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Original article

Accuracy of ultrasound-measured bladder wall thickness for the diagnosis of detrusor overactivity

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Abstract

Objectives: To evaluate the usefulness and accuracy of ultrasound-measured urinary bladder wall thickness (BWT) in the diagnosis of detrusor overactivity (DO).

Subjects and methods: Patients who had undergone urodynamic testing due to irritative lower urinary tract symptoms (LUTS) were evaluated for participation in this study. All patients were submitted to thorough history taking, general physical and genital examination, urine analysis, urine culture, blood chemistry, uroflowmetry and abdominal ultrasonography. The patients were categorized into 2 groups according to the urodynamic diagnosis: group 1 consisted of 62 patients with documented DO and group 2 of 36 patients with no evidence of DO (controls). Ultrasound measurement of BWT was performed with the bladder filled with 50 ml of normal saline solution. The data were analyzed and the results of both groups were compared using suitable analytical tests.

Results: The age and gender distribution were comparable. Urgency was the main symptom in both groups. Mean BWT measured by ultrasound was significantly higher in group 1 than in group 2 (5.54 ± 1.95 mm versus 3.22 ± 0.84 mm, $p < 0.001$) with an overall sensitivity of 91.9% in predicting DO at a cutoff point of 3.75 mm.

Conclusions: Measurement of BWT using ultrasonography is a sensitive diagnostic test for the prediction of DO. Further studies on a larger number of patients are required to validate these results.

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Introduction

Overactive bladder (OAB) is a symptom complex affecting approximately 10% of the population, and its prevalence increases with increasing age. In spite of not being a life-threatening condition, the symptoms associated with OAB have a deleterious effect on the patients' quality of life. OAB is defined as an involuntary detrusor contraction during filling cystometry (FCM). It may be spontaneous or provoked and of any magnitude and duration [1]. Although FCM is an accurate diagnostic test for OAB, it carries the disadvantages of being expensive, invasive, technically difficult and requiring physicians experienced in urodynamics to interpret the results [2].

Ultrasonography plays a role in the evaluation of patients with voiding dysfunction (VD). This is due to the fact that VD may result in an alteration of the anatomic structures of the urinary tract and vice versa [3]. Recently, ultrasound measurement of bladder wall thickness (BWT) has been used for the diagnosis of OAB. Many authors [4–8] reported that the increase in BWT can be a valuable biomarker for detrusor overactivity (DO) in patients with an OAB syndrome. They assumed that the increased BWT in OAB is secondary to detrusor hypertrophy associated with increased isometric detrusor contraction against a competent urethral sphincter. Although it is generally agreed upon that an increase in mean BWT is unique to DO, there is no fixed cutoff value for the definition of a thick bladder wall. Likewise, there is no standardized method for bladder scanning and measurement of BWT, as bladder filling greatly affects the results.

In our study, the usefulness and accuracy of transabdominal ultrasound-measured BWT in the diagnosis of DO in patients with irritative lower urinary tract symptoms (LUTS) were prospectively evaluated.

Patients and methods

After obtaining the approval of the local ethical committee, the study was conducted between March 2012 and March 2014 on adult patients with irritative LUTS who had undergone urodynamic testing at the urodynamic units of various university hospitals in Cairo, Egypt, and Al-Kharj, Saudi Arabia. All the patients were informed about the study procedure and invited to participate in the study. Patients who agreed to participate in the study provided their written informed consent.

Patients with obvious neurogenic disorders, diabetes mellitus, urinary tract infection, bladder outlet obstruction (BOO), stone disease, genitourinary malignancies and/or a history of lower urinary tract injury or surgery were excluded from the study. Pregnant women and those with genital prolapse were excluded as well.

Out of 127 patients who had been subjected to urodynamic testing, 14 refused to participate in the study. From the remaining 113, 15 had to be excluded as they met one or more of the above mentioned exclusion criteria, resulting in a total number of 98 study participants: 62 patients (45 females and 17 males) in group 1 and 36 patients (23 females and 13 males) in group 2.

