Original Article

Correlation Between Prostate Volume Measured by Ultrasound and Detrusor Wall Thickness in Men with Benign Prostatic Hypertrophy

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Abstract

Background: Benign prostatic hypertrophy (BPH) causes subvesical urinary obstruction in the elderly. It leads to changes in the bladder and upper urinary tract. This may be progressive with subsequent morbidities and mortalities. This study aims at determining the relationship between ultrasound-measured prostate volume and detrusor wall thickness (DWT) in men with BPH. **Materials and Methods:** One hundred and ten patients who met the inclusion criteria and were diagnosed with clinical BPH were enrolled. They had no other identifiable cause of bladder outlet obstruction. The International Prostate Symptoms Score (IPSS), Quality of Life (QOL) score, prostate volume, and DWT were measured. Correlation between prostate volume and DWT was done using SPSS version 20.0 (IBM, SPSS, Chicago, IL, USA). A *P*-value less than 0.05 was considered significant. **Results:** The mean age of patients was 68.3 ± 10.2 years, with a range of 40–100 years. The mean prostate volume and DWT were 94.2 ± 68.4 cm3 and 5.9 ± 3.0 mm, respectively. Mean QOL was 4.77 ± 1.35. The highest IPSS was 35 and lowest was 2. Nocturia was the major IPSS subscore. There was a positive correlation between prostate volume and DWT in men with BPH ($r = 0.37$; $P = 0.007$). This is statistically significant. **Conclusion:** Ultrasound-measured prostate volume correlates positively with DWT in men with BPH. This is statistically significant and is able to determine progression of the disease. Coexisting large prostate volume and thickened detrusor wall are an indicator of disease progression and eventual need for surgical intervention. This prevents renal damage.

Keywords: *Benign prostatic hypertrophy, detrusor wall thickness, International Prostate Symptoms Score, median lobe, prostate volume, quality of life*

Introduction

Bladder outlet obstruction (BOO) is a functional term for any cause of subvesical obstruction. It may be induced by specific functional and anatomic causes.[1]

Detrusor hypertrophy associated with BOO can be imaged on suprapubic ultrasound, and bladder weight can be quantified from the evaluation of bladder wall thickness (BWT) and bladder volume. Surgical treatment of benign prostatic obstruction (BPO) results in a significant decrease in detrusor wall thickness (DWT).[2]

In patients with benign prostatic hypertrophy (BPH), BOO is considered to contribute to both signs and symptoms of disease severity because of its effect on detrusor function. BPH is a progressive disease characterized by worsening of clinical parameters.

The increased outlet resistance is related to an anatomic component derived from the elevated bladder neck and the enlarged prostate lobes and to a dynamic component depending on the increased smooth muscle tone in the prostate gland and bladder neck.[3]

In the 18th century, the Scottish surgeon John Hunter described the effect of BPH on the detrusor. He said 'the disease of the bladder arising from obstruction and its consequence is an increased irritability, by which the bladder admits of little distension, because quick its action and thick its coats.'[4]

With partial outlet obstruction, there is a significant increase of bladder weight, neo-angiogenesis, and reduction of the blood flow to smooth muscle fibres after initial increase.[5]

With the onset of bladder decompensation, there is reduction of detrusor contractility as measured on isolated bladder strips.[5]

There is a theoretical cascade of events leading from BOO to urinary tract infection (UTI), bladder stones, chronic renal failure, and the need for surgery.[2]

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Urodynamics investigations, particularly pressure-flow studies, have been the gold standard for the diagnosis and grading of outflow obstruction and detrusor contractility.[6]

In addition to measuring post-void residual (PVR), the bladder ultrasound device can be used to determine the DWT.[7]

Recent studies and analyses have confirmed that baseline prostate volume is related to BPH progression, as well as negative outcomes related to BPH, such as acute urinary retention and need for surgery, and can predict response to therapy.[8] Men with larger prostate volumes and high PSA values experience a clinically significant response to therapy when compared with those with smaller prostate volumes and lower PSA values.[9]

Prostate growth appears to be related to prostate volume, as median prostate growth correlates positively with baseline prostate volume.[10]

Prostate volume is an important predictor of BPH progression.[11]

The DWT has the highest accuracy (88%), the highest specificity (92.6%), and the highest positive predictive value (90.5%) among non-invasive tests in evaluating men with BOO.[12] Among non-invasive methods, ultrasound-derived measures such as DWT were considered promising tools.[13] Ultrasound is available and relatively cost-effective in estimating DWT at no extra cost during pelvic ultrasound scan.

