Cross-sectional Study

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Association of detrusor wall thickness (DWT) with lower urinary tract symptom severity in benign prostatic hyperplasia: a cross-sectional study

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Background and objective: Benign prostatic hyperplasia manifests as lower urinary tract symptoms (LUTS) and prostate gland enlargement, leading to bladder outlet obstruction with consequent structural and functional impacts on the bladder. Urodynamic studies are resource-intensive and invasive. Detrusor wall thickness (DWT) assessment offers a cost-effective, reproducible alternative for evaluating LUTS severity in males with bladder outlet obstruction, utilizing ultrasonographic examination.

Methods: This prospective cross-sectional study, conducted at a tertiary care center from May 2023 to January 2024, included 171 patients with LUTS who underwent transabdominal ultrasound for DWT measurements. LUTS severity, assessed using International Prostate Symptom Scores (IPSS) classified participants into mild and moderate-to-severe symptom groups. Pearson's correlation coefficient assessed the association between DWT and IPSS, and an independent sample *t*-test compared means, using a significance level of 5% (*P*-value ≤ 0.05).

Results: This study involved participants aged 65.01 ± 11.55 years with an IPSS score ranging from 1 to 35, with a mean for mild and moderate-to-severe symptom groups were 4 ± 2.12 and 15.93 ± 6.74, respectively. DWT mean of 1.64 ± 0.38 mm for mild, and 2.4 ± 0.43 mm for moderate to severe symptoms. Pearson's correlation ($r = 0.697$, $n = 171$, $P < 0.001$) indicated a strong DWT-LUTS correlation and a significant DWT mean difference between mild and moderate-to-severe symptom groups was found via an independent *t*-test ($P < 0.001$, 95% CI: −0.8970 to −0.6414).

Conclusion: The study establishes the value of transabdominal ultrasound-detected DWT as a cost-effective, noninvasive, and reproducible tool for assessing LUTS severity in males with benign prostatic hyperplasia.

Keywords: benign prostatic hyperplasia, bladder outlet obstruction, detrusor wall thickness, international prostate symptom score, lower urinary tract symptoms, transabdominal ultrasound

Introduction

Benign prostatic hyperplasia (BPH), characterized by prostatic cell proliferation leading to an enlarged prostate in elderly males, often results in bladder outlet obstruction (BOO) and lower urinary tract symptoms (LUTS)[1]. While voiding pressure flow studies are the gold standard for BOO diagnosis, their limitations include invasiveness, availability, and cost. Recent studies suggest that BPH symptoms and obstruction are not solely dependent on prostate volume. Detrusor wall thickness (DWT) and intravesical prostatic protrusion serve as noninvasive, reliable, and cost-effective surrogates for BOO[2]. The preferred noninvasive method for visualizing detrusor muscle hypertrophy is measuring DWT through suprapubic ultrasonography[3]. The study recognizes the continuous decrease in DWT while the bladder fills to 50% of its capacity, remaining constant until 100%. Therefore, detrusor wall measurements are conducted when the bladder is filled to maximum capacity[4]. The International Prostate Symptom Score (IPSS), comprising validated questionnaires, is commonly used for clinically reliable LUTS severity

HIGHLIGHTS

- This study establishes a significant and positive correlation ($r = 0.697$, $P < 0.001$) between detrusor wall thickness (DWT), measured via transabdominal ultrasound, and the severity of lower urinary tract symptoms in males diagnosed with benign prostatic hyperplasia.
- Utilizing the International Prostate Symptom Score (IPSS) for symptom classification, the study demonstrates a statistically significant difference in DWT means between groups with mild and moderate-to-severe symptoms ($P < 0.001$, 95% CI: −0.8970 to −0.6414).
- The findings highlight the clinical relevance of transabdominal ultrasound-detected DWT as a cost-effective, noninvasive, and reproducible tool for assessing lower urinary tract symptoms severity in benign prostatic hyperplasia patients, offering a potential means for efficient patient prioritization in resource-limited settings.

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measurement[5]. The rationale behind utilizing DWT as a surrogate for BOO stems from studies indicating detrusor hypertrophy as a consistent consequence of BOO in animal models and humans[3].

This study aims to investigate the relationship between DWT and the severity of LUTS in BPH patients assessing LUTS severity, measuring DWT, examining their association, and comparing means between IPSS-defined groups.

