Original Article

Correlation between Bladder Wall Thickness and Uroflowmetry in West African Patients with Benign Prostatic Enlargement

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Abstract

Background: Pressure flow urodynamic study remains the gold standard for the diagnosis of bladder outlet obstruction; however, their use is limited by their relative unavailability in our environment, cost, and invasiveness. Measurement of bladder wall thickness (BWT) by transabdominal ultrasonography is a promising tool that can be used to diagnose bladder outlet obstruction in our environment where pressure-flow urodynamic study is not readily available. **Objective:** The study aimed to correlate BWT with uroflowmetry and to establish a BWT cut-off in patients with lower urinary tract symptoms (LUTS) due to benign prostatic enlargement. **Materials and Methods:** This was a prospective one-year study of patients with LUTS due to benign prostatic enlargement. The patients were divided into obstructed and non-obstructed groups with Q- max of 10 ml/s serving as the cut-off value. Receiver Operator Curve (ROC) was used to evaluate the performance of BWT in diagnosing BOO. Statistical significance was set at $P < 0.05$. **Results:** The mean BWT and Q-max were 4.53 ± 2.70 mm and 15.06 ± 9.43 ml/s. There was a negative correlation between BWT and Q-max (r = -0.452, P = 0.000), Q-average (r = -0.336, P = 0.000), and voided volume (r = -0.228, P = 0.046). A BWT cut-off of 5.85 mm was found to be the best threshold to differentiate obstructed from non-obstructed patients with a sensitivity and specificity of 70 and 88.2 percent respectively. **Conclusion:** Bladder wall thickness showed an inverse relationship with maximum flow rate with high sensitivity and specificity. This non-invasive test can be used as a screening tool for BOO in our setting, where the pressure flow urodynamic study is not readily available.

Keywords: *Bladder outlet obstruction, bladder wall thickness, lower urinary tract symptoms, Nigeria, uroflowmetry*

Introduction

Benign prostatic enlargement is a common cause of lower urinary tract symptoms (LUTS) in aging men.[1-3] Globally, an estimated 1.1 billion men have lower urinary tract symptoms/bladder outlet obstruction. The prevalence is estimated to increase in the developing world, particularly in Africa.[4] The prevalence of BPH in Ghana is estimated to be 13.3%.[5] In Port Harcourt, Nigeria, Bock-Oruma *et al*.[6] reported a prevalence rate of 72.2% of LUTS due to BPH in a cross-sectional hospital-based study. In western countries, 40% of men in their 50s and 90% of men in their 80s have histologic evidence of BPH respectively.[7] The International Continence Society (ICS) categorized LUTS into storage, voiding, and post-micturition symptoms.[8] Patients with bladder outlet obstruction (BOO) complain of mixed storage and voiding phase symptoms.[9] These symptoms can reduce health-related quality of life, and can be incapacitating with a huge economic and human burden.[10]

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Pressure-flow urodynamic study remains the gold standard for the diagnosis of BOO.[11] However, this is expensive, and invasive, with the risk of urinary tract infection.[11,12] Studies have shown that BWT increases in BOO[13-16] and this increase can be measured by transabdominal ultrasonography. Earlier studies done in Europe and North Africa showed that BWT was noted to be higher in patients with lower peak flow rates (Q-max).[13,17,18] Cut-off values for BWT in these aforementioned studies ranged from 3.25 mm to 5.0 mm.[10,17] To our knowledge there has been no report of similar studies in the West African Sub-region.

This study hence aimed to determine the correlation between bladder wall thickness (BWT) and maximum flow rate (Q-max) in patients with LUTS due to BPE. This is important in our environment where the burden of LUTS is high and access to the pressure-flow study is limited.[19-21]

