

Bladder wall thickness and ultrasound estimated bladder weight in healthy adults with portative ultrasound device

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Background: The aim of this study was to investigate bladder wall thickness (BWT) and ultrasound estimated bladder weight (UEBW) values in healthy population with a portative ultrasound device and their relationship with demographic parameters. **Materials and Methods:** The study was carried out in Neurorehabilitation Clinic of Ege University Hospital. Ninety-five subjects (48 women and 47 men) aged between 18 and 56 were included in the study. BWT and UEBW were determined non-invasively with a portative ultrasound device; Bladder Scan BVM 6500 (Verathon Inc., WA, USA) at a frequency of 3.7 MHz at functional bladder capacity. These values were compared by gender, and their relation was assessed with age, body mass index (BMI) and parity. **Results:** Mean BWT was 2.0 ± 0.4 mm and UEBW was 44.6 ± 8.3 g at a mean volume of 338.0 ± 82.1 ml. Although higher results were obtained in men at higher bladder volumes, the results did not differ significantly by gender. Correlation analyses revealed statistically significant correlation between UEBW and age ($r = 0.32$). BWT was negatively correlated with volume ($r = -0.50$) and bladder surface area ($r = -0.57$). Also, statistically significant correlations were observed between UEBW and volume ($r = 0.36$), bladder surface area ($r = 0.48$) and BWT ($r = 0.25$). **Conclusion:** Determined values of BWT and UEBW in healthy population are estimated with portative ultrasound devices, which are future promising, for their convenient, easy, non-invasive, time-efficient hand-held use for screening.

Key words: BladderScan BVM 6500, bladder wall thickness, ultrasound, ultrasound estimated bladder weight

INTRODUCTION

Bladder outlet obstruction (BOO) is a clinical condition in association with a number of disorders in the lower urinary tract such as external sphincter dyssynergia, urethral valves, neurogenic bladder dysfunction and benign prostatic enlargement. In the experimental studies, it has been shown that BOO is followed by compensatory increases in bladder wall thickness (BWT) and bladder weight as a result of smooth muscle hypertrophy and decomposition of connective tissue.^[1-3] These findings in response to BOO have been confirmed in humans.^[4-6] In the clinical setting, the detection of these histological changes is an important issue in the early stages of BOO in order to avoid complications including renal failure, recurrent urinary tract infection, urinary incontinence, urinary retention, and bladder and renal calculi.

Although some methods such as cystoscopy and cystography can be used to show bladder wall trabeculations suggesting detrusor hypertrophy, they do not quantitatively evaluate the degree of detrusor hypertrophy.^[7,8] On the other hand, ultrasonography (US) is a non-invasive, simple, fast and wide-acceptable method in evaluating detrusor hypertrophy.^[9-11] By using US, the BWT as an indicator of detrusor hypertrophy

has been noted for many years. Ultrasound estimated bladder weight (UEBW) was reported as a useful method for the objective and quantitative measurement of bladder hypertrophy in the studies.^[6,10,12,13]

Recently, portable handheld US device was introduced to obtain easier and quicker results for BWT and UEBW with understanding significance of diagnosing and evaluating BOO by clinicians. Although this device is commonly used to assess these values, there is only one study that used this device in healthy adults to our knowledge.^[14] However, it is well known that providing BWT and UEBW values in healthy adults is necessary before measurement of these parameters in the patients, to be able to provide normal-pathologic boundaries. For this reason, we aimed to investigate BWT and UEBW values in healthy population with a portative ultrasound device and their relationship with demographic parameters.

MATERIALS AND METHODS

The study was carried out in Neurorehabilitation Clinic of Ege University Hospital. According to a power of 90% and a two-sided alpha value of $P = 0.05$, 95 healthy volunteers (48 women and 47 men) between 18 and 56 years of age were included in the study. They were recruited among

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Received: 02-01-2012; **Revised:** 19-09-2012; **Accepted:** 01-01-2013

hospital employees and inpatients' and outpatients' relatives or caregivers. The subjects were excluded if they had history of lower urinary tract injury or surgery, if they had benign prostatic enlargement or prostatic neoplasm, if they had neurologic disease or diabetes mellitus that would affect functions of lower urinary tract, if they had renal disease, and if they had open wound in or around suprapubic area. The cases with renal stasis or other signs of bladder dysfunction affecting the kidneys were also excluded. The women were excluded if they were pregnant, if they had overactive bladder and pelvic organ prolapse. After the subjects were briefed about the study, and written consent was obtained from all subjects, their demographic characteristics (weight, height, body mass index [BMI], age, gender, and parity) were recorded. The study was approved by the local ethical committee.