Patient assessment included thorough history taking, general physical and genital examination, routine urine analysis, urine culture and sensitivity, uroflowmetry and abdominal ultrasonography. Prior to ultrasound scanning, the urinary bladder was emptied completely and then refilled with 50 ml of normal saline solution through a urodynamic catheter. Scanning was done with the patient in supine position, using an ultrasound device (BK Medical, Herlev, Denmark) and aconvex abdominal 3.5 MHz probe. The bladder was scanned in transverse and longitudinal planes, and BWT was measured from the interface of urine and bladder mucosa to the outer part of the muscle layer. After scanning, the patients were asked to drink large amounts of fluids, and free uroflowmetry was performed in complete privacy. Then, post-void residual (PVR) urine was measured within 5 min of ordinary toilet voiding. The results of uroflowmetry and the PVR urine volume were correlated with each other to rule out BOO.

FCM was performed with the patient in sitting position, using an Ellipse 4 AUDACT device. The terms and methods complied with the recommendations of the International Continence Society (ICS) [9]. DO was diagnosed when involuntary contractions, either spontaneous or provoked, were observed during bladder filling.

The patients were categorized into 2 groups according to the results of FCM: group 1 included patients with documented DO and group 2 patients with no evidence of DO (controls).

Statistical analysis

The data were statistically analyzed using SPSS 13.0 for Windows (SPSS Inc.; Chicago, IL). A test of normality was done to assess the distribution of variables. The Student's *t*-test was used to compare continuous variables, while the Chi-Square and Fisher exact tests were used to compare the categorical variables of both groups, with $p < 0.05$ being considered statistically significant. The two-way ANOVA test was used to detect the relationship between BWT, gender and DO, while the Pearson correlation coefficient was used to detect the relationship between BWT and age. The specificity and sensitivity of BWT in the diagnosis of DO were determined using the receiver–operator characteristic (ROC) curve.

Results

No statistically significant differences were observed between both groups regarding age and gender distribution. Urgency was the main presenting symptom in all patients in both groups. The second most common presenting symptom was urinary frequency that was recorded in 93.5% of patients in group 1 and 63.9% of group 2. In group 1, urge incontinence and nocturia were recorded in 32.3% and 14.5% of patients, respectively, while none of the patients in group 2 had urge incontinence and only one patient had nocturia (Table 1).

BWT estimated by ultrasonography was significantly higher in group 1 than in group 2 (5.54 ± 1.95 mm versus 3.22 ± 0.84 mm, $p < 0.001$). In group 1, the BWT was >3–5 mm in 32 patients (51.6%), >5–10 mm in 26 patients (41.9%) and <10 mm in 4 patients (6.5%). In group 2, it was ≤3 mm in 19 patients (52.8%), <3–5 mm in 15 patients (41.7%) and >5–10 mm in 2 patients (5.6%) (Table 2 and Fig. 1).

Depending on the results of FCM as a final diagnostic tool, the increased BWT >3.75 mm had a sensitivity of 91.94% (95% CI:

Table 1 Clinical characteristics of both groups.

Variables	Group 1 Documented DO ($n=62$)	Group 2 No evidence of DO ($n=36$)	p-Value
Age	34.02 ± 7.11	32.08 ± 7.68	0.211
Gender			0.375
Females	45 (72.6%)	23 (63.9%)	
Males	17 (27.4%)	13 (36.1%)	
Clinical presentation			
Urgency	62 (100%)	36 (100%)	–
Frequency	58 (93.5%)	23 (63.9%)	<0.001
Urge incontinence	20 (32.3%)	0 (0.0%)	<0.001
Nocturia	9 (14.5%)	1 (2.8%)	0.087

DO, detrusor overactivity.

Table 2 Difference in BWT in both groups.

BWT	Group 1 Documented DO ($n=62$)	Group 2 No evidence of DO ($n=36$)	p-Value
Mean, mm	5.54 ± 1.95	3.22 ± 0.84	<0.001
Category			<0.001
≤3	0 (0.0%)	19 (52.8%)	
>3–5	32 (51.6%)	15 (41.7%)	
>5–10	26 (41.9%)	2 (5.6%)	
>10	4 (6.5%)	0 (0.0%)	

BWT, bladder wall thickness; DO, detrusor overactivity.