Methodology

This observational analytical study was carried out in the Department of Radiology and Imaging between May 2023 to January 2024. Ethical approval for conducting the study was taken from the Institutional Review Committee (IRC) (approval number:872/2079/80). The work is reported in line with the strengthening of the reporting of cohort, cross-sectional, and case–control studies in surgery (STROCSS) guidelines[6]. The study is registered retrospectively in the research registry.

A sample size of 171 was calculated using a confidence level of 95% (Z score of 1.96), SD of 0.8 mm and margin of error 0.12, based on a similar study conducted by Park *et al.*[7].

All male patients aged 40 years or older diagnosed with BPH and experiencing LUTS were included in the study. Males with a history of urinary tract or pelvic surgery, prostate or bladder cancer, urethral stricture, and those with extravesical or systemic disorders potentially impacting bladder function, such as chronic renal insufficiency, neurological disorders, or diabetes mellitus were excluded from the study.

Patients meeting the inclusion criteria were enrolled following informed written consent. A predetermined proforma collected comprehensive patient information, including age, medical, surgical, and past history. The initial assessment involved evaluating patients with the International Prostate Symptom Score (IPSS) questionnaire, categorizing them into two groups based on scores: the first group had mildly symptomatic patients (IPSS scores <8), and the second group included those with moderate to severe symptoms (IPSS scores ≥ 8) (Fig. 1). Subsequently, eligible men were instructed to drink water until experienced a strong urge to void. In a supine position, patients underwent real-time suprapubic transabdominal ultrasonography using a 7.5 MHz linear ultrasound array to measure DWT at the anterior urinary bladder wall. While trans-rectal ultrasound may offer detailed visualization, it can be invasive and less comfortable for patients, making it less ideal for large-scale studies. The ultrasound procedure included identifying the adventitia, detrusor muscle, and mucosa, with two measurements in both longitudinal and transverse scans (Fig. 2)[8]. The average of these measurements

Name: **Date:**

	Not at all	Less than 1 time in 5	Less than half the time	About half the time	More than half the time	Almost always	Your score
Incomplete emptying Over the past month, how often have you had a sensation of not emptying your bladder completely after you finish urinating?	0	1	2	3	4	5	
Frequency Over the past month, how often have you had to urinate again less than two hours after you finished urinating?	0	1	2	3	4	5	
Intermittency Over the past month, how often have you found you stopped and started again several times when you urinated?	0	1	2	3	4	5	
Urgency Over the last month, how difficult have you found it to postpone urination?	0	1	2	3	4	5	
Weak stream Over the past month, how often have you had a weak urinary stream?	0	1	2	3	4	5	
Straining Over the past month, how often have you had to push or strain to begin urination?	0	1	2	3	4	5	

	None	1 time	2 times	3 times	4 times	5 times or more	Your score
Nocturia Over the past month, many times did you most typically get up to urinate from the time you went to bed until the time you got up in the morning?	0	1	2	3	4	5	

Add Your scores and write total in the box to the right.	

Total score: 0-7 Mildly symptomatic; 8-19 moderately symptomatic; 20-35 severely symptomatic.

Figure 1. Chart for IPSS score.

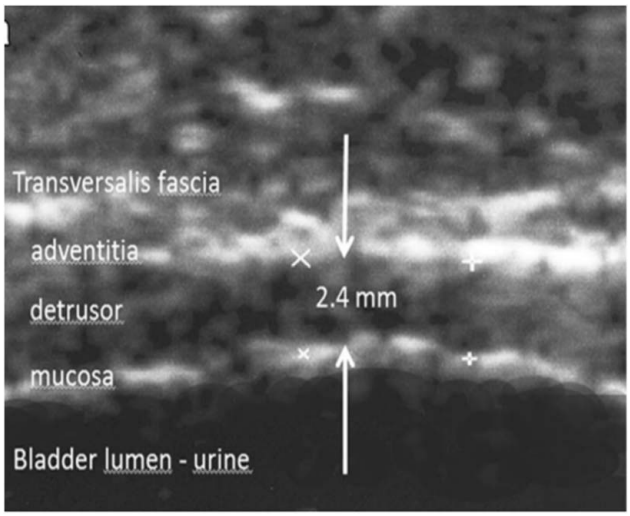

Figure 2. USG image of anterior urinary bladder wall showing measurement of detrusor wall thickness (measured in between the echogenic mucosal and adventitial layers)[8].

represented the final DWT value in millimeters (mm). All ultrasound measurements were performed using a SIUI Apogee 5300 system. Ultrasound examinations were performed by specialized radiologist with significant experience, averaging 300 examinations annually, demonstrating proficiency and familiarity with the technique. After ultrasound examination participants were allowed to void. Regular meetings and continuous monitoring were done for quality control.