Patients and Methods

This was a cross-sectional, prospective hospital-based study of patients presenting with LUTS at Alex-Ekwueme Federal Teaching Hospital, Abakaliki, Ebonyi State, Nigeria. Ethical clearance was obtained from the Hospital Research and Ethical Committee (FETHA/REC/VOL2/2019/275). The subjects were drawn from new male patients older than forty years who presented to the urology outpatient clinics with LUTS due to BPE over a one-year period from October 2019 to September 2020. The sample size was calculated using the Leslie Fishers formula for a sample population less than 10,000 using our hospital BPE prevalence value of 6.8 percent. Exclusion criteria included patients who were already on any form of medical or surgical treatment for bladder outlet obstruction, patients with a history, physical examination, or laboratory investigation reports suggestive of prostate or bladder cancer, patients with complications of BOO (cystitis, urinary retention, renal insufficiency), patients with diabetes mellitus, neurogenic bladder, and patients on α-adrenoceptor blockers for the treatment of hypertension. A detailed history was obtained to characterize the patient's lower urinary tract symptoms and duration. Patients were asked to complete the International Prostate Symptoms Score (IPSS) questionnaire. A complete physical examination, including a digital rectal examination, was carried out. Urinalysis, urine microscopy culture and sensitivity, prostate-specific antigen (PSA), serum electrolyte urea, and creatinine were done on each patient. Patients with suspicious PSA had prostate biopsies. Uroflowmetry was performed with Uro-010 (ARK MEDITECH SYSTEMS®), a weight-based uroflowmetry system with auto-calibration. It measured the following parameters: voided volume (ml), maximum flow rate (ml/s), average flow rate (ml/s), voiding time (sec), flow time (sec), and time to maximum flow (sec). The sensitivity of the uroflowmetry relies on voided volume. The contractile efficiency of the detrusor increases in relation to filling volume.[22] The International Continence Society has recommended that Q-max at voided volumes of less than 150 mL is erroneously low.[22] Voided volumes in excess of 150 ml were taken into account for all patients. Q-max of less than 10 ml/s was considered as the cut-off for BOO. The abdominopelvic ultrasonography was done with the patient in the supine position using a 3.5 MHZ curvilinear array transducer of the Accuvix Medison A30 Ultrasound machine (MEDISON LV Korea 2013). This was done with a full bladder when the patient had the urge to void. A bladder volume of at least 200 ml was considered adequate for this measurement because, beyond this volume, there is no significant change in bladder wall thickness.[23] Two measurements of the anterior bladder wall thickness in longitudinal and transverse views were taken, and the average was used as the value of BWT in millimeters (mm). A bladder wall thickness of more than 5 mm was considered as the cut-off value for bladder outlet obstruction.

Data analysis was done using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. Test of normality was done using the Shapiro-Wilk test. Abnormally distributed data were summarized as median and mean was used for normally distributed data. Student's independent T-test was used to compare continuous variables while the Chi-square test was used to compare categorical data. The correlation between anterior bladder wall thickness and uroflowmetry parameters was assessed using Pearson's correlation coefficient. A P value less than 0.05 was considered statistically significant. Receiver Operator Curve was used to determine the diagnostic accuracy and BWT cut-off for diagnosing bladder outlet obstruction.

Results

A total of 88 patients were recruited for the study. Four patients who had bladder cancer and six patients who were on alpha-blockers were excluded, leaving 78 patients for analysis. The age ranged from 42 to 92 years with a mean of 64.74 ± 11.25 years. The mean BWT, IPSS, Q-max, post-void residual urine volume (PVR) were 4.53 ± 2.70 mm, 13.17 ± 7.45, 15.06 ± 9.43 ml/s, 64.96 ± 89.07 ml/s respectively. The median PSA was 3.2 ng/ml (IQR 4.58) as shown in Table 1.

Table 1: Clinical Characteristics of Patients with LUTS

Variable	Mean±SD/Median + Interquartile range (IQR)	*n* (%)
Age (years)	64.74±11.25	
Duration of symptoms (years)	2.0 (IQR 1.50)	
<1 year		25 (32%)
1-2 years		37 (47%)
>2 years		16 (21%)
International Prostate Symptoms Score (IPSS)	13.17±7.45	
0-7		16 (20.5)
8-19		45 (57.7)
20-35		17 (21.8)
Storage Subscore	6.58±3.49	
Voiding subscore	6.59±5.26	
Prostate Specific Antigen (ng/mL)	3.2 ng/ml (IQR 4.58)	
Post void residual urine volume (mL)	20 (IQR 70.13)	
Bladder wall thickness (mm)	4.53±2.70	
Maximum flow rate Q-max (mL/s)	15.06±9.43	
Average flow rate Q-ave (mL/s)	6.53±4.55	
Voided Volume (mL)	202.44±91.63	

Table 2: Correlation between Bladder wall thickness and uroflowmetry parameters

Variable	Mean±SD	*r*	*P*
Q-max (mL/sec)	15.06±9.43	-0.452	0.000
Q-ave (mL/sec)	6.53±4.55	-0.336	0.003
Voided volume (mL)	202.44±91.63	-0.228	0.046
Voiding time (sec)	33.9±30.91	0.117	0.318
Flow time (sec)	34.07±33.25	0.156	0.184
Time to Max flow rate (sec)	13.49±21.66	0.059	0.614

