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Is Ultrasound a Reliable Method for Quantifying Postvoid Urine Volume?

Ferec Efendiyev [1] *, Belma Çevik [2]

[1]Lokman Hekim University, Faculty of Medicine, Department of Urology, Ankara, Türkiye.
[2]Lokman Hekim University, Faculty Of Medicine, Department of Radiology,Ankara, Türkiye.

Abstract

Introduction: In the treatment and follow-up of patients with Benign Prostatic Obstruction (BPO), uroflowmetry and evaluation of post voiding residual urine volume (PVR) are of great importance. Methods such as urethral catheter and suprapubic ultrasonography are generally used to measure PVR. In this study, we aimed to compare the accuracy of urethral catheter and suprapubic ultrasonography methods in detecting PVR.

Materials and Methods: We included patients who underwent catheterisation for various clinical reasons. A total of 103 patients were included in the study. All patients were evaluated by suprapubic ultrasonography (USG) in the supine position to confirm that their bladders were empty. After 200 ml of saline was injected into the bladder with the help of a urethral catheter, the catheter was removed and the patients were instructed to urinate into a graduated cup.PVR was calculated by subtracting the volume voided by the patient from the volume injected into the bladder (200 ml).Abdominal USG was performed again within 5 minutes after voiding. Finally, the PVR values obtained were compared.

Results: The accuracy of urethral catheter measurements was higher than suprapubic ultrasonography. The sensitivity and specificity of suprapubic ultrasonography were found to be 100% (1.000 (0.904-1.000)) and 94% (0.940 (0.856-0.977)), respectively.

Conclusions:USG demonstrating high specificity and sensitivity in assessing postvoid residual urine volume.

Key words: Benign prostatic hyperplasia; ultrasonography; uroflowmetry.

Introduction

In managing patients with Benign Prostatic Obstruction (BPO), a combination of follow-up, medical intervention, and surgical treatment is employed. Uroflowmetry and the assessment of post-voiding residual urine (PVR) play a crucial role in evaluating treatment response.(1) Both suprapubic ultrasonography and urethral catheterization are commonly used methods to evaluation of PVR (2-6) While urinary catheterization offers a high accuracy rate in identifying PVR, it is associated with drawbacks such as patient discomfort, pain, trauma, and the risk of urinary infection (2,6). In contrast, ultrasonography is non-invasive, cost-effective, painless, and easy to administer, unlike catheterization. As a result, ultrasonography is the more frequently employed method for PVR detection (7). In this study, we conducted a comparison of these two methods and evaluated the sensitivity and specificity of abdominal ultrasonography in detecting PVR.

Materials and Methods

We included male patients who had undergone catheterization for various clinical indications(transurethral prostate resection,radical prostatectomy,intravesical chemotherapy, TUR-bladder) between January 2020 and March 2022. Patients were provided with both oral and written information and we adhered to the principles of the Declaration of Helsinki. The study was carried out prospectively.This study was approved by the ethical committee of the Lokman Hekim University(Decision No: 2023234). A total of 167 patients took part in the study. Sixty-four patients were excluded because it was not possible to measure the voided urine volume accurately due to bad patient cooperation. The study was carried out with a final group of 103 participants. First,

*Corresponding Author: Ferec Efendiyev, Department of Urology, Faculty of Medicine, Lokman Hekim University Söğütözü, 2179. Sk. **No:6,** 06510 Çankaya/Ankara. **E-mail:** ferecefendiyev@gmail.com
Orcid: Ferec Efendiyev 0000-0002-4824-1271, Belma Çevik 0000-0001-9616-8622

