

# Ultrasound derived-parameters and symptom severity scores as noninvasive predictors of bladder outlet obstruction in patients with benign prostatic enlargement

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## Abstract

**Introduction:** Benign prostatic hyperplasia (BPH) is common in men over 50 years and causes lower urinary tract (LUT) symptoms. There is an emerging need to explore the value of utilizing ultrasound (US)-derived parameters of the LUT as noninvasive predictors of the degree of bladder outlet obstruction (BOO) from BPH and determine if they correlate with the symptom severity observed in these patients. This study aimed to determine the utility of US-derived parameters of the LUT (prostate volume [PV], bladder wall thickness [BWT], and postvoid residual volume [PVR]) in predicting severity of BOO and correlating them with the symptom severity scores – International Prostate Symptom Score (IPSS) and quality of life (QoL) – in patients with BPH in our practice.

**Methodology:** We prospectively studied 100 newly diagnosed patients with symptomatic BPH who presented to the urology outpatient clinic and were referred to the radiology department for transabdominal scan of the urinary bladder and prostate. The patients' age, IPSS, and QoL and their BWT1 (full bladder), BWT2 (empty bladder), PV, and PVR were measured using transabdominal US scan. Correlation was done using Pearson's correlation coefficient, and  $P < 0.05$  was considered statistically significant.

**Results:** The mean age of the participants was 60 years. The mean BTW1 and BTW2 were 4.66 mm and 25.80 mm, respectively. The mean IPSS was 16, with a majority (42%) having severe symptoms. There is a negative insignificant correlation between PVR and BTW2 ( $r = -0.053$ ,  $P = 0.603$ ). There is a weak but statistically insignificant correlation between QoL and BWT. There is a weak but insignificant correlation between PV and IPSS ( $r = 0.193$ ,  $P = 0.055$ ). There is a weak but insignificant correlation between IPSS and BWT. There is a moderate and statistically significant correlation between IPSS and PVR ( $r = 0.350$ ,  $P < 0.001$ ).

**Conclusion:** In our patients, we found that BWT had an insignificant correlation with QoL and a negative correlation with PVR, respectively. We could show, however, that in them, PVR and IPSS were significantly correlated.

**Keywords:** Benign prostatic hyperplasia, International Prostate Symptom Score, lower urinary tract symptoms, quality of life, ultrasound

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## INTRODUCTION

Benign prostatic hyperplasia (BPH) is common in men over 50 years and may cause lower urinary tract symptoms (LUTS). About 28% of men with BPH have moderate-to-severe LUTS. Bladder outlet obstruction (BOO) is seen in 52% of asymptomatic patients and in 60% of symptomatic patients.<sup>[1]</sup> Studies have demonstrated that BOO is associated with changes in detrusor structure caused by smooth muscle hypertrophy, fibroelastic hyperplasia, and collagen deposition in the bladder wall, and the features of BOO are similar in both symptomatic and asymptomatic patients.<sup>[2]</sup>

In Nigeria, it has been reported that one in four men older than 40 years has symptoms suggestive of BPH,<sup>[3]</sup> with a reported prevalence of 25.35%.<sup>[4]</sup> Prostatic hyperplasia increases urethral resistance resulting in compensatory changes in bladder function. However, the elevated detrusor pressure required to maintain urinary flow in the presence of increased outflow resistance occurs at the expense of normal bladder storage function. Obstruction-induced changes in detrusor function compounded by age-related changes in both bladder and nervous system function lead to LUTS such as urinary frequency, urgency, and nocturia.<sup>[2]</sup>

The International Prostate Symptom Score (IPSS) though widely studied and the most validated tool internationally for symptom quantification in patients with BPH is fraught with some complexities for patients such as the need for literacy, difficulty in appreciating the questions, language barriers, and lack of compatibility because of individual differences in perception of symptoms. This situation with the IPSS has made it imperative to explore the potential of ultrasonography – a cheap and readily available diagnostic tool to utilize ultrasound (US)-derived parameters of the lower urinary tract (LUT) as noninvasive predictors of the severity of BOO from BPH, thus providing a more objective and perhaps reliable assessment of symptom severity in these patients. This study, therefore, aimed at determining the utility of US-derived parameters of the LUT (prostate volume [PV], bladder wall thickness (BWT), and postvoid residual volume [PVR]) in predicting severity of BOO and correlating them with symptom severity scores (IPSS and quality of life [QoL]) in patients with BPH in our practice.