The study involved patients and the public in the research objectives, design, and outcome measures. They facilitated recruitment, provided feedback, and participated in meetings, dissemination, and knowledge translation activities.

Statistical analysis

Proformas were meticulously reviewed for data completeness, followed by entry into MS Excel 2016, limiting access to investigators and supervisors. Patient confidentiality was rigorously maintained. Presentation formats included tables, graphs, and narratives using Microsoft Word and Excel. Statistical Package for the Social Sciences (SPSS) version 26 analyzed data, employing Pearson's correlation coefficient to assess the association between DWT and IPSS. An independent sample *t*-test compared the means of IPSS-scored groups, with $P < 0.05$ as the significance threshold.

Results

This study included 171 male patients meeting the inclusion criteria and referred by a clinician for an ultrasound examination of the abdomen and pelvis. The mean age of the patient is 65.01 ± 11.55 years (Fig. 3).

The study analyzed 171 patients with mild and moderate to severe prostate symptoms. The International Prostate Symptom Score (IPSS) ranged from 1 to 35, with a mean of 11.40 ± 7.97. The mean IPSS score for mild and moderate to severe symptoms were 4 ± 2.12 and 15.93 ± 6.74, respectively. The mean DWT ranged from 0.8 mm to 3.7 mm, with mild symptoms having a

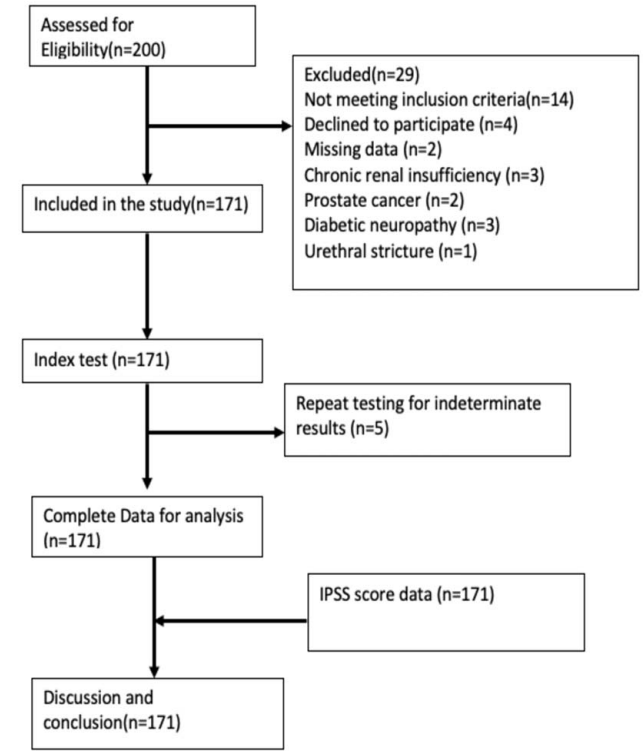

Figure 3. STROCSS flow diagram illustrating the participant flow of the Benign Prostatic Hyperplasia.

mean of 1.64 ± 0.38 mm and moderate to severe symptoms having a mean of 2.4 ± 0.43 mm.

The study found that the maximum thickness of DWT was 2.424 ± 0.5075 mm in the 70–79 age group, while the minimum thickness was 1.500 ± 0.5392 mm in the 40–49 age group. The average bladder urine volume during DWT measurement was 314.16 ± 67.44 ml.

Analysis with Pearson's correlation coefficient (r) showed a correlation of $r = 0.697$, $n = 171$ ($P < 0.001$) between DWT and LUTS which indicates strong, positive, and significant correlation (Fig. 4).

Applying an independent two-sample *t*-test with an assumption of equal variances revealed a significant disparity in the means of DWT between the designated groups, categorized as mild symptoms and moderate to severe symptoms (Table 1).

