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## ORIGINAL RESEARCH

# Sonographic Correlations Between Intravesical Prostatic Protrusion and Bladder Outlet Obstruction in Patients with Symptomatic Benign Prostatic Hyperplasia in Ibadan, Nigeria

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## Abstract

**Background:** Evaluating bladder outlet obstruction (BOO) in patients with prostatic enlargement may reflect the severity of the disease and aid in predicting the treatment outcome.

**Objectives:** To determine the sonological correlation between intravesical prostatic protrusion and bladder outlet obstruction in patients with symptomatic benign prostatic enlargement.

**Methods:** This prospective study was conducted over one year at the Department of Radiology, University College Hospital, Ibadan. A transabdominal ultrasound scan of the urinary bladder and prostate gland was carried out on patients with prostatic enlargement and BOO. The intravesical prostatic protrusion, pre-and post-void urine volumes, prostate volume and bladder wall thickness were measured.

**Results:** A total of 132 men aged 43 to 90 years (mean age: 63.8±8.64 years) were studied. The median size of the intravesical prostatic protrusion (IPP) was 7.25 mm (IQR: 0.00 mm; 14.9 mm). The mean prostate volume was 63.3ml±36.0ml. Most subjects (55; 41.7%) had a prostate volume above 60ml, and most patients (101, 77.2%) had bladder wall thickness less than 5mm. The mean bladder wall thickness was 4.26mm±1.54mm. There was a statistically significant correlation between IPP and pre-void urine volume and prostate volume ( $p = 0.002$  and  $<0.001$ , respectively). Patients over 70 years had increasing IPP and post-void urine, which lacked statistical significance ( $p = 0.15$ ).

**Conclusion:** The severity of bladder outlet obstruction was reflected in the pre-void urine volume, which correlated with the size of IPP.

**Keywords:** Benign Prostatic Hyperplasia, Bladder Outlet Obstruction, Intravesical Prostatic Protrusion, Post-void Residual Urine, Prostatic Enlargement.

## Introduction

In older men, benign prostatic hyperplasia (BPH) is the most common neoplasm, possibly leading

to prostatic enlargement. [1] The prevalence of histologically confirmed BPH increases with age and appears in approximately 40% of men aged 50-60 years and approximately 90% of men aged more than 80 years. [1-3] In Nigeria, it has been

reported that one in four men older than 40 years have BPH symptoms. [3] Enlargement of the prostate may lead to bladder outlet obstruction, characterized by increased detrusor pressure, and may manifest as impaired voiding of urine, referred to as lower urinary tract symptoms (LUTS). [3-5] Studies have shown that the symptoms and degree of obstruction do not entirely depend on the size of the prostate. [4]

Intravesical prostatic protrusion (IPP) is a phenomenon in which the prostate gland enlarges into the bladder along the plane of least resistance. IPP causes a 'ball-valve' type of obstruction, disrupting the funnelling effect of the bladder neck and causing dyskinetic movement of the bladder during voiding. This condition usually affects the prostatic median lobe with or without the lateral prostatic lobes, contributing significantly to bladder outlet obstruction. [4] In contrast to prostatic size, intravesical prostatic protrusion (IPP) has been found to correlate with BOO.

The evaluation of BOO is a crucial factor that can reflect the severity and progression of the disease and may aid in predicting the outcome of the treatment of BPH. [5] Pressure flow studies are the gold standard for BOO, but this method is invasive and expensive with limited availability. [5, 6] Given the non-availability of uroflowmetry and cost, novel and less invasive parameters, such as ultrasound measurement of the intravesical prostatic protrusion (IPP), are being evaluated to determine the severity of BOO and predict treatment response. [6-8] Some studies [7, 8] in high-income countries have assessed the relationship of IPP to BOO using trans-abdominal ultrasound, and they reported that BOO grade increased with an increase in the grade of IPP. Therefore, it was concluded that IPP has high sensitivity and specificity in predicting BOO in the population studied.

In Nigeria and Africa, where the prevalence of prostatic enlargement is high in the geriatric population [3, 4] and the cost of assessing quality health care is also exorbitant, there needs to be more literature on this subject matter. Therefore, this study examined the sonographic correlation between intravesical prostatic protrusion and bladder outlet obstruction as a measure of disease severity in patients with symptomatic benign prostatic hyperplasia in a Nigerian population.