## METHODOLOGY

This cross-sectional study which spanned the period of February 2017 to January 2018 was conducted at the

University of Abuja Teaching Hospital, Gwagwalada, a tertiary health referral institution in Abuja which also attends to patients from neighboring states of Nasarawa, Kogi, Niger, and Kaduna.

One hundred consecutive patients with symptomatic BPH were recruited into the study from the Urology and General Outpatient Clinics, respectively, and referred to the Radiology Department for transabdominal scan of the urinary bladder and the prostate gland. Following a detailed history and physical examination, we excluded patients with urinary tract infection, prostatitis, urinary retention, bladder tumor, urolithiasis, or diabetes mellitus, those on urethral catheters, those with digital rectal examination findings suggestive of prostate cancer or a prostate-specific antigen >4 ng/ml, those with a history of the use of drugs such as 5-alpha-reductase inhibitors, antimuscarinics, or alpha-blocker therapy, and those with a history of LUT instrumentation (whether for diagnostics or therapeutic intent). All participants consented to the study after which we obtained information about age, IPSS, QOL, BWT (full and empty bladder) (BWT1 and BWT2, respectively), PV, and PVR.

### Transabdominal ultrasound technique

All scans were performed by a consultant radiologist.

### Prostate gland

All participants were scanned using GE LOGIQ F® series ultrasound machine 2016 with 3–5 MHz curvilinear probe. Participants were instructed to drinking about a liter to 1.5 L of water to induce diuresis and fill their urinary bladder. This was to ensure that the prostate could be well visualized using full urinary bladder as a sonic window. All measurements were performed with full bladder, which was determined as the patient having a strong urge to micturate. With the USS probe placed in the lower abdomen after coupling gel was applied, the prostate was identified as an oval-shaped hyperechoic structure posterior to the bladder with fairly homogeneous echo pattern [Figure 1]. PV was automatically generated by the US machine software after the transverse (width), craniocaudal (length), and anteroposterior (height) dimensions of the prostate were measured.

### Urinary bladder volume

With the urinary bladder fully distended, the largest longitudinal height and length of the bladder were obtained in the longitudinal plane, whereas the largest width was obtained in the transverse plane. The urinary bladder volume was automatically generated by the USS machine software using the calculated

measurements ( $\text{length} \times \text{height} \times \text{weight} \times 0.52$ ) which assumes that the bladder was a sphere.

### Urinary bladder wall thickness

The urinary bladder wall consists of the adventitial, muscle, and mucosal layers. The adventitial and the mucosal layers give a hyperechoic (bright) appearance on US, whereas the muscle layer gives a hypoechoic (dark) appearance on US. BWT is measured by including the inner and outer hyperechoic lines in the measurement.<sup>[5]</sup> The urinary BWT was measured when the bladder was fully distended [BWT1, Figure 2] and after voiding (BWT2). Measurements were taken from the interface of urine and internal mucosal layer of the bladder (hyperechoic) to the outer part of the hypoechoic muscular layer at the right lateral wall, left lateral wall, and posterior-lateral wall of the bladder, respectively [Figure 2].