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abdominal ultrasonography (USG) was performed with the patient supine to confirm an empty bladder. Next, 200 ml of saline was introduced into the bladder, followed by removing the catheter, and patients were instructed to void into a graduated cup. The post-void residual (PVR) volume was calculated bysubtracting the volume voided by the patient from the administered saline volume (200 ml). Another abdominal USG was conducted within 5 minutes post-voiding. The PVR measurement using USG was determined using the following formula: PVR = (Width (cm) x Length (cm) x Depth (cm)) x 0.52. Additionally, the volume automatically calculated by the USG machine was considered. The obtained PVR values were then compared. The abdominal ultrasonography (USG) was conducted by single experienced radiologist, each having 15 and 18 years of professional experience, respectively. Features of the USG device Performed all ultrasonographic examinations with an SDU2200 color Doppler ultrasonographic scanner (Shimadzu Corporation, Kyoto, Japan) equipped with a 2 to 5.5 MHz convex probe. Statistical analyses. Descriptive statistics are summarized as counts and percentages for categorical variables; mean and standard deviations for normally distributed continuous variables and median (minimum, maximum and interquartile range) for others. Wilcoxon Signed Ranks test was used to evaluate difference between USG and catheter measurements. The area under the ROC curve gives an estimate of the overall accuracy of alternative tests. An area of 0.50 implies that the variable adds no information. The areas under the ROC curves and 95% confidence intervals for an alternative test was calculated in the manner described by Hanley and McNeil (8). P value less than 0.05 was considered significant.

Table 1: Demographic data of the study.

Total number of patients	(n=103;%100)
Age(years) (mean±SD)	63.28±10.97
PVR(with USG) (ml) (mean±SD)	79.70±147.90
PVR(with Urethral Catheter) (ml) (mean±SD)	99.06±204.90
Reason for catheterizati	
BCG	29 (28.2)
Mitomycin	9 (8.7)
TUR-prostate	17 (16.5)
TUR-bladder	20 (19.4)
Urethral stricture	7 (6.8)
Radical Prostatectomy	5 (4.9)
Other reason	4 (3.9)
Transvesical prostatectomy	7 (6.8)
Urinary retantion	5 (4.9)

n: Number of patients, **%:** Percentage of column, Numerical variables are given as mean±standard. **PVR:** Postvoiding residual urine volume; **USG:** Ultrasonography; **BCG**: Bacillus calmette-guerin. **TUR-prostate:** Transurethral resection of the prostate; **TUR-bladder:** Transurethral resection of bladder tumor.

Results

The total number of patients included in the study is 103. The average age of the patients is 63.28±10.97 years.Transurethral prostate resection (TUR-prostate) was applied to 17 patients, and transurethral bladder tumor resection (TUR-bladder) was applied to 20 patients due to bladder tumor (Table 1). It seems that in patients who underwent, there was a significant difference in the measurement of postvoid residual urine (PVR) between transabdominal ultrasound and catheterization. Specifically, the PVR measurement medians obtained through catheterization was higher than that obtained through transabdominal ultrasound (p = 0.028)

Table 2: Comparison of postvoid residual urine (PVR) volume measurements via suprapubic ultrasound and urethral catheterization.

	n	Mean	Median (Min.-Max.)	Percentile 25 - 75	P
Probe PVR (ml)	103	99.06±204.91	22.0 (0.0-1002.0)	10.0 - 88.0	
USG PVR (ml)	103	79.70±147.39	24.0 (0.0-718.0)	10.0 - 73.0	0.028
Difference USG-Probe (ml)	103	19.36±64.43	2.00 (-56.0-304.0)	-6.0 - 18.0	

The agreement between the probe/catheter and USG was evaluated by Bland Altman and ICC. **n:** Number of patients, **%:** Percentage of column, Numerical variables are given as mean±standard **PVR:** Postvoiding residual urine volume; **USG:** Ultrasonography; Probe **PVR:** Postvoiding residual urine volume with uretrhral catheter .

(Table 2). Based on the information provided, it appears that USG postvoid residual urine volume (PVR) has a high predictive ability to discriminate between pathological and normal subjects using a cutoff value of 40 ml. The ROC analysis indicates that the area under the curve (AUC) is 0.986 ± 0.008 (95% confidence interval: 0.970-1.000, p<0.001), which is very close to the maximum possible AUC of 1,0, indicating that USG PVR has very high sensitivity and specificity. The sensitivity and specificity of suprapubic ultrasonography were found to be 100% (1.000 (0.904-1.000)) and 94% (0.940 (0.856-0.977)), respectively.The positive predictive value(PPV) of the USG PVR (the proportion of true positives among all positive results) is % 90, indicating that among those who USG PVR ≥ 40 ml. The negative predictive valueof (NPV) the USG PVR (the proportion of true negatives among all negative results) is %100, indicating that among those who USG PVR < 40 ml. Overall, the information provided suggests that USG PVR with a cutoff value of 40 ml is a highly accurate test for predicting pathology, with high sensitivity, specificity, PPV, and NPV. The ROC curve and AUC provide additional evidence of the test's predictive ability, indicating that it is a useful alternative to other diagnostic tests for this condition.