Ultrasonographic measurements were performed by using BladderScan® BVM 6500 (Verathon Inc., 20001 North Creek Parkway, Bothell, WA 98011 USA) patented "V" mode technology. The measurements were made according to the manufacturer's instructions. The subjects were scanned in the supine position with a 130° angle rotating ultrasound probe positioned in the midline above the pubic symphysis by 1 of 2 physicians. The scanner automatically detects misalignment and directs the user to the optimal position. Subjects were asked to drink as much water as possible prior to their exam. If the bladder was not of sufficient capacity at the time of measurement, subjects were rescanned after taking free fluids until a capacity of at least 200 ml was reached. Data from the scans were uploaded via the Internet using the proprietary ScanPoint® (Verathon Inc., WA, USA) software program for verification of scan accuracy and automatic calculation of bladder weight according to the algorithm developed by the manufacturer. Then, bladder volume, wall thickness, bladder surface area (BSA) and UEBW were determined automatically by the machine at a frequency of 3.7 MHz at functional bladder capacity [Figure 1]. An individual scanning procedure was completed in 5-10 min.

Statistical analysis

Data were statistically analyzed by using 13.0 Statistical Package for the Social Sciences. The subgroups regarding age and gender were compared using independent samples *t*-test. Correlations between age, gender, BMI, and parity and ultrasound measurement values were computed by Spearman's correlation analysis. All the results were expressed as mean ± standard deviation. A *P* value below 0.05 was considered to indicate statistical significance.

RESULTS

Table 1 summarizes subjects' characteristics. In a total of 95 subjects, 48 (50.5%) were women and 47 (49.5%) were

men. There was no significant difference for age between women and men. BMI was significantly higher in men when compared to women ($P < 0.05$).

The results of the ultrasonographic measurements are presented in Table 2. Although higher results were obtained in men, either BWT or UEBW at higher bladder volumes, compared to women, no statistically significant difference was found between men and women. Parity did not differ regarding BWT and UEBW in women.

Correlation analyses revealed statistically significant correlation between UEBW and age ($r = 0.32$), while no substantial correlations were found between age and other ultrasonographic measurements. BWT was negatively correlated with volume ($r = -0.50$) and BSA ($r = -0.57$). Also, statistically significant correlations were observed between UEBW and volume ($r = 0.36$), BSA ($r = 0.48$) and BWT ($r = 0.25$).

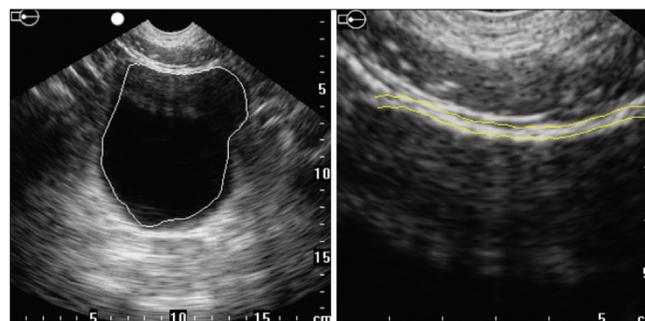


Figure 1: Bladder wall thickness measurement (image on the right side) of a male patient aged 35, at a volume of 385 ml (image on the left side), estimated 2.1 mm

Table 1: The demographic characteristics of subjects

Demographic characteristics	Women (n=48)	Men (n=47)	Total (n=95)	<i>P</i>
Age (years, mean±SD)	36.9±10.1	38.1±10.3	37.5±10.2	0.59
Body mass index (kg/m ² , mean±SD)	23.1±3.5	26.7±3.9	24.9±4.1	0
Parity (mean±SD)	1.3±1.6			

P=comparison by gender with independent samples *t*-test; SD=Standard deviation

Table 2: The results of the ultrasonographic measurements

Ultrasonographic measurements	Women (n=48)	Men (n=47)	Total (n=95)	<i>P</i>
Bladder volume (ml, mean±SD)	325.0±76.7	351.3±86.0	338.0±82.1	0.12
BSA (m ² , mean±SD)	221.0±60.1	238.9±66.3	229.8±63.5	0.17
BWT (mm, mean±SD)	1.9±0.4	2.1±0.5	2.0±0.4	0.16
UEBW (g, mean±SD)	43.0±8.4	46.2±8.0	44.6±8.3	0.06

BWT=Bladder wall thickness; UEBW=Ultrasound estimated bladder weight; BSA=Bladder surface area; SD=Standard deviation; *P*=Comparison by gender with independent samples *t*-test

DISCUSSION

The results of the present study showed that normal BWT value was 2.0 ± 0.4 mm and normal UEBW value was 44.6 ± 8.3 g by using BladderScan BVM 6500, which is a portable ultrasound device. In addition, the association between age and UEBW values was found in this study, as expected, although it was not strong. This finding supports that the increased UEBW values were results of the increased collagen deposition in older women and age-associated detrusor hypertrophy expected in men with increasing bladder outflow tract obstruction, in accordance with previous data.^[15,16]