### Residual urine

The patient was placed in the supine position immediately after voiding, and a midline longitudinal scan was made above the symphysis pubis. If the bladder is not completely empty, it presents on the scan as a well-delineated echo-free structure. The widest longitudinal (height) and sagittal (length) diameters are measured in the longitudinal planes. The widest transverse diameter (width) of the bladder was measured on a transverse scan above the symphysis. The residual urine volume was calculated from these measurements ( $\text{length} \times \text{height} \times \text{width} \times 0.52$ ), which was automatically generated from the machine.

To reduce intraobserver error, measurements were repeated twice for each of the variables: BWT1, BWT2, prostatic volume, bladder volume, and postvoid residual urine, unfreezing for each measurement. The mean of the two measurements was recorded for each variable.

### Data analysis

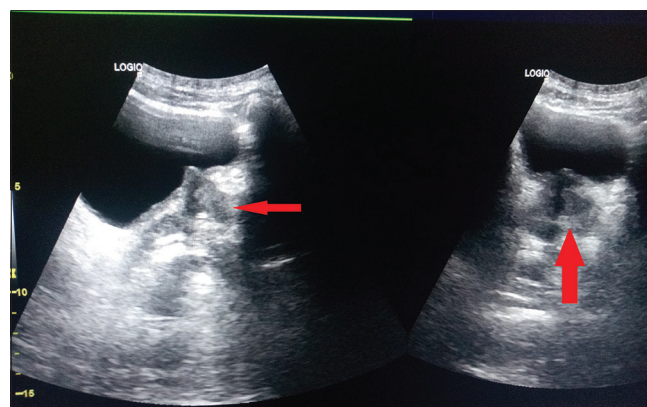
Data were collated and analyzed using Statistical Package for Social Sciences (SPSS) for Windows version 20.0 (IBM®, Armonk, New York, USA).  $P < 0.05$  was taken as statistically significant. Pearson's correlation coefficient test was applied to determine the linear correlation between variables. The results are presented in the form of tables and charts.

### Ethical consideration

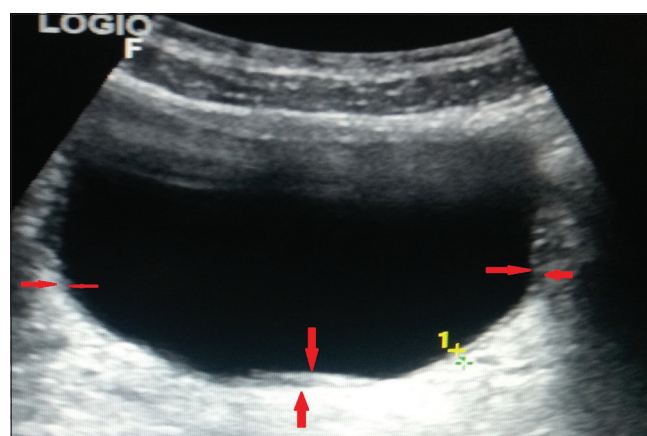
Ethical approval was sought and received from the University of Abuja Teaching Hospital Health Research Ethics Committee.

## RESULTS

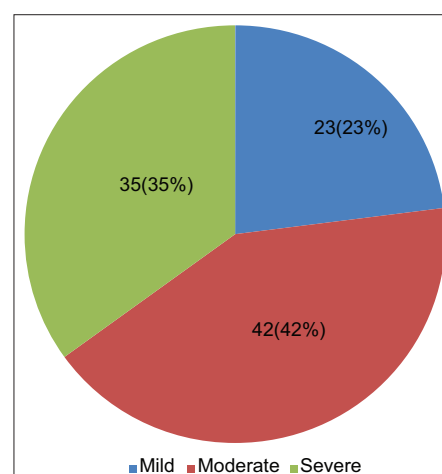
Patients' mean age was  $60 \pm 9.9$  years, whereas the mean PV