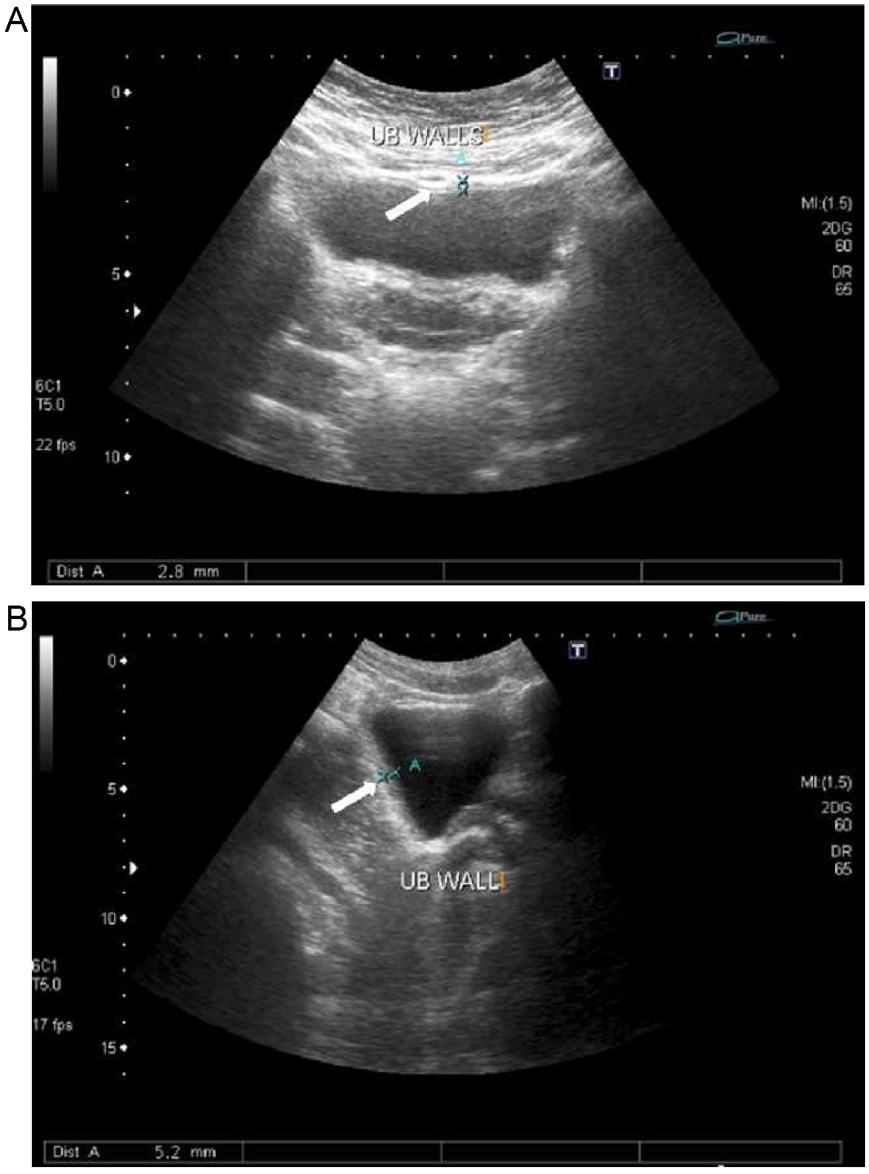

Fig. 1 (A) An ultrasound image of the urinary bladder (transverse scan) showing normal bladder wall thickness (BWT) (a, arrow) in a middle-aged woman with irritative lower urinary tract symptoms (LUTS) and normal filling cystometry (FCM); (B) Ultrasound image (longitudinal scan) showing increased BWT (b, arrow) in a middle-aged man with irritative LUTS and detrusor overactivity diagnosed by FCM.

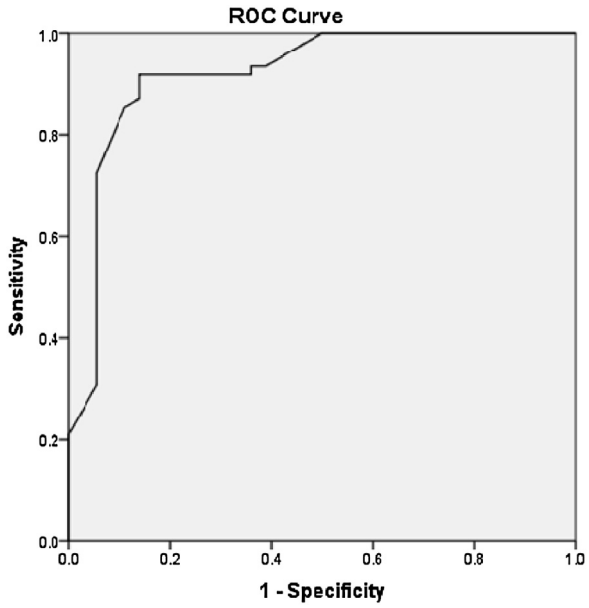

Fig. 2 ROC curve analysis of BWT. Cut off point = 3.75; Sensitivity = 91.9%; Specificity = 86.1%; Positive predictive value (PPV) = 91.9%; Negative predictive value (NPV) = 86.1%; Overall agreement = 89.8%; Area under the Curve = 0.92.

