



Role of Ultrasound-Measured Bladder Wall Thickness for the Diagnosis of Detrusor Overactivity

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Abstract

Background: Detrusor overactivity (DO) is a biomarker for overactive bladder (OAB) which is seen in urodynamic study. Urodynamic study is indicated in OAB when occult diagnosis suspected which may alter management, refractory OAB; and potential morbid surgery planned. Urodynamic test is costly, invasive and time consuming. Ultrasonogram (USG) measured bladder wall thickness is the simplest option as it is cheap, available and noninvasive procedure. This study has been designed to find the role of trans-abdominal USG measured urinary bladder wall thickness (BWT) to diagnose urodynamically proven detrusor overactivity.

Materials and methods: Total 30 refractory OAB patients were included for the study. All study population underwent BWT measurement and urodynamic study. Study population was categorized into Group A and Group B according to presence and absence of DO in urodynamic study. Student t-test and Chi-square test were used to compare continuous and categorical variable respectively. Pearson Correlation test was used to detect the relationship between BWT and age. Sensitivity and specificity of BWT in the diagnosis of DO were measured by ROC curve.

Result: Bladder wall thickness was significantly greater in DO group compared to no DO group ($p < 0.001$). But the area under the curve (AUC) was 0.0928 denoting very low diagnostic accuracy of bladder wall thickness for the diagnosis of DO.

Conclusion: Higher bladder wall thickness may be a useful method to detect DO. Ultrasound for bladder wall thickness is not standardized for at which point of bladder volume to measure BWT, probe frequency, routes of measurement and site of measurement in urinary bladder. Bladder wall thickness is not an alternate diagnostic tool for DO. Trans-abdominal ultrasound measured BWT can't be used as biomarkers for DO in OAB patient.

Keywords: Detrusor overactivity (DO), overactive bladder (OAB), bladder wall thickness (BWT), Trans-abdominal Ultrasonogram (USG)

Background:

Overactive bladder is common in both men and women. It has significant impact on overall quality of life (QOL), sexual function, sleep and mental health.

The European Prospective Investigation into Cancer and Nutrition (EPIC) study, a multinational study

conducted in Canada, Germany, Italy, Sweden and UK showed that the prevalence of lower urinary tract symptom (LUTS) suggestive of OAB was 10.8% in male and 12.8% in female. Overall prevalence of LUTS was found similar in both sexes in multiple other studies and prevalence is increased with increasing age¹.

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According to the International Continence Society (ICS) definition, OAB consists of urinary urgency with or without urge incontinence, often accompanied by frequency and nocturia². Overactive bladder is a symptomatic diagnosis, whereas detrusor overactivity (DO) is a urodynamic observation.

Urodynamic is the functional study of lower urinary tract and DO observed during filling cystometry, which is characterized by involuntary detrusor contraction during filling phase which may be spontaneous and provoked². Filling cystometry carries the disadvantages of being expensive, technically difficult, requiring physicians experienced in urodynamics to interpret the results, having complication and not available in the periphery of our country.

Ambulatory urodynamic is more sensitive in detecting DO. But ambulatory urodynamics is more labour intensive, requires different equipment and takes longer time to perform³. Mean bladder wall thickness measured on trans-abdominal ultrasonogram (USG) appeared to be a sensitive method of detecting DO. Increase in detrusor wall thickness is probably due to the detrusor muscle hypertrophy secondary to isometric detrusor contraction against patent external sphincter. During the contraction of the detrusor muscle intravesical pressure rises, causing an urgent desire to void. On attempt to remain continent patient is increases urethral closure pressure using urethral sphincter and pelvic floor muscle. This leads to an isometric detrusor contraction and eventually detrusor hypertrophy⁴. It would be impractical to use ambulatory urodynamics as a first line test because it takes so long to perform. Additionally, ambulatory urodynamics is not as sensitive as laboratory urodynamics at detecting urethral sphincter incompetence.