**Figure 1:** Longitudinal and transverse ultrasound image of the prostate gland (red arrows) posterior to the bladder



**Figure 2:** Measurement of the urinary bladder wall thickness (red arrow)



**Figure 3:** Distribution of symptom severity among the participants (n = 100)

was 66 g (range: 16–200 g). The mean urinary bladder volume was  $203 \pm 121.2$  ml, whereas the mean PVR and mean IPSS were 72 ml (range: 2.5–306 ml) and 16 (range: 4–34), respectively [Table 1]. Of the hundred patients, 23% ( $n = 23$ ), 35% ( $n = 35$ ), and 42% ( $n = 42$ ) had mild, moderate, and

**Table 1: The mean, standard deviation, and range of variables among study population**

	PV	BWT1	BWT2	BV	PVR	IPSS
Mean	65.7852	0.4657	0.5815	202.5659	71.8660	15.6100
Median	58.4850	0.4550	0.5600	169.2500	45.8000	16.0000
Mode	45.30	0.43	0.50	140.00	10.00	6.00
Standard deviation	36.24101	0.13645	0.15236	121.22527	64.29061	7.64476
Minimum	15.85	0.10	0.30	42.90	2.50	4.00
Maximum	200.00	0.87	1.20	687.00	306.34	34.00

PV – Prostate volume; BWT1 – Bladder wall thickness with full bladder; BWT2 – Bladder wall thickness with empty bladder; BV – Bladder volume; PVR – Postvoid residual urine; IPSS – International Prostate Symptom Score

severe LUTS, respectively [Figure 3]. Using Pearson's correlation coefficient to measure the linear correlation between two variables – the USS-derived parameters and the LUT symptom severity in these patients, we found a negative and insignificant correlation between BTW2 and PVR ( $r = -0.053$ ,  $P = 0.603$ ) as well as a weak and insignificant correlation between QoL and BWT1/BWT2 ( $r = 0.106$ ,  $P = 0.296$ / $r = 0.126$ ,  $P = 0.211$ ), respectively. In addition, we found the correlations between IPSS and PV ( $r = 0.193$ ,  $P = 0.055$ ) and IPSS and BWT1/BWT2 ( $r = 0.077$ ,  $P = 0.447$ / $r = 0.158$ ,  $P = 0.116$ ) to be both weak and insignificant, respectively [Table 2]. However, there was a moderate and statistically significant correlation between IPSS and PVR ( $r = 0.350$ ,  $P < 0.001$ ) [Table 3].

## DISCUSSION

The IPSS is a widely used and validated means of assessing men with LUTS. It relies on answers to seven questions concerning frequency, nocturia, a weak urinary stream, hesitancy, intermittency, incomplete bladder emptying, and urgency as well as a global QoL question. The total symptom score ranges from 0 to 35, with scores of 0–7, 8–19, and 20–35, indicating mild, moderate, and severe LUTS, respectively. Noninvasive urodynamic parameters such as intravesical prostatic protrusion (IPP), detrusor wall thickness, the prostatic capsular artery resistive index (RI), and prostatic urethral angle can predict both the severity and the outcome of medical therapy in patients with BPH.<sup>[6]</sup> No known study in our environment had aimed to correlate these noninvasive urodynamic parameters with symptom severity in patients with BPH.

Other workers have tried to determine the utility of USS-derived parameters (e.g., PV, BWT, PVR, and IPP) and uroflowmetry for identifying BOO by correlating them with the results of pressure–flow urodynamic studies. They found that BWT, PV, and PVR in conjunction with IPP are good predictors of clinically significant BOO due to BPH.<sup>[7]</sup>

Although urodynamic examination is the gold standard to evaluate LUTS, its invasive nature limits its use. Previous studies advocated that BWT could be used to evaluate LUT

**Table 2: Correlation between International Prostate Symptom Score and bladder wall thickness, quality of life and bladder wall thickness, bladder wall thickness and postvoid residual urine, prostate volume and International Prostate Symptom Score, and postvoid residual urine and International Prostate Symptom Score (n=100)**