It is well known that the bladder wall as well as the different layers of the bladder can be imaged with ultrasound technology. By measuring with US device, the BWT has received increasing interest as a non-invasive test to diagnose BOO. On the other hand, measurement of mean BWT is important in order to show women with detrusor instability. Previous studies reported that they had thicker bladder walls than those with genuine stress incontinence suggesting that this change may be due to hypertrophy of the detrusor muscle secondary to repeated detrusor contractions against a closed urethral sphincter.^[17-19] Khullar *et al.*^[20] also reported that detrusor hypertrophy may be result of an increased workload such as detrusor instability. Thus, the assessment of BWT allows an indirect measurement of the detrusor muscle thickness and this provides a potential index of detrusor activity. Previous studies showed that it is a reliable method^[21] and the BWT has been found to correlate well with other measures of BOO such as uroflowmetry and post-void residual.^[4,7]

However, some authors showed that measurement of the bladder wall cannot be used to compare the grade of wall hypertrophy, not only between various patients, but also during follow-up of the same patient due to the fact that the BWT is dependent on the degree of bladder filling.^[22,23]

UEBW, which is independent of volume has the promise to become an important indicator for the diagnosis of BOO. By measuring the anterior BWT and calculating bladder surface area, it can be estimated. The studies showed that UEBW can be used as a reliable tool in the management of BOO and neurogenic bladder dysfunction. Several researchers have proposed the measurement of UEBW. However, in these methods, as the thickness was measured manually; the bladder wall measurements suffered from high inter- and intra-observer variability. In addition, such measurements required filling the patient's bladder to a known fixed volume using a catheter and an expensive high-resolution B-mode ultrasound machine and an ultrasound technician.^[6,10,11,13] Accordingly, Chalana *et al.*^[12]

have developed an automatic and convenient method to estimate UEBW with BladderScan BVM 6500, which is a non-invasive, accurate, reliable, and easy to use. We have used this method to measure UEBW in our study. The results showed the association between age and UEBW values supporting findings of studies that used high-resolution B-mode ultrasound machine.

Although portable handheld US device was introduced to obtain easier and quicker results for BWT and UEBW in the clinical setting, there is only 1 previous study reporting BWT and UEBW normal values in the literature to our knowledge.^[12] In that study, they reported a surprising finding that there was no correlation between UEBW and age. Although we found a significant relation, we cannot explain why its strength was not strong. On the other hand, we have observed an association between UEBW and BSA supporting the results of that study.

Our study has several limitations. Firstly, it can be argued that the number of subjects studied was relatively small. Despite we have decided to admit a number of the subjects according to the power analysis, it can be argued that statistically advised sample sizes for each sex (10 per decade of life of each sex) might increase the real magnitude of the findings. Secondly, because there was no subject over the age of 56, we cannot conclude these results for older ages. It should be, however, noted the difficulty to find the subject without any disease that would affect functions of lower urinary tract in the elderly population. Another limitation can be concluded that BWT values varied with the volume of urine contained in the bladder and this finding may influence the results. Considering the fact that all subjects were scanned with same instructions, including a capacity of at least 200 ml in the bladder, it is obvious that there was no doubt about the accuracy of the results. It is well known that BWT is dependent on the degree of bladder filling as concluded above.

In summary, we have demonstrated normal values of BWT and UEBW by using BladderScan BVM 6500, which is a portative ultrasound device. Results showed that the values of BWT and UEBW in healthy population did not differ significantly by gender and age. The BWT and UEBW can be estimated with portative ultrasound devices which are convenient, easy, non-invasive, time-efficient hand-held use for screening. In the future, determined cut-off values for conditions effecting both BWT and UEBW such as BOO and overactive bladder with portative ultrasound devices may be very useful in our clinical practice.

REFERENCES

1. Schoor RA, Canning DA, Bella RD, Broderick GA, Snyder HM 3rd, Duckett JW, *et al.* Ultrasound diagnosis of bladder outlet obstruction in rabbits. *Neurourol Urodyn* 1994;13:559-69.