A thickened or trabeculated bladder wall is considered to be of great significance in the diagnosis of obstruction. The clinical usefulness of DWT remains controversial, but interest is increasing in its clinical significance.[14] The initial response of the bladder to increased outlet resistance guarantees complete bladder emptying, despite the increased workload.

No consensus has been reached as to the 'point of no return,' beyond which bladder function will not recover after the removal of outlet obstruction.[15]

In men treated for BPH by transurethral resection of prostate, a significant decrease in DWT was noted after surgery.[16] As DWT increased, the responsiveness of storage symptoms to alpha-blocker decreased in lower urinary tract symptoms (LUTS)/BPH patients.[17]

Hakenberg *et al*.[18] established normal DWT to be approximately 3 ± 1.1 mm for men and 3 ± 1.0 mm for women. DWT of >5 mm at 150 mL was the best cut-off point at which to diagnose BOO.[19] Men with obstruction had been found to have bladder weight as double as that of control subjects and decreased significantly after prostatectomies.[20] There is a positive correlation between BWT and prostate volume, age, and PVR.[21] Measurement of the BWT or DWT by ultrasound is reliable with acceptable intra-operator and inter-operator variabilities.[22] The prostate volume is measured using the prolate ellipsoid formula.[23] The conventional ultrasound detects established signs of bladder damage: diverticula, trabecula, calculi, and PVR urine (>50 cc). The DWT can be calculated using the average of minimum of three measurements of the anterior bladder wall taken at least 1 cm apart.[24] There is no significant difference in DWT between the various parts of the bladder.[25]

If prostate volume correlates positively with DWT, early identification of the thickened detrusor wall, in addition to other established ultrasound parameters, has the advantage of suggesting the adoption of therapeutic measures sufficient to prevent progression of bladder damage. Treatment options are offered earlier and renal function preserved.

Materials and Methods

This was a descriptive cross-sectional study to determine the correlation between prostate volume and DWT in men with BPH presenting at the urology units of a single tertiary institution in South Eastern Nigeria.

New patients presenting with LUTS and age above 40 years formed the cohort of the study.

All patients who gave informed consent and also fulfilled the inclusion criteria were recruited for the study. Ethical approval was obtained from the research and Ethics Committee of the study centre.

Included in the study were all new patients attending urology clinics of our teaching hospital, with clinical features suggestive of BPH. These patients presented with different forms of LUTS and had their individual International Prostate Symptoms Score (IPSS) recorded. They were clinically evaluated, including a digital rectal examination, bulbocavernosus, anal and deep tendon reflexes in order to exclude other possible causes of BOO other than BPH. Those with clinical indications for biopsies also underwent the procedure to rule out malignancy. Those with clinical features suggestive of neurogenic bladder, urethral stricture disease, previous treatment for BPH, UTI, pelvic anatomical disorders, prostate cancer, urethral stricture disease, stroke, Parkinson's disease, and diabetes mellitus were excluded from the study. Prostate volume and DWT were assessed in all patients using trans-abdominal ultrasound performed by a consultant radiologist and assisted by one of the researchers. The prostate volume was calculated using the prolate ellipsoid formular, whereas DWT was calculated by getting the average of minimum of three measurements of the anterior bladder wall taken at least 1 cm apart at a bladder volume of approximately 150 mL, as the patient develops urge to void. The High-Resolution Prosound 3.5 MHz ALOKA model was used for all patients in supine position.

All answered questionnaires were coded before analysis. The determinant variable was the prostate volume in patients with BPH, whereas the outcome variable in the correlation was the DWT.

The extent of this outcome variable was correlated with the prostate volume as measured by ultrasound.

Data were analyzed with a multipurpose computer statistical programme—Statistical Package for Social Sciences Version