Table 3: Comparison of BWT in obstructed and non-obstructed groups of patients

Variable	Q-max <10 ml/s *n*=27	Q-max >10 ml/s *n*=51	*P*
Bladder wall thickness (mm)	6.35±3.50	3.71±1.74	0.002

Table 4: Cut off value for BWT using the Reciever Operator Curve

Variable	Cutoff	AUC	Sensitivity (%)	Specificity (%)
BWT (mm)	5.85	0.825	70	88.2

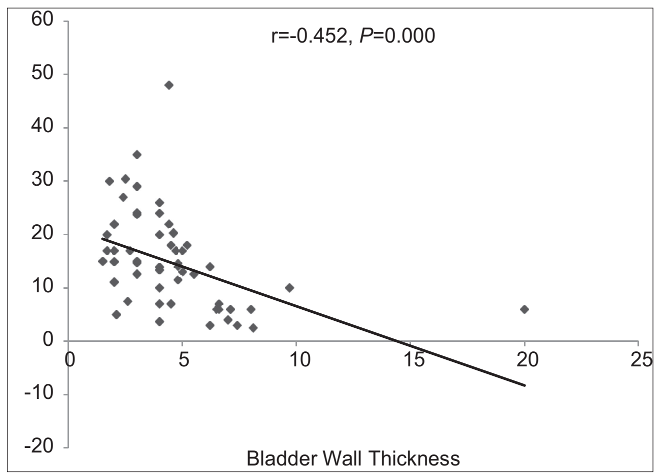

Figure 1: Linear regression curve between anterior bladder wall thickness and maximum flow rate

Of the uroflowmetry parameters, there was a statistically-significant negative correlation between BWT, Q-max (r = -0.452, P = 0.000), and Q-ave (r = -0.336, P = 0.003). There was a low negative but statistically-significant correlation between BWT and voided volume (r = -0.228, P = 0.046). The other uroflowmetry parameters did not show statistically significant correlations with bladder wall thickness. Table 2 shows these relationships.

Subgroup analysis of patients in obstructed and unobstructed by uroflowmetry (Q- max less than 10 ml/s) revealed that 51 patients had Q-max of more than 10 ml/s while 27 had Q-max of lower than 10 ml/s. The mean BWT in patients with obstruction (Q-ma × 10 ml/s or less) was higher than the non-obstructed group 6.35 ± 3.50 mm versus 3.71 ± 1.74 mm (P = 0.002) as shown in Table 3.

Bladder wall thickness demonstrated a negative correlation with maximum flow rate as shown in Figure 1.

The Area under the Curve for BWT was 0.825 (95 CI) with sensitivity and specificity of 70.4 percent and 88.2 percent respectively. See Figure 2.

A BWT cut-off of 5.85 mm was found to be the best threshold to distinguish between obstructed and non-obstructed patients as shown in Table 4.

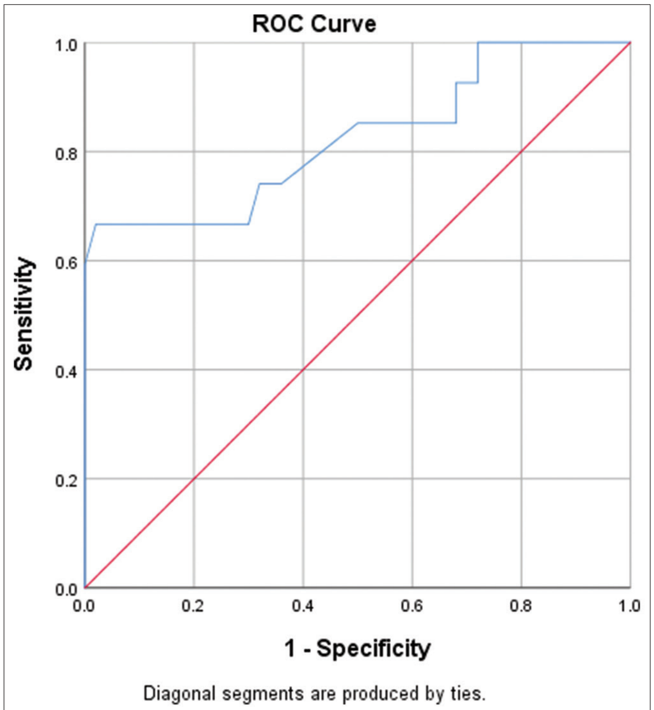

Figure 2: Receiver operator Curve for BWT, Area under the curve (AUC): 0.82

Discussion

Pressure flow urodynamic study has remained a mainstay for assessing the lower urinary tract obstruction but this investigation has a lot of limitations.[11,17] Attempts have been made to assess the lower urinary tracts non-invasively.[24,25] Measurement of bladder wall thickness by transabdominal ultrasonography is cheap, rapid, easy, non-invasive, and reproducible. It has high sensitivity and can be used to monitor response to treatment.[1,13,26]