Comparison	R	P
IPSS and BWT1	0.077	0.447
IPSS and BWT2	0.158	0.116
BWT1 and QOL	0.106	0.296
BWT2 and QOL	0.126	0.211
BWT1 and PVR	0.005	0.958
BWT2 and PVR	-0.053	0.603
PV and IPSS	0.193	0.055
PVR and IPSS	0.350	<0.001*

\*Significant at 0.05.  $r$  – Correlation coefficient; PV – Prostate volume; BWT1 – Bladder wall thickness with full bladder; BWT2 – Bladder wall thickness with empty bladder; PVR – Postvoid residual urine; IPSS – International Prostate Symptom Score; QOL – Quality of life

**Table 3: Correlation of International Prostate Symptom Score with prostate volume and postvoid residual urine and bladder wall thickness (bladder wall thickness with full bladder and bladder wall thickness with empty bladder)**

	PV	PVR	BWT1	BWT2
IPSS				
Correlation coefficient ( $r$ )	0.193	0.350	0.077	0.158
$P$	0.055	<0.001	0.477	0.116

PV – Prostate volume; BWT1 – Bladder wall thickness with full bladder; BWT2 – Bladder wall thickness with empty bladder; PVR – Postvoid residual urine; IPSS – International Prostate Symptom Score

obstruction. When Oelke *et al.* performed urodynamic evaluation in patients with BPH and/or LUTS, they found that BWT was more valuable compared to uroflowmetry, PVR, and PV.<sup>[8]</sup>

Manieri *et al.* investigated the data of patients who were clinically diagnosed with BPH using urodynamic evaluation and found a strong association between urodynamic pressure parameters and BWT and a weak association between urodynamic pressure parameters and Qmax and PVR.<sup>[9]</sup>

Our findings of a negative correlation between PVR and BWT2, though not statistically significant ( $r = -0.053$ ,  $P = 0.603$ ), are supported by the report of Oelke *et al.* who proposed that BWT measurement may be more suggestive of BOO compared to uroflowmetry and the assessment

of PVR.<sup>[8]</sup> We also observe that our findings of a weak and insignificant correlation between IPSS and BWT are similar to the report by Ozlem *et al.* who showed that there is a direct correlation between IPSS and BWT (BWT1 and BWT2)<sup>[10]</sup> as well as to the study by Salinas *et al.* who found a significant correlation between BWT and IPSS in patients with BPH.<sup>[11]</sup>

Finally, our study revealed a moderate and statistically significant correlation between IPSS and PVR ( $r = 0.350$ ,  $P < 0.001$ ). This finding is similar to Ezz *et al.* who reported that although statistically significant but weak correlations were found between the IPSS and results of uroflowmetry and PVR in their cohort, there was no correlation between the IPSS and PV measurements leading them to conclude that the correlation between objective noninvasive parameters of LUT dysfunction and LUTS was probably weak.<sup>[12]</sup>

A study of a large series of patients ( $n = 1295$ ) to evaluate the relationship between LUTS as stipulated in the IPSS and the objective parameters related to BPH found statistically significant correlations between IPSS and objective parameters by means of Spearman's correlation coefficients. However, they concluded that albeit the correlation between objective parameters of BPH and LUTS was significant, they found it hard to predict the severity of symptoms by these parameters.<sup>[13]</sup>

## CONCLUSION AND RECOMMENDATION

Our study though limited by its small sample size was able to report a moderate and statistically significant correlation between IPSS and PVR in patients with symptomatic BPH. Although the other cited works reported findings similar to the observations in our study, we want to caution that the degree of significance and level of correlations reported in our study strongly suggests that reliance on the combined use of USS-derived parameters of the LUT and symptom severity score assessment tools (IPSS and QOL) is advised for the proper evaluation of the severity of BOO in patients with symptomatic BPH. The implication of our study for clinical practice is that the use of these parameters as individual stand-alone assessment tools may be inadequate for proper patient assessment.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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