USG measured BWT is a sensitive indicator of DO. A bladder wall thickness (BWT) value over 3.75 mm at bladder volume 50ml without bladder outflow obstruction with irritative LUTS is a biomarker for DO, found high sensitivity and specificity⁵. Detrusor wall thickness much varies with volume of filling. There is no standard guideline for measuring BWT to bladder volume. There are different routes of bladder wall thickness measurement like trans-abdominal, trans-vaginal or trans-perineal. Study showed that no significant difference in BWT at volume 200ml and beyond or bladder filled 50% of volume to bladder capacity⁶. Increase BWT usually takes place in detrusor muscle, so detrusor wall thickness (DWT) is actually measured. Measuring bladder wall thickness by trans-abdominal ultrasonogram of overactive bladder patient and by doing laboratory urodynamic study and correlation of two results can establish

ultrasonogram measured bladder wall thickness (BWT) as a suitable alternative to diagnose detrusor overactivity. We tried to develop an easier, office-based noninvasive diagnostic tool for DO.

Methods:

After obtaining the approval of the local ethical committee, the study was conducted between July 2018 and August 2019 on adult patients with overactive bladder symptoms at the urodynamic unit of BSMMU hospital. All the patients were informed about the study procedure and invited to participate in the study. Patients who agreed to participate in the study written informed consent was taken from them.

Patient assessment included - history taking, 3 days voiding diary, overactive bladder symptom score (OABSS) questionnaire, examination of genitor-urinary system, digital rectal examination, routine urine analysis, urine culture and sensitivity, uroflowmetry and abdominal ultrasonography and urodynamic study.

USG was done at bladder capacity when bladder volume more than 200ml. Scanning was done with the patient in supine position, using an ultrasound device LOGIC-P3-GE Healthcare (USA) and Siemens (Germany) and abdominal 7.5 MHz convex transducer. The bladder was scanned and BWT was measured from the interface of urine and bladder mucosa to the outer part of the muscle layer. Anterior and lateral bladder wall thickness was measured in transverse and longitudinal planes. Then average measurement was calculated. Then volume of bladder at bladder capacity was measured by following formula:

Volume = $\frac{\pi}{6} \times (X \times Y \times Z)$, where X, Y, and Z represent the measured distances of the largest transverse measurement, longitudinal measurement, and depth of the bladder⁷.



Figure 01: Ultrasound image of increase BWT in patients with DO

Urodynamic study was performed with the patient in lying position and those with urge incontinence on sitting position. The machine was Menfix Biomedica using Pico Smart software. The terms and methods will be complied with the recommendations of the International Continence Society (ICS). Before the urodynamic examination patients was asked to void. A dual channel water filled urodynamic catheter placed in bladder and another fluid filled catheter placed in rectum. Then residual urine volume was measured after draining the bladder. Then catheter was flushed with water to make air free. Then zeroing of machine was done. Bladder filling was maintained at 30ml/min. During bladder filling patients was instructed to report bladder sensations to the examiner. Quality of signals was checked by asking patient to gently cough. DO was diagnosed when involuntary detrusor contractions, either spontaneous or provoked, observed during bladder filling. At the point of strong desire to void patient was instructed to void in uroflowmeter and voiding phase was then recorded. If uodynamically bladder outflow obstruction seen then that patient excluded from study. Rest of the patients was kept into the study.

The patients were categorized into 2 groups according to the results of urodynamic study-Group A: patients with documented DO

Group B: patients with no evidence of DO

Bladder wall thickness of group A and group B were compared and statistical analysis done with other variables.

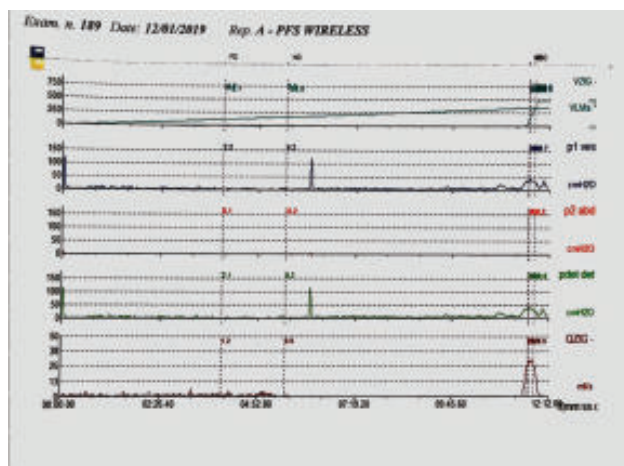


Figure 02: Urodynamic tracing of OAB patient with DO

The data was statistically analyzed using SPSS 25.0 for Windows (SPSS Inc. Chicago, IL, USA). The Student t-test was used to compare continuous variables- age, weight, volume at bladder capacity by USG. Chi-Square test was used to compare the categorical variables- sex, urge incontinence, OABSS symptom score, urinary bladder wall thickness, detrusor overactivity. The Pearson Correlation test was used to detect the relationship between BWT and age. The specificity and sensitivity of BWT in the diagnosis of DO was determined using the receiver-operator characteristic (ROC) curve. $P < 0.05$ being considered statistically significant.