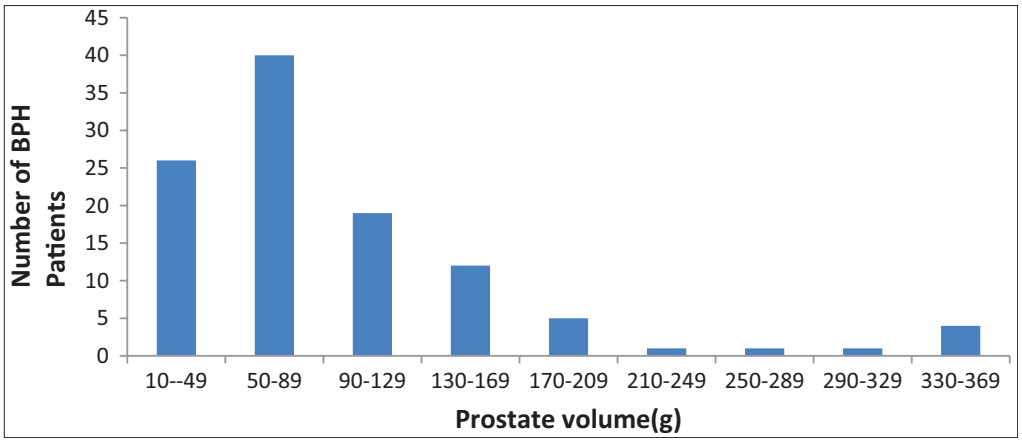

Figure 1: Distribution of prostate volume in BPH patients

20 (SPSS v 20). Results obtained were expressed using tables and charts where necessary. Data were subjected to linear regression test. Pearson's correlation was used to assess correlation.

Results

A total of 110 men diagnosed with clinical BPH were studied. The mean age was 68.3 ± 10.2 years, with a range of 40–100 years. Ninety-two percent (92%) of them were in their sixth and eighth decades of life.

Mean prostate volume was 94.2 ± 68.4 cm3 with a range of 19–350 cm^3, whereas the total IPSS ranged from 2 to 35, with a mean of 14.7 ± 7.5. Distribution of prostate volumes showed that the commonest volumes recorded were between 50 and 89 cm3 [Figure 1]. Mild symptoms were seen in 22%, moderate symptoms in 55%, and 31% of patients had severe symptom scores. Mean DWT was 5.9 ± 3 mm with a range of 2–16 mm [Table 1].

In terms of frequency of occurrence of the individual IPSS parameters, nocturia was 90%, urinary frequency 68.2%, weak stream 61.8%, urgency 61.8%, incomplete bladder emptying 63.4%, intermittency 60%, and straining 46.4% [Table 2].

Median lobe was prominent in 22 patients with mean DWT, IPSS, and quality of life score (QOL) of 6 mm, 14.8 and 4.74, respectively.

QOL score ranged from 0 to 6. The mean QOL was 4.77 ± 1.35.

Table 1: DWT in BPH patients

DWT (mm)	Number of patients	Percentage (%)
0–2	11	10.0
3–5	43	39.1
6–8	40	36.4
9–11	7	6.4
12–14	7	6.4
15–17	2	1.8

DWT: detrusor wall thickness

Table 2: The mean and frequency of individual subscores of IPSS

IPSS variables	Frequency (%)	Mean
Nocturia	90	3.22
Frequency	68.2	2.53
Incomplete emptying	63.4	2.18
Weak stream	62.8	2.49
Urgency	61.8	2.27
Intermittency	60	1.71
Straining	46.4	1.66

IPSS: International Prostate Symptoms Score

Discussion

We studied 110 men with BPH between the ages of 40 and 100 years with a mean of 68.3 ± 10.2 years. This is similar to other works by Franco *et al.*,[24] Aganovic *et al.*,[26] Kang *et al.*,[15] and Kojima *et al.*[27] BPH has been shown to be common in men above 50 years.[28] Prostate volume was in the range of 19–350 cm^3 with a mean of 94.2 ± 68.4 cm^3, whereas the mean of DWT was 5.9 ± 3.0 mm with a range of 2–16 mm. This is in consonance with the works by Hakenberg *et al.*,[18] in which they established that normal DWT in men is approximately 3 ± 1.1 mm and those men with LUTS and prostatic enlargement had a significantly increased DWT. In our study, the mean DWT was 5.9 mm at a mean urine volume of 150 mL. Most patients had voiding and filling phase symptoms. This correlates with the work by Manieri *et al.*[19] in 174 patients, in which it was found that DWT >5 mm at 150 mL of urine in bladder was the cut-off point at which to diagnose BOO. In our study, 82% of patients had DWT >3 mm (mean = 6.8 mm), whereas 58% had DWT >5 mm (mean=7.8 mm). They all had lower urinary tract symptoms, with degrees of obstruction before presenting to the urology clinics.

