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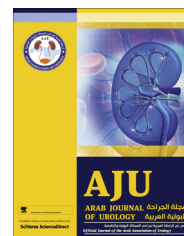


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ORIGINAL ARTICLE

The reliability and reproducibility of ultrasonography for measuring the residual urine volume in men with lower urinary tract symptoms



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ABBREVIATIONS

PVR, postvoid residual
urine volume;
US, ultrasonography

Abstract Objective: To assess the reliability and reproducibility of abdominal ultrasonography (US) for measuring the postvoid residual urine volume (PVR), and to compare measurements by a radiologist and urologist, in men with lower urinary tract symptoms (LUTS), as a significant PVR is common in patients with LUTS and an assessment of the PVR could protect patients from unnecessary catheterisation.

Patients and methods: This was a prospective comparative study of 45 men aged ≥ 45 years with LUTS attending a urological outpatient clinic from July 2011 to May 2012. A detailed history was taken, with an assessment of LUTS using the Arabic Validated International Prostate Symptom Score (IPSS) and complete general and local examination. The PVR was measured by US twice by a radiologist and urologist, and then repeated after 1 week. Within ≤ 2 min after US a urethral catheter was used to measure the PVR.

Results: The mean (range) age of the patients was 63.8 (45–88) years and the mean IPSS was 16.18. Reliability testing between the PVR measured by US and the catheterised measure of PVR showed that US was not reliable (Cronbach's $\alpha < 0.7$). The US measurement was reproducible for both single examiner over

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two sessions, and with two examiners in one session. The PVR obtained by the urethral catheter was significantly higher than the US measurement ($P < 0.05$).

Conclusions: The measurement of PVR by US is reproducible by either a urologist or radiologist, but it is not reliable, as the urethral catheter estimate gives a significantly higher PVR.

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Introduction

The postvoid residual volume of urine (PVR) is defined as the volume of urine remaining in the bladder immediately after complete voiding [1], and a significant PVR is common in patients with LUTS [2]. A significant PVR results from inadequate evacuation of the bladder, either due to infravesical obstruction or a weak detrusor muscle, or a combination of both. Thus assessing the PVR is important in the diagnosis, follow-up and clinical progress of lower urinary tract diseases [3,4].

There are different opinions about the threshold PVR considered to be 'significant', and the values reported are very variable. The standard method for measuring the PVR is urethral catheterisation [5], which is reported to have 100% sensitivity and specificity for estimating the PVR [6]. However, a urethral catheter can be a hazard to the patient, as it can cause trauma to the urethra and carries the risk of a UTI [4].

The measurement of PVR by ultrasonography (US) could protect patients from the discomfort and risk of urethral injury caused by catheters [7]. US is easy, safe, noninvasive, cost-effective, painless, repeatable, less time-consuming and demands little co-operation from the patient [4].

The objectives of the present study were to assess the reliability and reproducibility of abdominal US for measuring the PVR in men with LUTS, and to compare estimates of PVR as measured by radiologists and urologists.

Patients and methods

This was a prospective comparative study conducted between 2011 and 2012 among men attending an outpatient clinic of a urology department for an investigation of persistent LUTS. Patients included were aged ≥ 45 years and had a history of persistent LUTS. Patients with any of the following were excluded: a history of urinary bladder surgery; difficulty in catheterisation (e.g., due to urethral strictures); with an indwelling bladder catheter due to acute urinary retention or neurological disorders; refusal to participate in the study; US evidence of dilatation of the upper renal tract and bladder diverticula.

The study included 45 patients, all of whom had a complete history taken, including demographic data (name, age, sex, residence and smoking habit), and an assessment of LUTS using the Arabic-Validated IPSS. They also had a physical examination, including general and local examination (DRE, bimanual examination and reflexes).

The patient was asked to present with a full bladder and was examined immediately after voiding in complete privacy, and with no abdominal straining, coughing or sneezing. The ultrasound system used was the Diagnostic Ultrasound System 5684779-LH600, with a 5-MHz recording head (Siemens Medical System, Inc., Ultrasound Group, Issaquah, WA, USA).

With the patient supine the probe was passed over the suprapubic area and the sagittal height and depth, and transverse width and depth, were measured. Areas from the longitudinal and transverse images were also measured. Scans were repeated until maximum values were obtained. The PVR was calculated automatically by the ultrasound system. The US was repeated twice by a radiologist and urologist, and then repeated after 1 week.

After the US measurement of PVR a 14-F Nelaton urethral catheter (without balloon) was inserted via a sterile technique under local anaesthesia. The bladder was drained into a urine collecting bag, with the endpoint of collection of residual urine defined as the cessation of flow and slow withdrawal of the catheter into the proximal urethra, and this volume was recorded. The interval from the end of the US measurement and collection of residual urine was 1.5–2.5 min.

