Arab Journal of Urology (2014) **12**, 209–213

Arab Journal of Urology
(Official Journal of the Arab Association of Urology)

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VOIDING DYSFUNCTION/FEMALE UROLOGY
ORIGINAL ARTICLE

The accuracy of three-dimensional bladder ultrasonography in determining the residual urinary volume compared with conventional catheterisation

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Received 29 December 2013, Received in revised form 23 April 2014, Accepted 3 May 2014
Available online 30 July 2014

KEYWORDS

Bladder scans;
Cystometrogram;
Catheterisation;
Residual urinary volume;
Urodynamics

ABBREVIATIONS

CMG, cystometrography;
US, ultrasonography;
PVR, postvoid residual;
BMI, body mass index;
RPI, real-time pre-scan imaging

Abstract ***Objective:*** To determine the accuracy of three-dimensional bladder ultrasonography (US, using the BVI 3000, Verathon, WA, USA) for determining the residual urinary volume, compared with the conventional catheterisation method.

Patients and methods: We conducted a cross-sectional study at day-care unit of a University hospital after obtaining approval from the Ethics Review Committee of the hospital. Thirty-four patients with lower urinary tract symptoms requiring cystometrography were included. The postvoid volume was measured by bladder US, with three readings taken, and then patient was catheterised using a 12-F Nelaton catheter to measure the urinary volume. The mean of the three readings was compared with the catheterisation volume.

Results: The mean (SD) urinary volumes by US and catheterisation were 261 (186) and 260 (175) mL, respectively, and the correlation (r^2) was 0.97. There was no effect of age, gender or body mass index on the accuracy of bladder US, which was accurate even when the urinary volume was $\leqslant$100 mL.

Conclusion: The bladder US estimate is as accurate as catheterisation for determining the postvoid residual urinary volume. Its accuracy was also comparable

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Peer review under responsibility of Arab Association of Urology.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.aju.2014.05.001

when the urinary volume is < 100 mL, and there was no significant effect of age, gender and body mass index. This system could replace the more invasive catheterisation, and with excellent accuracy.

Introduction

LUTS in both in men and women are evaluated using an objective assessment, e.g., by using the IPSS for men and the Female LUTS instrument in women [1]. The subsequent systematic diagnostic evaluation includes a physical examination, urine analysis, blood analysis, ultrasonography (US) of the prostate, bladder and kidneys, uroflowmetry, a measurement of postvoid residual urine (PVR) volume by US, and a bladder diary in patients with urinary frequency or nocturia [2]. Uroflowmetry is an important and basic urodynamic investigation, which is used in patients with LUTS [3], but the indications for more invasive assessment are limited, and warranted only in specific situations [4]. A non-invasive estimate of bladder pressure, with an estimate of the free flow rate, gives useful information in the assessment of men with LUTS. Determinations of bladder voiding efficiency [5] or residual fraction [6] using the volume before and after voiding are other non-invasive methods.

The PVR volume can be measured using different methods, and although catheterisation is the standard method it is invasive and can result in morbidity. Other methods include B-mode US and a bladder US system. US is also time-consuming, costly and requires training. Bladder US systems were first introduced in 1994 and the initial models were all two-dimensional because they only measured the width and length and did not assess the depth of the bladder. Currently, a three-dimensional bladder scanner (BVI 3000™, Verathon, WA, USA) was suggested to be more accurate than other systems [7,8]. However, there are no reports comparing the BVI 3000 with the standard method and determining its efficacy at extremes of volume; in the present study we evaluated these points.

Patients and methods

The study was conducted in the urodynamic suite of a University hospital. The patients comprised those undergoing cystometrography (CMG), and included those aged > 18 years who had a suspected neurogenic bladder and who were referred for urodynamic studies. We excluded patients with a reduced bladder capacity due to diseases like tuberculosis or interstitial cystitis, with impaired cognitive function, pregnant woman, any with a lower abdominal surgical scar (which could potentially affect the bladder scan), those who could not lie supine, and those with previous bladder augmentation surgery. Patients had a previous US evaluation to exclude diverticulae, and patients with bladder wall deformities, including a thick-walled bladder, were also excluded. As a matter of protocol, patients with significant faecal loading noted during urodynamic catheter insertion or a DRE had the assessment cancelled were also excluded from the study.

The level of significance was set at 0.05, with 80% power, and the minimum sample size, calculated using PASS 12™ software (NCSS, Kaysville, Utah, USA), was 34. We assumed a coefficient of correlation between A and B of 0.97. The normality of the distribution of the data was evaluated and whether outcome frequencies followed a specified distribution (using Pearson's chi-squared test).

Continuous variables are given as the mean (SD) and the correlation coefficient was calculated for urinary volumes estimated by the two methods. Categorical variables were analysed as a proportion with percentages. A paired *t*-test was used to compare the volumes, with $P < 0.05$ considered to indicate a significant difference.

The correlation between bladder US volumes and catheterisation volumes, with adjustment for confounding factors, i.e., age, body mass index (BMI) and gender, was assessed using multiple linear regression analysis.

Patients initially had uroflowmetry, after which they were asked to lie supine and had their bladder scanned using the BVI 3000, using three scans, with the mean of the three taken as the final value. The nurse in the urodynamic suite (not part of the study team) performed the bladder scan. Immediately after scanning the patients were catheterised (by a resident, on rotation through the urodynamic and flexible cystoscopy suite) to determine the PVR volume. A Nelaton catheter (a stiff straight catheter) was used to empty the bladder before starting CMG.

Approval was obtained from the Ethics Review Committee for the study (approval #1721-SUR-ERC-10). Neither the institution nor the investigators had any support, financial, technical or otherwise, from the manufacturer during the conduct of this study.

Results

Thirty-four patients were included in the study (19 male) with a mean (SD) age at presentation of 50.2 (20.2) years and a mean (SD, range) BMI of 26.2 (5.9, 17.6–40.3) kg/