Discussion

Although IPSS is a helpful and validated tool for the evaluation of IPSS, a poor level of education impacts the result of the IPSS questionnaire[9]. This study helps to overcome that obstacle by finding the association between the DWT (measured by transabdominal USG) and the IPSS score[10].

The study included 171 patients with BPH and LUTS, with a mean age of 65.01 ± 11.55 years similar to previous studies by Karakose *et al.* (63.2 ± 8.1 years) and Eghbali *et al.* (61.7 ± 9.2 years)[11,12]. The mean age in Port Harcourt, South Nigeria, was 62.0 ± 11.66 years, which is comparable to our study[13]. However, Ogunbiyi and Shittu[14] reported a mean age of 71.4 ± 14.3 years in Nigeria, which differs from the average age

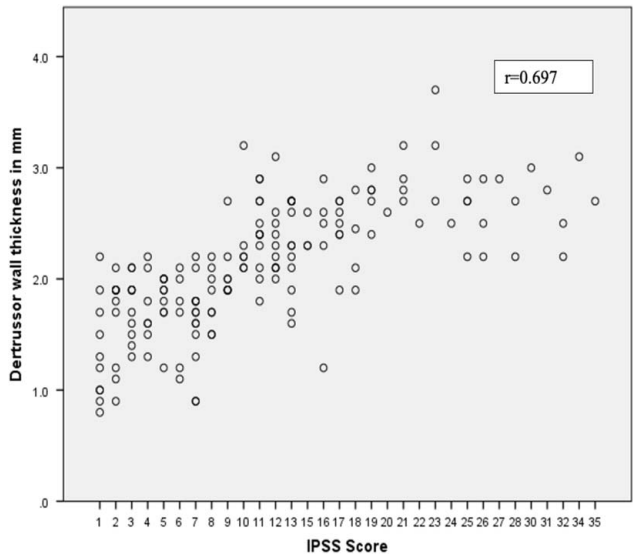

Figure 4. Scatter Plot of Detrusor Wall Thickness (DWT) and Lower Urinary Tract Symptom Severity (LUTS).

found in this study. The difference in mean ages may be due to late health-seeking behavior in Nigeria and the study's location in Nepal's capital city, where urban populations are expected to have early health-seeking behavior.

The study recorded a mean bladder volume of 314.16 ± 67.43 ml (range: 250–800 ml), surpassing the 250 ml threshold, consistent with Oelke *et al.*[15]'s observation of constant DWT beyond 250 ml. In contrast to Yilmaz *et al.*[16]'s findings (53.54 ± 35.31 ml), our study observed a mean prostate volume of 40.91 ± 12.48 ml, possibly influenced by the urban study center or varied study population.

In this study, the average International Prostate Symptom Score (IPSS) was 11.40 ± 7.97, contrasting with Yilmaz *et al.*'s study (20.70 ± 6.43) but aligning closely with Eghbali *et al.*'s findings (14.60 ± 5.00)[12,16]. The mild symptoms group had a mean IPSS of 4 ± 2.12, while the moderate to severe symptoms group scored 15.93 ± 6.7. Among 171 patients, 38% had mild symptoms, and 62% had moderate to severe symptoms. This contrasts with Bock *et al.*'s study where 72.2% had moderate to severe LUTS, and 27.8% had mild LUTS. Eghbali *et al.* also reported 77.3% with moderate to severe LUTS[12,13]. Differences may stem from a larger number of relatively younger patients in our study, variations in study populations, or different study centers.

This study established a significant positive correlation ($r = 0.697$, $P < 0.001$) between DWT and IPSS. Oelke *et al.*[15] demonstrated a significant DWT-IPSS association ($r^2 = 0.38$, $P < 0.0001$) in 160 males with LUTS due to BPH. Casado *et al.*[17] found a significant correlation ($r^2 = 0.38$, $P < 0.0001$) in a study of 74 males with symptomatic BPH. Manieri *et al.*[18] discovered a significant association ($r^2 = 0.60$, $P = 0.007$) in 174 patients with LUTS related to prostate diseases. In contrast, Yilmaz *et al.* ($r^2 = 0.0045$, $P = 0.9769$) and Kamyar *et al.* ($r^2 = 0.023$, $P = 0.812$), found weak and statistically insignificant correlation[12,16]. Hackenberg *et al.*[19]'s study, like this one, found a weak but statistically insignificant DWT-IPSS association ($r^2 = 0.0075$, $P = 0.6728$).