Results

The study population was refractory OAB patients indicated for urodynamic study. A total 30 patients was selected for the study. Study sample categorized into Group A and Group B depend on presence and absence of DO. Student t test was used for quantitative variable and Chi-Square test was used for qualitative variable. Sensitivity and specificity measured by ROC curve. Among the 30 patients, Group A: 14 (46.7%) patients had detrusor overactivity while Group B: 16 (53.3%) patients did not have detrusor over activity (Figure 03).

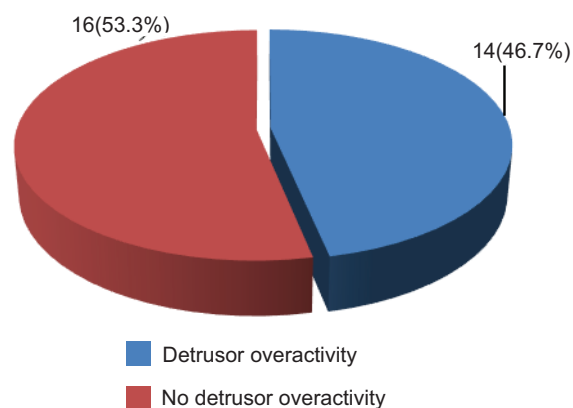


Figure 03: Distribution of study population by detrusor overactivity (N=30)

Mean age was in group A: 34.7 years and in group B: 35.06 years. There was no statistical difference regarding age between two groups as the p value was 0.941 (obtained by Student t test) (Table 1).

Table I : Comparison of study population by age (N=30)

Age (in years)	Group A (n=14)	Group B (n=16)	P value
Mean \pm SD	34.71 \pm 15.03	35.06 \pm 10.42	0.941

In this study 18 patients were male and 12 patients were female. No significant gender difference was seen between the study population as the p-value was >0.05 . Mean weight was 58.31kg in Group A and 60.21kg in Group B. There was no statistical difference regarding weight between two groups as the p value was 0.515. (Table II).

Table II : Comparison between Group A and Group B study population by sex (N=30)

Traits	Group A (n=14) No. (%)	Group B (n=16) No. (%)	P value
Gender Male	6 (42.9%)	12 (75.0%)	0.135
Female	8 (57.1%)	4 (25.0%)	
Weight (in kg) Mean \pm SD	58.31 \pm 8.74	60.21 \pm 6.75	0.515

In Group A, 4 (28.6%) patients had OABSS of 10 and another 4 (28.6%) patients had OABSS of 11. In Group B, 11 (68.8%) patients had OABSS of 10, 4 (28.6%) patients had OABSS of 11. No patient in group B had score of 13 and 14. There was no statistical difference regarding OABSS score between two groups as the p value was 0.135 (Table - III).

Table III : Distribution of Group A and Group B study population by Over Active Bladder Symptom Score (OABSS) (N=30)

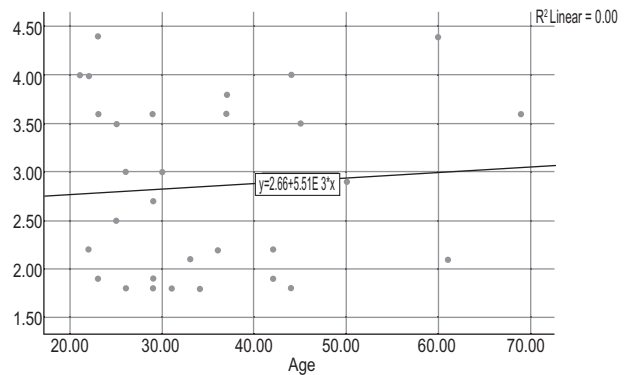
OABSS	Group A (n=14) No. (%)	Group B (n=16) No. (%)	P value
10	4 (28.6%)	11 (68.8%)	0.135
11	4 (28.6%)	4 (25.0%)	
12	3 (21.4%)	1 (6.3%)	
13	2 (14.3%)	0 (0.0%)	
14	1 (7.1%)	0 (0.0%)	
Total	14 (100.0)	16 (100.0)	