Lower urinary tract symptoms are common in men after middle age with a majority being due to BPE.[1,3] The mean age of 64.74 years found in this study is similar to the age group of patients presenting with benign prostatic enlargement from earlier studies in Nigeria, Asia, and Europe where the mean age of patients with BPE were 66.6 and 67.9 years and 64.5 years respectively.[1,13,27,28]

The mean bladder wall thickness of 4.53 mm found in this study is similar to the findings of earlier studies in Nigeria and Italy.[13,27,29] Eze *et al*.[27] in Nnewi South East, Nigeria where he reported a mean BWT of 4.55 mm in patients with BPE.[27] Manieri *et al*.[13] in Italy demonstrated a BWT of 4.54 mm in their studies. In contrast, this value was lower than the mean BWT of 6.1 mm described by Park *et al*.[30] in South Korea. This wide difference can be accounted for by the bladder volume at which bladder wall thickness was measured. Bladder wall thickness is inversely related to the bladder volume, It decreases with increasing bladder volume and, no significant difference in the thickness usually occurs from 200-300 ml.[31] Park *et al*.[30] measured bladder wall thickness at 100 ml of bladder capacity. This factor may explain the wide difference in BWT values obtained.

The maximum flow rate of 15.06 ml/s observed in this study was similar to the finding of Sundaram and colleagues in India where they noted a Q-max of 14 ml/s.[32] However, Odusanya *et al*.[33] in their study in Lagos, Nigeria, found a lower Q-max of 11.86 ml/s. This can be explained by the difference in their study population. Their patients had higher post-void residual urine volume and International Prostate Symptoms Score. These indices of obstruction may account for the low Q-max found in their study.

There have been conflicting reports regarding bladder wall thickness and BOO with some studies finding increased bladder wall thickness in patients with BOO and others refuting it.[13,15,17,23,34,35] The mean BWT in patients with Q-max less than 10 ml/s in this study was higher than those whose Q-max was above 10 ml/s; 6.35 mm versus 3.71 mm (P = 0.002). Isikay *et al*.[18] in Turkey noted that patients who had Q-max of less than 10 ml/s had a statistically significantly thicker bladder wall than their counterparts who had Q-max of more than 10 ml/s. Similarly, Oelke *et al*.[15] in Amsterdam measured detrusor wall thickness in their study, and found that study groups who had obstruction as defined by pressure flow studies had a thicker detrusor wall than their unobstructed counterparts.

Earlier studies showed that bladder wall thickness correlated negatively with uroflowmetry parameters, particularly the maximum flow rate.[1,13,17,30] In this study, a moderate statistically-significant negative correlation was noted between BWT and Q-max (r = -0.452, P = 0.000). A similar observation was reported by Karakose *et al*.[1] in Turkey. They noted a lower maximum flow rate in patients with BWT exceeding 5 mm. In those patients with bladder wall thickness greater than 5 mm, Q-max was 9.8 ml/s while those with less thickened bladder walls had a Q-max of 13.6 ml/s. This finding from our study implies that in addition to Q-max, bladder wall thickness can be used to objectively identify patients with BOO.

Numerous authors have demonstrated various cut-off values for BWT.[13,17,23] In this study, we found a cut-off value of 5.85 mm as the threshold for BOO. This cut-off was lower than the findings of Güzel *et al*.[17] The BWT cut-off for the diagnosis of BOO in their study was 3.25 mm. The difference in cut-off values can be accounted for by the frequency of the ultrasound probe used in their study. While they used a 7.5 MHZ probe to measure BWT, a 3.5 MHZ probe was used to measure BWT in this study.

The main limitation of this study was the inter- and intra- individual variability associated with uroflowmetry.

Conclusion

Bladder wall thickness was shown to have an inverse correlation with maximum flow rate, Q-average, and voided volume with good sensitivity and specificity. This cheap, non-invasive, and relatively easy-to-perform investigation can be used in evaluating patients with lower urinary tract symptoms. This routine investigation can be used as a screening test for bladder outlet obstruction just like uroflowmetry. This is important in our setting where the pressure flow study is not readily available.

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Conflicts of interest

There are no conflicts of interest.

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