, International prostate symptom score; PSA, Prostate specific antigen

and urinalysis were also obtained to exclude other pelvic disorders. Patients with a diagnosis of prostate or urothelial cancer, urinary tract infection, distal ureteral or bladder stones, urethral stricture, chronic pelvic pain syndrome, neurological disorder and unstable diabetes were not included into the study. In addition, patients on any medication for LUTS or with a history of urinary tract surgery or instrumental intervention were excluded. The study was performed at the urology and radiology departments of our university hospital between March and September 2017 and was approved by the Ethical Committee of our university and written informed consent was obtained from all patients.

All patients underwent uroflowmetry and transabdominal ultrasound (Logic E9 with XD clear ultrasonographic scanner, General Healthcare, United States, equipped with a 4.5 to 6 -MHz convex probe) for the examination of the urinary tract and measurement of prevoiding bladder volume, prostate volume and PVR in the radiology department. Both of the examinations were again carried out at the next day by the same radiologist and nurse. All ultrasonographic measurements including prevoiding bladder volume and PVR measurements were performed by the same radiologist (M.E.K). Patients were advised to take an increased amount of water orally prior to examinations without limiting the time and hydration rate. The examinations were performed while the patients had first or strong desire to void. We intended to pretend daily routine practice, therefore urinary catheterisation was not applied for artificial bladder filling. At the first day, the ultrasound was carried out while the patients had first desire to void (mild bladder sensation). Prevoiding bladder volume was measured and the patients were asked to empty their bladders during uroflowmetry. Then, the first PVR (PVR1) was measured by the radiologist under ultrasound by using the prolate ellipsoid method based on the formula: Volume = length x width x height x 0.52 on two dimensions.[9] The next day the same patients underwent a second prevoiding and postvoiding residual volume (PVR2) measurement while the patients had strong desire to void (severe bladder sensation). Uroflowmetry was again performed prior to PVR2 measurement. Maximum urine flow rate (Qmax), average flow rate (Qave) and voided volume were recorded.

Wilcoxon signed rank test was used to compare the first and next day PVR values and uroflowmetry parameters. Spearman's correlation rank test was used to determine whether the first and next day PVR was correlated with IPSS total score, prostate volume, prostate specific antigen (PSA), age, prevoiding bladder volume and serum creatinine levels. In addition, correlation between uroflowmetry parameters and IPSS total score was analysed by the same statistical method. SPPS 23 was used for statistical analyses and $P < 0.05$ was considered as statistically significant.

RESULTS

Sixty men with bladder outlet obstruction and a mean age of 69.7 ± 8.6 years were evaluated. Descriptive characteristics of the patients are shown in Table 1. Most of the patients had moderate (15/60) or severe symptoms (41/60). Only 4 patients presented with mild symptoms (IPPS <7). The mean prostate volume and

Table 2. Wilcoxon signed rank test showed statistical significance between measurements at the first desire and strong desire to void.

	Mean	SD	Significance (P)
PVR1	80.79	72.18	
PVR2	158.35	115.82	
PVR2 – PVR1			< 0.001
PreV1	203.16	108.18	
PreV2	422.33	203.22	
PreV2 – PreV1			< 0.001
Qmax1	10.74	5.77	
Qmax2	13.53	6.32	
Qmax2 – Qmax1			0.021
Qave1	4.03	1.90	
Qave2	5.32	2.31	
Qave2 – Qave1			0.018
Vv1	162.05	103.28	
Vv2	270.40	128.62	
Vv2 –Vv1			< 0.001

Abbreviations: PVR1, Postvoiding residual volume measured at first desire to void; PVR2, Postvoiding residual volume measured at strong desire to void; PreV1, Prevoiding bladder volume measured at first desire to void; PreV2, Prevoiding bladder volume measured at strong desire to void; Qmax1, Q maximum measured at first desire to void; Qmax2, Q maximum measured at strong desire to void; Qave1, Q average measured at first desire to void; Qave2, Q average measured at strong desire to void; Vv1, Voided volume at uroflowmetry at first desire to void; Vv2, Voided volume at uroflowmetry at strong desire to void

Table 3. Correlations between postvoiding residual volume at the first desire and strong desire to void and examined parameters.

	PVR1		PVR2	
	rs	*P*	rs	*P*
IPSS total score	0.380	0.012	0.113	0.396
Serum creatinine	-0.003	0.987	-0.008	0.961
PreV1	0.639	0.000	N/A	N/A
PreV2	N/A	N/A	0.709	0.000
PSA	0.114	0.472	-0.088	0.580
Prostate volume	0.221	0.154	0.179	0.250
Age	0.058	0.714	-0.188	0.227

Abbreviations: PVR1, Postvoiding residual volume measured at first desire to void; PVR2, Postvoiding residual volume measured at strong desire to void; PreV1, Prevoiding bladder volume measured at first desire to void; PreV2, Prevoiding bladder volume measured at first desire to void; IPSS, International Prostate Symptom Score; PSA, Prostate specific antigen; rs, Spearman's correlation coefficient.

mean serum PSA was measured 67.8 mg and 4.12 ng/dL, respectively.

Prevoiding bladder volume and postvoiding residual volume at the first desire to void (PVR1, measured at the first day) were significantly found lower than the strong desire to void (PVR2, measured at the next day) ($P < 0.001$) (**Table 2**). Furthermore, Qmax and Qave values and voided volume were also significantly lower at the first desire to void in comparison to the strong desire to void (**Table 2**).