Quantitative data are expressed as the mean (SD) and qualitative data as n (%). Student's t -test and a one-way anova were used to test the significance of differences in quantitative variables. Cronbach's α was used to assess the reliability of different estimates. In all tests $P < 0.05$ was considered to indicate statistical significance.

The study was approved by the medical ethics committee, and all patients gave written informed consent. All patients had the right to be involved or withdraw whenever they chose, without affecting their medical care. The confidentiality of all data and test results of all the study participants was preserved.

Results

The demographic data for the 45 patients are shown in Table 1. Most men had moderate LUTS (19, 42%). A one-way anova showed a statistically significant difference between IPSS categories, especially for severe symptoms, and the mean PVR, which was significantly greater than in men with mild-moderate symptoms ($P < 0.05$; Table 2).

Using Cronbach's α , the reliability of US for measuring the PVR in the first bladder reading was 65% with values of 82.3 (60.8) mL by US and of 108.4 (72.1) mL by urethral catheterisation ($P < 0.05$). In the second bladder reading, the PVR measured by US and catheter was 78.8 (68.57) and 104.3 (75.58) mL, respectively, giving a reliability of 68% ($P < 0.05$). This indicated that the test was not reliable, as Cronbach's α was < 0.7 . The PVR obtained by urethral catheterisation was significantly higher than that obtained by US (Table 3, Fig. 1).

The mean PVR obtained by the urologist in the two sessions (1 week apart) was 81.9 (60.28) and 76.6

(67.26) mL ($P = 0.32$). There was no statistically significant difference, indicating that the reproducibility was good for the urologist's US assessment in two different sessions (Table 4). The mean PVR obtained by the radiologist in the two sessions (1 week apart) was 82.2 (60.14) and 79.1 (68.96) mL ($P = 0.56$). There was no statistically significant difference, indicating that the reproducibility was also good for the radiologist's US assessment in two different sessions (Table 4).

There was no statistically significant difference ($P > 0.05$) in the mean readings obtained by the urologist and radiologist using US in the two reading sessions, indicating that the US measurement was reproducible either by urologist or radiologist in one session (Table 4).

Discussion

A significant PVR is common in patients with LUTS such as urinary frequency, nocturia, overflow incontinence and recurrent UTI. The measurement of PVR is important to exclude both neurological abnormalities and/or obstructive voiding disorders [2,4].

Table 1 Demographic data of the 45 patients.

Variable	Mean (SD, range)
Age (years)	63.8 (10.47, 45–88)
IPSS	16.18 (8.65, 4–34)
Quality of life score	2.47 (1.44, 1–6)
Maximum flow rate (mL/s)	10.46 (4.1, 3–17)
PSA (ng/mL)	1.74 (0.85, 0.5–3.9)
Prostate size (g)	54.66 (21.52, 15–126)

Table 2 Comparison between IPSS categories according to the mean PVR.

IPSS category (<i>n</i>)	Mean (SD) PVR (mL)	<i>P</i> *
Mild (13)	60 (69.4)	< 0.001
Moderate (19)	87.6 (41.5)	
Severe (13)	171.9 (69.3)	

* One way anova.

Table 3 Reliability of abdominal US and urethral catheterisation for measuring PVR in the two bladder readings.

Reading	US	Catheter
<i>First reading</i>		108.4 (72.1)
PVR	82.3 (60.83)	
Cronbach's α	0.65	
<i>P</i>	< 0.05	
<i>Second reading</i>		104.3 (75.58)
PVR	78.8 (68.57)	
Cronbach's α	0.68	
<i>P</i>	< 0.05	

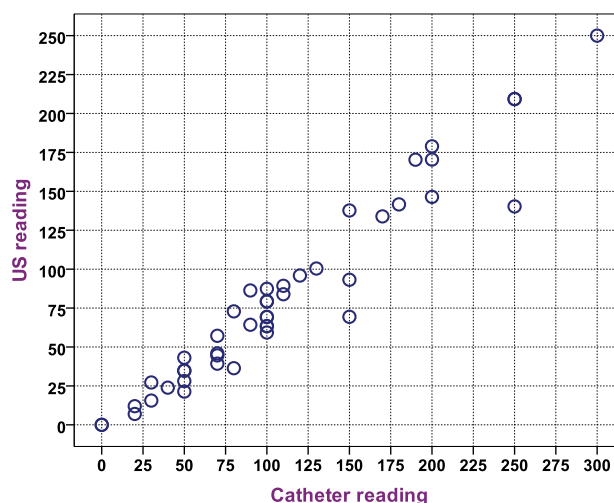


Figure 1 A scatter plot showing the variability of PVR readings between the US and catheter measurements by the urologist in the first reading session.

Table 4 Reproducibility of abdominal US for measuring PVR when done by one examiner in two sessions 1 week apart, or by two examiners in one session.