Aganovic *et al.*[26] studied 111 BPH patients and concluded that IPSS showed a positive correlation with prostate volume (r=0.61). In our study, median lobe was prominent in 20% of the patients with BPH. Most of these patients had increased DWT. They had a mean DWT of 7.9 mm, IPSS of 14.8, and QOL of 4.7. This shows that the presence of median

lobe worsens symptoms and increases DWT in patients with BPH. Most patients in this group were at least unhappy with their quality of lives. It has also been established that small volume prostates may give worse symptoms in the presence of prominent median lobes. This lobe can have a 'ball valve' effect, causing severe voiding phase symptoms in BPH patients.[29]

Apart from straining as a major complaint in BPH, which supports the work by Akino *et al.*,[21] weak stream and intermittency were also noted. This contrasts the work by Park *et al.*,[17] where storage symptoms subscores were higher. This finding can be accounted for by the large volume prostates seen in our clinics. The smallest recorded prostate size of 19 cm^3 identified in this study was seen in a 67-year-old man with an increased DWT of 6.1 mm, moderate IPSS of 10, and good QOL score of 2. He scored 3 in each of the independent variables of incomplete emptying and straining. This finding may be accounted for by an existing or previously treated subclinical and subvesical obstruction not diagnosed at the time of the study. Patient's detrusor wall may have compensated for this. The corollary is the observation that very large prostate volume of 350 mL seen in this study gave rise to DWT of 15 mm. IPSS was mild but terrible and QOL score was 6. He had a prominent median lobe. This finding may demonstrate a combined/synergistic effect of prostate volume and intravesical prostatic protrusion on obstructive uropathy.[24,27,29] Solitary or isolated prominent median lobes have also been documented to cause thickened detrusor wall and BPO.[29]

In Figure 2, the scatter diagram and correlation of prostate volume on DWT showed a positive correlation between prostate volume and DWT (r= 0.37; P = 0.007). The scatter diagram and 'line of best fit' show that the average DWT at prostate volume of 0 is 4.52 mm.

Each unit increase in prostate volume corresponds to an increase in DWT by 0.016. These observations are statistically significant (P = 0.007). This is similar to the works by Kojima *et al.*[20] and Akino *et al*.[21] In the latter study in University of Fukui, 77 patients with LUTS and age above 50 years were studied. A thickened bladder wall was found to be associated with a decrease in voiding efficiency, showing that a bladder with thick walls cannot efficiently eject urine.[21] The significance of the increase by 0.016 in DWT following a unit increase in prostate volume is worthy of note in our environment, as the postulated median prostate growth of 1.95% from a baseline of 30 cm^3 as postulated in the Olmsted Community-Based Study may be applicable.[9,10] The mean DWT of 5.9 mm in this study shows that most patients with BOO secondary to BPH develop bladder wall changes. When the prostate volume is at its minimum, the DWT is 4.52 mm and subsequently increases with every unit rise in prostate volume (P = 0.007). It therefore implies that each rise in prostate volume from the baseline is significant. This leads to an increase in DWT, with attendant outflow obstruction at the expense of normal bladder storage function.[30]

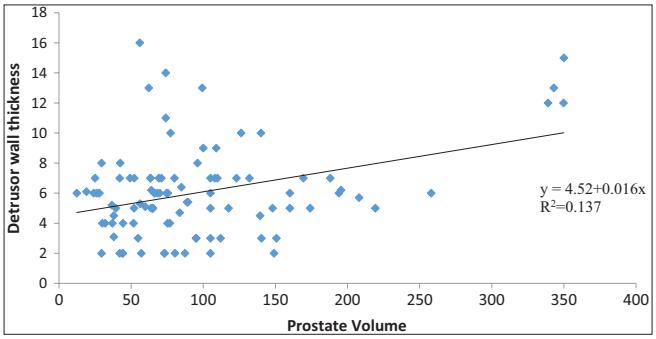

Figure 2: Scatter-gram and regression of prostate volume on bladder wall thickness. Correlation coefficient (r) = 0.37; P = 0.007

Progressive bladder wall and age-related detrusor wall changes are observed in men with LUTS secondary to BPH.[22] Detrusor hypertrophy is a consistent consequence of BOO in animal models.[18,31-33]

Identification of thickened bladder wall can be done by non-invasive abdominopelvic ultrasound. This can suggest early therapeutic choices to prevent further organ damage. Permanent renal damage with its attendant consequences is minimized.

Conclusion

There is a positive correlation between prostate volume and DWT in symptomatic patients with BPH in our environment.

Recommendation

It has been found out in this study that DWT correlates positively with prostate volume. Early identification of increased DWT in symptomatic patients with BPH has the advantage of suggesting the adoption of therapeutic measures sufficient to prevent progression of bladder damage and subsequent renal failure.

DWT should be measured while investigating BPH patients in our environment.

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Conflicts of interest

The authors declare that they have no conflicting interests.

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