While Spearman's rank correlation coefficient showed correlation between PRV1 and IPSS total score (rs =0.38, $P = 0.012$), PVR2 was not found correlated (**Table 3**). In addition, prevoiding bladder volume at first desire and strong desire to void correlated with residual volume measured at the first and next day, respectively (**Table 3**). Prostate volume, total PSA, age, and serum creatinine levels were not correlated with residual volume measured either at the first desire or strong desire to void. In contrary, Qmax and Qave values at the first desire to void did not show correlation with total IPSS, but showed significant correlation at the strong desire to void (rs = -0.335, $P = 0.28$ and rs = -0.492, $P = 0.001$, respectively) (**Table 4**).

DISCUSSION

Although PVR measurement and uroflowmetry are one of the most frequently performed urologic examinations worldwide for male patients with LUTS, the optimal time of these examinations in terms of bladder sensation has not been adequately investigated. To the best of our knowledge this is the first study that compared the PVR and uroflowmetry parameters according to bladder sensation in male patients with BOO. In our study, we found that patients at the strong desire to void showed higher prevoiding bladder volume and PVR. While PVR2 did not show correlation with LUTS, PVR1 was significantly correlated with LUTS. PVR measurement at mild bladder sensation of voiding (first desire to void) could be more reliable for the accurate diagnosis of BOO. On the other hand, in contrast to PVR findings, Qmax and Qave values did not correlate with LUTS at the first desire to void, but a significant correlation was found with symptoms at the strong desire to void. Severe bladder sensation for uroflowmetry could be more acceptable.

Table 4. Correlations between Q maximum and Q average at the first and strong desire to void and IPSS.

	IPSS total score	
	rs	*P*
Qmax1	-0.021	0.913
Qave1	-0.265	0.086
Qmax2	-0.335	0.028
Qave2	-0.492	0.001

Qmax1, Q maximum measured at first desire to void; Qmax2, Q maximum measured at strong desire to void; Qave1, Q average measured at first desire to void; Qave2, Q average measured at strong desire to void; rs, Spearman's correlation coefficient

Male patients with LUTS related to BOO are treated with medications (alpha blockers, antimuscarinics, 5 alpha reductase inhibitors) or surgery.[2] The choice of the treatment is mainly based on symptom severity and voiding examinations. Although there is no consensus for the PVR threshold, many urologists suggest that high values are an indication for invasive therapy.[10] Furthermore, large PVR volume has been reported to be associated with hydronephrosis, bladder calculi, nocturia, acute urinary retention and urinary tract infections.[11] All these relations show the importance of the accurate values of PVR. In a study by Mochtar et al. only over 300 mL of PVR has been found correlated with a need for an invasive therapy.[12] In our study, prevoiding bladder volume at first and strong desire to void significantly correlated with PVR1 and PVR2, respectively. An increase in prevoiding bladder volume caused an increase in PVR which was not correlated with the symptom severity of the patients. We believe that patients should have mild bladder sensation prior to PVR measurement for the accurate treatment modality. Previous studies that investigated the relationship of PVR with BOO might have included patients which PVR was measured under severe bladder sensation. According to our results these studies could be better performed with patients at mild bladder sensation. Further studies are needed for the re-evaluation of the relation between PVR and BOO.

Uroflowmetry is a non-invasive, easily practiced and non-expensive test for the evaluation of patients with BOO.[12] Qmax is found an independent predictor of urodynamic BOO[4] and 10 ml/sec is widely accepted as a threshold. However, similar to PVR, there is also a discrepancy and debate between the uroflowmetry parameters and diagnosis of BOO.[13] It is generally accepted that the voided volume should be over 150 mL for the accuracy of the test.[2] In our study the mean voided volume at the first desire to void was 162.05 mL. However, no correlation was found between IPSS total score and Qmax and Qave values when the pa-

tients voided at the first desire to void. On the other hand, mean voided volume at the strong desire to void was found increased and Qmax and Qave values were correlated with IPSS total score. However, whether the mean voided volume at the first desire to void is over 150 mL and mean Qmax is 10.7 mL/sec, uroflowmetry parameters might not be useful for the evaluation of the patients at mild bladder sensation. In contrast to PVR measurement, we claim that patients should undergo uroflowmetry at strong desire to void for the evaluation of relation between Qmax and Qave and urinary symptoms.

Alivizatos et al. studied the relation between PVR and increased oral intake of fluids.[8] They included the patients into their study with a PVR over 100 mL measured in the first examination after taking an amount of oral fluid. On a separate day, the same patients were let to drink as their usual days. PVR values significantly found higher at the first measurement but no correlation was found between neither first nor second PVR and IPSS. They claimed that increased oral intake of fluids may suddenly decompensate the bladder and result in high residual volume which do not represent the daily voiding practice. However the authors did not include the patients with PVR less than 100 mL after the first measurement which constitutes a significant amount of patients applied to outpatient clinics. In our study, we did not restrict the patients to take oral fluids prior to ultrasound examination which is also needed for a better visualisation of the urinary tract. While Alivizatos et al. concluded the negative effect of significant oral intake of fluids prior to PVR measurement, we advise the clinicians to measure PVR at the first desire to void which was correlated with LUTS. Additionally, in a group of young men without LUTS 60% of men with a PVR less than 50 ml after mild or moderate bladder sensation had a PVR over 50 mL when they voided after a distended bladder.[11] Although their study was performed on young healthy men which PVR was not needed to be measured in daily urology practice, it emphasized that bladder could fail to empty at very high capacities.

The limitations of the study it is performed at only one center and lack of follow up of the patients in order to find out if there is any relation between the findings of our study and response to therapy.

CONCLUSIONS

In conclusion, PVR measurement at the first desire to void with mild bladder sensation correlates with LUTS and should be performed in the evaluation of the male patients with BOO. However, uroflowmetry is advised to be performed when the patient has strong desire to void.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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