Benign prostatic enlargement with BOO causes LUTS with higher outlet resistance and IPSS score, which may explain the significant correlation between the DWT and IPSS found in this study and previous studies[15,17,18]. Unrelieved BOO with an increase in symptoms (IPSS) often causes detrusor muscle changes, leading to an increase in DWT as determined by ultrasonography. This results in a significant positive association between the DWT and IPSS in this study and others[12,17,20]. However, in other studies, a weak or lack of correlation may be related to compensatory changes in the bladder wall that may occur after prolonged, unrelieved BOO. These compensatory alterations may cause the bladder wall to thin and decrease DWT, leading to little or no correlation between the DWT and IPSS in cases with prolonged, unrelieved BOO[11,19].

The inconsistent results in the relationship between the DWT and IPSS may be due to differences in study design and patient selection. More multicenter studies are needed to confirm this research's findings, especially considering demographic variance.

This study revealed a mild positive and statistically significant correlation ($r = 0.419$, $P < 0.001$) between DWT and patient age. Similar observations were made by Hakenberg *et al.*[19], indicating a slight rise in DWT with aging in both sexes. Casado *et al.*[17] also noted a positive but statistically insignificant association ($r^2 = 0.12$, $P = 0.318$) between DWT and age. Contrary to young individuals, Oelke *et al.*[15] found a small but positive correlation between DWT and age in those over 40, consistent with this study's inclusion of male patients over 40. The maximum DWT occurred in the 70–79 age group (2.424 ± 0.5075 mm), while the minimum was in the 40–49 age group (1.500 ± 0.5392 mm). The decrease in DWT among those over 80 may be due to compensatory bladder wall alterations. These findings warrant further exploration and validation in future studies.

In this study, a significant difference in DWT means was observed between groups with mild and moderate to severe symptoms ($P < 0.001$, 95% CI: – 0.8970 to – 0.6414). This aligns with a previous study by Tokgöz *et al.*[21]. Further confirmation through similar studies in different settings is needed for conclusive evidence. If validated, this finding holds clinical significance, particularly in resource-limited settings with a high patient load awaiting treatment. The ability to categorize individuals based on symptom severity using simple diagnostic tools could aid in prioritizing patients efficiently and addressing the needs of those with more urgent conditions.

Table 1

Independent *t*-test between two groups for detrusor wall thickness (DWT) (equal variance assumed)

	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% CI of the difference	
Detrussor wall thickness in mm (Equal variances assumed)	0.749	0.388	– 11.884	169	< 0.001	– 0.7692	0.0647	Lower	Upper
								– 0.8970	– 0.6414

The study focused on the IPSS score in an urban center, ignoring potentially influential variables like age. It acknowledged the lack of a standardized chart in Nepal, measurement challenges due to high-frequency probe use in obese patients, and the generalizability of the study's application in the Nepali population.

Conclusion

Our study revealed a statistically significant positive correlation between LUTS severity and DWT, affirming the utility of transabdominal ultrasound as a cost-effective, noninvasive tool for assessing BPH-related LUTS. The observed differences in mean DWT between mild and moderate-severe IPSS scores further support its clinical relevance. Future research should investigate DWT variations across bladder locations to enhance our understanding.

Ethical approval

We have conducted an ethical approval base on the Declaration of Helsinki with registration research at the Institutional Review Board (IRB) of National Academy of Medical Sciences, Nepal Reference number: 872/2079/80.

Consent

Written informed consent was obtained from the patient for the publication of this case report and the accompanying images. A copy of the written consent is available for review by the Editor-in-chief of this journal on request.

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None.

Author contribution

K.B.: conceptualization, as mentor and reviewer for this original article and for data interpretation; H.K.: conceptualization and reviewer for this case; B.R.T.: reviewer and data interpretation; S. K.: contributed in performing literature review, editing, and writing the paper. All authors have read and approved the manuscript.

Conflicts of interest disclosure

All the authors declare that they have no competing interest.

Research registration unique identifying number (UIN)

1. Name of the registry: researchregistry.com.
2. Unique identifying number or registration ID: researchregistry9960.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): https://researchregistry.knack.com/research-registry#home/registrationdetails/65b515644d360800297dac17/.

Guarantor

Kishor Bhattarai is the person in charge of the publication of our manuscript.

Data availability statement

Data sharing is available upon reasonable request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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