Discussion

Both abdominal ultrasonography and urinary catheterization are frequently used methods for assessing PVR (2-6)Ultrasonography is non-invasive, cost-effective, painless, and relatively simple to perform, unlike catheterization. Hence, ultrasonography is more commonly utilized for PVR detection (7) In this study, we noted that abdominal ultrasonography was less successful in detecting PVR compared to urethral catheterization (p = 0.028). Regarding sensitivity and specificity, we found that USG proved highly effective in detecting .Furthermore, we observed that the positive and negative predictive values of ultrasonography for PVR detection were notably high. A study conducted by P.S. Goode et al. found that the success of urethral catheterization in detecting PVR did not exhibit a statistically significant difference when compared to abdominal ultrasound (p <0.197) (9). It's important to note that this study was limited to female subjects and utilized a portable ultrasound device. We hypothesize that the distinct anatomical structure in women, particularly the absence of the prostate, allows for accurate delineation of bladder boundaries, thereby improving the success rate of USG in assessing PVR. Unlike our study, this research did not include evaluations of sensitivity and specificity. A study conducted by Gerasimos A. et al. determined that the hydration status of patients before the procedure influenced the effectiveness of ultrasonography (USG) in assessing post-void residual (PVR) volüme (10). This specific variable was not assessed in our study. Additionally, the mentioned study did not include a comparison with urethral catheter ultrasonography, nor did it investigate sensitivity and specificity. In a study conducted by Khurshid R. G. et al. portable bladder scanners (Bladderscan and Bardscan) were compared with three-dimensional ultrasound for the detection of PVR. The findings showed similar levels of success across all three ultrasonographic devices(11). The mentioned study did not compare ultrasonography with urethral catheterization for PVR detection, nor did it include an assessment of sensitivity and specificity. In this present study, we utilized the SDU2200 color Doppler ultrasonographic scanner (Shimadzu Corporation, Kyoto, Japan) equipped

with a 2 to 5,5 MHz convex probe. As a result, we could not assess the effectiveness of various ultrasonographic devices. In a 2009 study conducted by Ghadeer A et al., the portable ultrasound device (BladderScan BVI 3000) was compared to urethral catheterization for PVR assessment. The results showed that the portable ultrasound achieved comparable success to urethral catheterization in measuring PVR ($p<0.001$) (12). In a study conducted in 2020, Yamaguchi Y et al. examined the comparative accuracy of the portable ultrasound bladder scanner, Lilium α-200, and conventional ultrasonography (CUS) in measuring bladder volüme (13). According to the results of the mentioned study, both the portable ultrasound and the Lilium α-200 exhibited similar accuracy compared to conventional ultrasonography. In addition, we investigated factors that could potentially impact the effectiveness of ultrasonography, including prostate volume and bladder wall thickness. However, our current study could not explore this aspect fully because several patients had undergone prostatectomy. Contrary to our study, the studies conducted by Ghadeer A and Yamaguchi Y did not include assessments of sensitivity, specificity, positive predictive value, or negative predictive value. When reviewing the literature, we observed that although abdominal ultrasound's effectiveness in measuring post-voiding residual urine volume was investigated, no assessments were conducted regarding sensitivity, specificity, positive predictive value, and negative predictive value. In contrast, our study determined the sensitivity and specificity of abdominal ultrasound for PVR detection to be 100% and 94%, respectively. Furthermore, we observed that the positive predictive value and negative predictive value of ultrasonography for PVR detection were also high (90% and 100%, respectively). We believe that our study makes a significant contribution to the scientific discussion in this field.

Study limitations: The number of patients in our study is small. This is the shortcoming of this research.

Conclusions

In conclusion, abdominal ultrasonography proves to be a dependable method, demonstrating high sensitivity and specificity and strong positive and negative predictive values in the measurement of post-voiding residual urine volume.

Ethical approval : This study was approved by the ethical committee of the Lokman Hekim University(Decision No:2023234)Written informed consent was obtained from each patient.

Conflict of interest: Authors have no competing interest to declare.

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Authors contributions: Concept-Design: FE; Literature review: FE; Data collection: B.Ç; Writing-review-revision: FE.

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