82.16–97.30%) and a specificity of 86.1 (95% CI: 70.49–95.28%) for the diagnosis of DO (Fig. 2).

BWT was 5.98 ± 2.31 mm in the male and 5.38 ± 1.79 mm in the female patients of group 1 compared to 3.49 ± 0.88 in the male and 3.07 ± 0.80 mm in the female patient of group 2.

Regarding the relationship between BWT as a dependent variable and gender and DO as independent variables, two-way ANOVA showed a significant relationship between BWT and DO ($p < 0.001$) and a non-significant relationship between BWT and gender ($p = 0.142$).

There was a positive correlation between the patients' age and BWT. This correlation was non-significant in both groups (Pearson correlation: $r = 0.266$, $p = 0.117$ for group 1 and $r = 0.090$, $p = 0.486$ for group 2).

Discussion

In the last decade, many studies have been conducted to evaluate the value of ultrasound-estimated BWT as a new simple, cheap and non-invasive method for the diagnosis of DO. This was based on the concept that in cases of DO the thickness of the bladder wall is increased due to repeated isometric contractions of the detrusor muscle against a competent urethral sphincter. These contractions lead to an increase in intravesical pressure, giving the patient a very strong desire to void. During this process the patient tries to keep himself dry depending on the competent urethral sphincter and contractions of pelvic floor muscles leading to more detrusor hypertrophy [7]. Therefore, a correlation between an increased BWT and DO can be assumed and may be used as an indicator for the detection of DO [4].

In our series, mean BWT as measured by trans-abdominal ultrasonography at a bladder capacity of 50 ml was sensitive in detecting DO (91.9% sensitivity and 86.1% specificity) at a cutoff value of 3.75 mm. These findings agree with those of Abou-Gamrah et al. [10] who reported a 90% sensitivity and a 78% specificity. Tangal et al. [11] who performed their study on children reported lower values (67% sensitivity and 80% specificity).

Our findings also agree with those of Khullar and associates [4] who recommend the use of ultrasound-measured BWT as a non-invasive screening technique for the assessment of DO in females with urinary incontinence without BOO. Our findings are also in accordance with the results obtained by Lekskulchai and Dietz [12] who found a statistically significant correlation between BWT and DO.

While Robinson et al. [13] reported normal BWT in female patients with incontinence due to an incompetent urethral sphincter, our patients with incontinence had thicker bladder walls than normal. There is no clear explanation for our finding. However, we assume that repeated isometric contractions of the detrusor muscle against the partially competent sphincter and the pelvic floor contraction in patients with DO can still lead to detrusor hypertrophy.

In the present study, BWT in patients with documented DO was significantly higher than in patients with normal cystometry. This complies with the results of Lekskulchai and Dietz [12], as well as with those of Blatt et al. [14] who reported significantly higher BWT in patients with DO than in control cases. On the other hand, according to Kanyilmaz et al. [15], measurement of the bladder wall cannot be used to compare the grade of bladder wall hypertrophy, not only between various patients, but also during follow-up of the same patient, due to the fact that BWT is variable and is changing with the degree of change of the bladder volume.

Regarding the relation between BWT and gender, Oelke et al. [16] reported greater BWT in males than females in normal individuals. However, Blatt et al. [14] and Kanyilmaz et al. [15] reported no significant difference. In patients with DO, Khullar et al. [4] and Blatt et al. [14] found significantly greater BWT in women with DO compared to controls [7]. The present study showed no significant relationship between BWT and gender distribution. However, there is a positive correlation between BWT and age in both groups. This association may be attributed to the possibility of hidden BOO, especially in elderly males.

Despite being a prospective study, our cohort of study participants is not without shortcomings. The lack of a healthy control group and the small number of patients are the main limitations of this study. Further three-arm studies including a healthy control group and a larger number of patients may be warranted to validate the results.

Conclusions

Ultrasound-measured BWT is a sensitive technique for diagnosis of patients with DO. This technique also has the advantage of being technically easy and non-invasive and of providing information about the anatomical structure of the urinary tract.

Conflict of interest

The authors declare no conflict of interest.

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