In Group A nine patients had urge incontinence and in Group B four patients had urge incontinence. No statistical difference found in urge incontinence between DO and no DO group ($p=0.063$) (Table 4)

Table IV : Comparison of study population by urinary urge incontinence (N=30)

Urge incontinence	Group A (n=14) No. (%)	Group B (n=16) No. (%)	P value
Absent	5 (35.7%)	12 (75.0%)	0.063
Present	9 (64.3%)	4 (25.0%)	
Total	14 (100.0)	16 (100.0)	

There was no statistical difference regarding bladder capacity between two groups as the p value was 0.515. Also there was no significant correlation present between bladder wall thickness and age of patients ($r=0.077$, $p=0.687$) (Figure IV).

**Figure 04:** Correlation between age and bladder wall thickness

In Group A, 13 (92.9%) patients had bladder wall thickness ≥ 2.8 mm while in Group B, 2 (12.5%) patients had bladder wall thickness ≥ 2.8 mm. There was highly significant statistical difference regarding bladder wall thickness between two groups as the p value was <0.001 (Table V).

Table V : Comparison of study population by bladder wall thickness (N=30)

Bladder wall thickness (in mm)	Group A (n=14)	Group B (n=16)	P value
<2.8	1 (7.1%)	14 (87.5%)	<0.001
≥ 2.8	13 (92.9%)	2 (12.5%)	
Mean \pm SD	3.67 \pm 0.50	2.13 \pm 0.39	

Receiver Operator Characteristics (ROC) curve analysis of bladder wall thickness for the diagnosis of

detrusor overactivity. The area under the curve was 0.0928 denoting very low diagnostic accuracy of bladder wall thickness for the diagnosis of detrusor overactivity (Figure 5 and table VI).

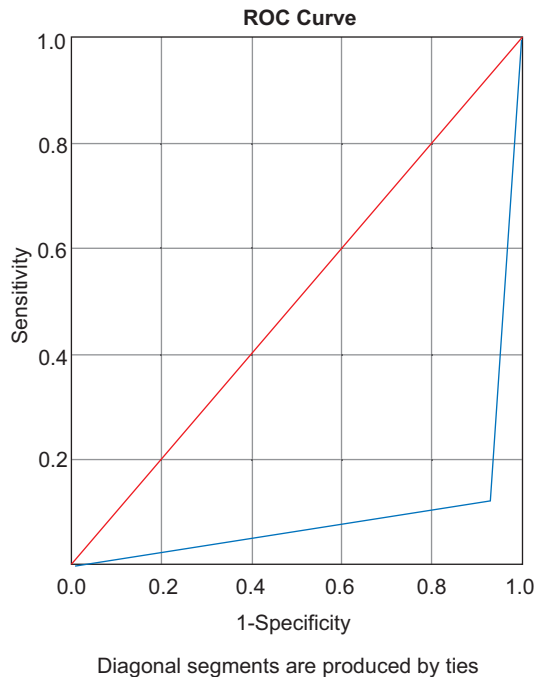


Figure 05: ROC curve of bladder wall thickness among the study population

Table X: ROC curve analysis for detrusor overactivity

ROC curve analysis for BWT

Area under the ROC curve	0.098
Standard error	0.063
95% Confidence interval	0.000-0.223
P value	<0.001

Discussion

This study was designed to evaluate the role of trans-abdominal USG measure BWT for the diagnosis of urodynamically proven detrusor overactivity. Total 30 OAB patients were included in this study. In the analysis of variables urgency, frequency and nocturia were present in all study population. Other variables differ between group A and group B. In group A 14 (46.7%) patients had detrusor overactivity while group B 16 (53.3%) patients did not have detrusor overactivity on urodynamic study. Setrati et al, (2010) found 59.5% patient had detrusor overactivity on OAB patient. Hashim and Abram (2006) found 65% OAB patients having DO.