Session	Mean (SD) PVR (mL)	
	Urologist	Radiologist
First	81.9 (60.28)	82.2 (60.14)
Second	76.6 (67.26)	79.1 (68.96)
<i>P</i> * first vs. second	0.322	0.560
<i>P</i> * urologist vs. radiologist	0.710	0.680

* Student's *t*-test.

Although bladder catheterisation is widely regarded as the standard for measuring PVR, it can cause discomfort to the patients and carries the risk of infection and trauma to the urethra. US, as a noninvasive method of rapidly assessing the PVR, has thus been recommended as an alternative to catheter estimations by many authors. However, while some advocate caution when interpreting PVR measurements made by abdominal US, others consider it to be too inaccurate [4,8].

Given this background the present study was conducted to investigate the reliability and reproducibility of US vs. catheterisation for measuring PVR in men with LUTS. The mean (range) age of the present patients was 63.8 (10.47, 45–88) years, and was comparable to that of the patients included in the study of Amole et al. [4], who assessed 52 consecutive patients with BPH, with a mean age of 64.98 (9.57) years. Simforoosh et al. [1] studied 324 men with persistent LUTS (mean age 61.5, range 48–75 years), to assess the value of US for measuring the PVR.

The mean IPSS of the present patients was 16.2 (8.65), categorised as ‘moderate’. This was comparable to the value in the study of Drasa et al. [9], who included 54 patients with LUTS, with a mean IPSS of 16.9 (7.0), also categorised as moderate.

According to the reliability testing between US and urethral catheterisation for PVR in the two bladder readings (two sessions), the results showed that the US estimate was not reliable, as Cronbach’s α was <0.7 ($P < 0.05$). Inconsistent with our findings, Kiely et al. [10] found that US could provide an approximate measurement of bladder urine volume, but it was not sufficiently reliable and accurate in situations where more precise measurements of changes in PVR were required.

Roehrborn and Peters [11], in agreement with the present results, showed that catheterisation was more accurate and reliable than US for predicting the actual bladder urine volume. However, abdominal US is less invasive than catheterisation, and can also be used to assess bladder wall thickness. Also, in agreement with our results, Simforoosh et al. [1] reported a poor correlation between bladder volumes measured by US and those obtained by urethral catheterisation. They concluded that US cannot reliably and accurately measure bladder volumes, and catheterisation is the most accurate method of measuring PVR, especially at low values. Poston et al. [12] suggested that a correction factor is needed to make US more reliable and accurate in assessing bladder volumes, supporting our data. Estimating PVR by abdominal US is an imperfect measure of the actual volume, and can be subject to considerable variability [1,10,12–14].

A systematic overview by Nwosu et al. [15] and the reports of others [4,16,17] show that US is useful and accurate for measuring PVR, and a good correlation

with the catheterisation volume has been reported. Some suggest that some US systems can provide more accurate information than others [18].

These differences might be due to the design and analysis of these studies, which were often inadequate. Also, previous studies used different methods, techniques and equipment, and the inclusion and exclusion criteria of the recruited patients also differed.

There was no significant variability ($P > 0.05$) in the mean readings obtained by the urologist or the radiologist using US in the two reading sessions, indicating that the US estimate is reproducible with one examiner and several examiners using a single tool. Elsamra et al. [19] reported that a US estimate of PVR was accurate and reproducible. In the present study we confirmed that the reproducibility of the US estimate of PVR urine was good when made by a radiologist or urologist. Several studies agreed with these findings [20–22], noting that recent developments and modifications in ultrasound technology have led to improved reliability and portability of ultrasound instruments that can be used to measure bladder volume.

By contrast with our results, it was suggested that a single measurement of PVR by US might not be useful because it might not be reproducible [14,23,24]. Also, Elsamra et al. [19] stated that although the US estimate is reproducible, it cannot differentiate between a distended bladder and other cystic pelvic structures. They presented several case reports showing falsely high PVR values by bladder US in adults with cystic pelvic structures.

In the present study, the PVR obtained by a urethral catheter was significantly higher than that obtained by US, in the first and second reading session ($P < 0.05$), with a poor correlation between the methods. By contrast with these results, Lertbunnaphong et al. [25] evaluated the correlation between an assessment of PVR by abdominal US and catheterisation. The calculated PVR by US correlated significantly with the catheterised urine volume ($P < 0.001$). This might be because the mean age of the present patients was significantly higher than that of those patients, with a mean age of 63.8 and 55.9 years, respectively. From a review of the Cochrane Database System, Zeif and Subramonian [8] reported that in adults aged > 60 years, because of the decreased contractility of the detrusor muscle, the PVR can be > 100 mL and US of the bladder might show a massive increase in bladder capacity.

In conclusion, the measurement of PVR by US is reproducible either by a urologist or radiologist, but it is not reliable. An estimate of PVR by urethral catheterisation is significantly higher than the US estimate.

Conflict of interest

None.

Funding

None.

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