2. Levin RM, Haugaard N, O'Connor L, Buttyan R, Das A, Dixon JS, *et al.* Obstructive response of human bladder to BPH vs. rabbit bladder response to partial outlet obstruction: A direct comparison. *Neurourol Urodyn* 2000;19:609-29.
3. Uvelius B, Persson L, Mattiasson A. Smooth muscle cell hypertrophy and hyperplasia in the rat detrusor after short-time infravesical outflow obstruction. *J Urol* 1984;131:173-6.
4. Gilpin SA, Gosling JA, Barnard RJ. Morphological and morphometric studies of the human obstructed, trabeculated urinary bladder. *Br J Urol* 1985;57:525-9.
5. Hakenberg OW, Linne C, Manseck A, Wirth MP. Bladder wall thickness in normal adults and men with mild lower urinary tract symptoms and benign prostatic enlargement. *Neurourol Urodyn* 2000;19:585-93.
6. Kojima M, Inui E, Ochiai A, Naya Y, Ukimura O, Watanabe H. Ultrasonic estimation of bladder weight as a measure of bladder hypertrophy in men with infravesical obstruction: A preliminary report. *Urology* 1996;47:942-7.
7. Landau EH, Jayanthi VR, Churchill BM, Shapiro E, Gilmour RF, Khoury AE, *et al.* Loss of elasticity in dysfunctional bladders: Urodynamic and histochemical correlation. *J Urol* 1994;152:702-5.
8. Ghoniem GM, Regnier CH, Biancani P, Johnson L, Susset JG. Effect of vesical outlet obstruction on detrusor contractility and passive properties in rabbits. *J Urol* 1986;135:1284-9.
9. Manieri C, Carter SS, Romano G, Trucchi A, Valenti M, Tubaro A. The diagnosis of bladder outlet obstruction in men by ultrasound measurement of bladder wall thickness. *J Urol* 1998;159:761-5.
10. Naya Y, Kojima M, Honjyo H, Ochiai A, Ukimura O, Watanabe H. Intraobserver and interobserver variance in the measurement of ultrasound-estimated bladder weight. *Ultrasound Med Biol* 1998;24:771-3.
11. Müller L, Bergström T, Hellström M, Svensson E, Jacobsson B. Standardized ultrasound method for assessing detrusor muscle thickness in children. *J Urol* 2000;164:134-8.
12. Chalana V, Dudycha S, Yuk JT, McMorro G. Automatic measurement of ultrasound-estimated bladder weight (UEBW) from three-dimensional ultrasound. *Rev Urol* 2005;7:S22-8.
13. Ukimura O, Kojima M, Iwata T, Inaba M, Miki T. Ultrasonic measurement of bladder weight as a novel urodynamic modality. *Adv Exp Med Biol* 2003;539:311-5.
14. Morris V, Steventon N, Hazbun S, Wagg A. A cross-sectional study of ultrasound estimated bladder weight in a sample of men and women without lower urinary tract symptoms. *Neurourol Urodyn* 2009;28:995-7.
15. Yang JM, Huang WC. Bladder wall thickness on ultrasonographic cystourethrography: Affecting factors and their implications. *J Ultrasound Med* 2003;22:777-82.
16. Irwin DE, Milsom I, Hunskaar S, Reilly K, Kopp Z, Herschorn S, *et al.* Population-based survey of urinary incontinence, overactive bladder, and other lower urinary tract symptoms in five countries: Results of the EPIC study. *Eur Urol* 2006;50:1306-14.
17. Khullar V, Cardozo LD, Salvatore S, Hill S. Ultrasound: A noninvasive screening test for detrusor instability. *Br J Obstet Gynaecol* 1996;103:904-8.
18. Robinson D, Anders K, Cardozo L, Bidmead J, Toozs-Hobson P, Khullar V. Can ultrasound replace ambulatory urodynamics when investigating women with irritative urinary symptoms? *BJOG* 2002;109:145-8.
19. Serati M, Salvatore S, Cattoni E, Soligo M, Cromi A, Ghezzi F. Ultrasound measurement of bladder wall thickness in different forms of detrusor overactivity. *Int Urogynecol J* 2010;21:1405-11.
20. Khullar V, Salvatore S, Cardozo L, Bourne TH, Abbott D, Kelleher C. A novel technique for measuring bladder wall thickness in women using transvaginal ultrasound. *Ultrasound Obstet Gynecol* 1994;4:220-3.
21. Panayi DC, Khullar V, Fernando R, Tekkis P. Transvaginal ultrasound measurement of bladder wall thickness: A more reliable approach than transperineal and transabdominal approaches. *BJU Int* 2010;106:1519-22.
22. Brkljacić B, Kuzmić AC, Dmitrović R. Ultrasound-estimated bladder weight in healthy children. *Eur Radiol* 2004;14:1596-9.
23. Jequier S, Rousseau O. Sonographic measurements of the normal bladder wall in children. *AJR Am J Roentgenol* 1987;149:563-6.

How to cite this article: Kanyilmaz S, Calis FA, Cinar Y, Akkoc Y. Bladder wall thickness and ultrasound estimated bladder weight in healthy adults with portative ultrasound device. *J Res Med Sci* 2013;18:103-6.

Source of Support: The equipment and financial support was provided by Ege University for the project., **Conflict of Interest:** None declared.