Mean age of patients was 34 ± 15.03 and 35 ± 10.42 in group A and group B respectively. This age group coincides with Ali et al, (2015). But in the study of Kuhn et al, (2011), Blat et al, (2008), Hashim and Abram (2006) mean age was more than 50 years.

Total 18 male and 12 female was included in this study. Whereas Khuller et al, (1996), Robinson et al, (2002), Kuhn et al, (2011), Serati et al, (2010), Kuo et al, (2009) and Chung et al, (2009) conducted study among female. Other study which took both sexes, female patients was more - Hashim and Abram (2006), Ali et al, (2015) and Blat et al, (2008).

Average group A patient was 58 ± 8.74 kg weight and group B patient was 60.21 ± 6.75 kg weight ($p = 0.515$). In this study 9 patients were OAB wet in DO group and 3 patients were OAB wet on without DO group. There was no significant difference of OABSS score in both groups ($p = 0.135$).

Mean bladder capacity 312.86 ± 44.28 and 343 ± 47.15 in group A and group B respectively ($p = 0.515$). Yang and Huang (2003), Serati et al, (2010), Kuhn et al, (2011), Abou-Gamrah et al, (2014) conducted study less than 50ml of bladder volume. Ali et al, (2015) measure BWT on 50ml bladder volume. Kuo (2009) and Chung et al, (2009) measure BWT at 250 and bladder capacity. Blatt et al, (2008) and Ozturk et al, (2011) measure bladder wall thickness at 200ml bladder volume. There is no standard protocol of which fixed volume bladder wall thickness should measure. In general empty or minimal bladder volume (<50ml) measured by trans vaginal route in female and full bladder scanned through trans-abdominal route.

Regarding correlation of bladder wall thickness with age, that no significant correlation was present between bladder wall thickness and age of patients ($r = 0.077$, $p = 0.687$) (Pearson Correlation). This study supports the findings of Ali et al, (2015) and others.

Mean bladder wall thickness was 3.67 ± 0.5 in DO group and 2.13 ± 0.39 in without DO group. In this study highest bladder wall thickness was 4.4mm. There was statistical significant difference in bladder wall thickness observed in two groups ($p < 0.001$). There was also overlap in bladder wall thickness between both groups. But in ROC curve, area under the curve was only 0.098. This means poor sensitivity and specificity in BWT in detrusor overactivity diagnosis. This findings support the result of Lekskulchai and Dietz (2008). They showed patients with detrusor

overactivity had higher detrusor wall thickness ($4.7 \pm 1.9\text{mm}$ vs. $4.1 \pm 1.6\text{mm}$, $p < 0.001$). But ROC curve showed area under the curve 0.606 and demonstrated DWT of little use as a diagnostic test for DO. Serati et al, (2010) also showed significant increase in bladder wall thickness in DO group $5.22 \pm 1.17\text{mm}$ ($p < 0.0001$). But this study also show low sensitivity for DO diagnosis by BWT in ROC curve analysis.

In contrary to this study, other study like Ali et al, (2015), Kuo (2009), Abou-Gamrah et al, (2014) got significant AUC on ROC curve analysis. Moreover they measure BWT in fixed bladder volume 50ml or empty bladder.

Conclusion

Higher bladder wall thickness may be a useful method to detect DO. But to use it as diagnostic method is limited. Ultrasound for bladder wall thickness is not standardized for at which point of bladder volume to measure BWT, probe frequency, routes of measurement and site of measurement in urinary bladder. Bladder wall thickness is not an alternate diagnostic tool for DO. Trans-abdominal ultrasound measured BWT can't be used as biomarkers for DO in OAB patient.

Limitations of the study

1. Small sample size.
2. Single centre study.
3. Absence of inter-observer reliability of ultrasound to measure BWT.
4. Bladder wall thickness not measured at fixed bladder volume.
5. There was no healthy control group
6. Authentication of OABSS symptom score in bengali language not taken.

Recommendations

Urodynamic study continues to be a relevant diagnostic tool for DO. Further clarification required for BWT as an additional test in a primary care setting for DO. Multicentre study should be conducted taking large sample size.

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