## Methods

This prospective study was conducted over one year (January to December 2020). Patients with prostatic enlargement who met the inclusion criteria were recruited for this study. Lower Urinary Tract Symptoms (LUTS) were defined by voiding or obstructive symptoms such as hesitancy, poor or intermittent urinary stream, straining, prolonged micturition, feeling of incomplete bladder emptying, dribbling, and storage or irritative symptoms such as frequency, urgency, urge incontinence, and nocturia. [7]

Ethical approval for the study was obtained from the joint University of Ibadan and University College Hospital ethics review committee (UI/EC/18/0718). The inclusion criteria included age above 40 years, clinically diagnosed BOO referred from the urology clinic to the ultrasound suite of the Department of Radiology, UCH. The exclusion criteria included a known history of previous prostate/bladder/lower urinary tract surgery, suprapubic or urethral catheterization, neurogenic bladder with voiding dysfunction and inability to have a full bladder and any form of bladder mass.

A transabdominal pelvic ultrasound scan was conducted to evaluate the entire urinary bladder and prostate gland using a GE Logiq S8® ultrasound scan machine with a 3-5 MHz

curvilinear transducer. The parameters employed in this sonographic evaluation included IPP, prostate volume, bladder wall thickness, and pre-void as well as post-void residual urine volumes. The urinary bladder was allowed to fill with urine until the patient had the urge to void; after that, the pre-void urine volume was measured and documented.

To ensure standardization, a straight line was drawn through the base of the urinary bladder; after that, the intravesical prostatic protrusion was measured in millimetres as the perpendicular distance from the tip of the protrusion of the enlarged prostate to the base of the urinary bladder in a sagittal view. The measurements were classified into three grades, namely grade I (IPP = 0-5mm), II (IPP = 6-10mm), and III (IPP = >10mm), in increasing order of severity according to the classification by Lee *et al.* [7]

The patients were asked to void after that, and the corresponding post-void urine volume was measured. Prostate volume and bladder wall thickness (BWT) were also measured in each case. The prostate volume was measured by dividing the screen of the ultrasound machine into two. The first screen was used to display the image of the prostate gland in a longitudinal scan, and the second screen, in a transverse scan, was captured orthogonally. The longitudinal measurements were taken on the first screen, while the anteroposterior and transverse dimensions were taken on the second. The machine generated the volumes automatically using the elliptical formula for computing volumes. The pre-and post-void urine volumes were also computed using the same principle. The parameters evaluated in the prostate were the size, outline, intactness of the capsule, echotexture and extent of intravesical prostatic protrusion. The bladder wall thickness was measured as the distance between the inner and outer surfaces of the urinary bladder wall.

The data obtained were analysed using the Statistical Package for Social Sciences (SPSS) version 21, and the output was presented as tables and figures as applicable. Categorical variables such as grades of intravesical prostatic protrusion were expressed as proportions, ratios and percentages. Continuous data such as bladder wall thickness, prostate volume and post-void urine volume were summarised in mean values (with standard deviation). Appropriate tests of significance were deployed. Pearson's correlational analysis was used to test the relationship between intravesical prostatic protrusion and post-void residual urine volume (PVR) in patients with symptomatic bladder outlet obstruction. A multivariate analysis of factors associated with intravesical prostatic protrusion was performed. The statistical significance level was defined as  $p < 0.05$  for all tests.

## Results

One hundred and thirty-two patients aged 43 to 90 years were studied, and the mean age was  $63.8 \pm 8.64$  years (Figure 1). The median size of IPP was 7.25 mm (IQR: 0.00 mm; 14.9 mm). The post-void residual urine volume was less than 50ml in 47.7% of the subjects and greater than 60ml in 41.7%. The mean post-void residual volume was  $96.1 \pm 121.6$ ml. The mean prostate volume of the participants was  $63.3 \pm 36.0$  mm<sup>3</sup>. Over three-quarters of the participants (101, 77.2%) had bladder wall thickness (BWT) less than 5mm. The mean BWT was  $4.26 \pm 1.54$ mm. (Table I)

Patients aged 40-50 years either had grade I (15; 71.4%) or grade II (2; 28.6%) IPP, while a majority of those aged 70 years and above (18; 54.5%) had grade III IPP. (Figure 2). There was a statistically significant relationship between IPP and pre-void urine volume ( $p = 0.002$ ) and between IPP and prostate volume ( $p = 0.001$ ) (Table I). The

proportion of participants with post-void residual urine volume greater than 200ml was highest among those aged above 70 years of age (15.2%), followed by those aged 61-70 years (14.3%) (Figure 3). The majority of the participants within the age group 40 – 50 years (57.1%) and age group 51 – 60 years (34.9%) had a prostate volume of less than 40ml, while

participants aged 61 – 70 years (34.7%) and those over 70 years (54.5%) had a prostate volume of over 60ml. (Figure 4). IPP had a strong positive correlation with prostate volume ( $r = 0.463$ ,  $p < 0.001$ ), while there was a negative correlation between IPP and pre-void urine volume ( $r = -0.263$ ,  $p = 0.002$ ) as shown in Table II.

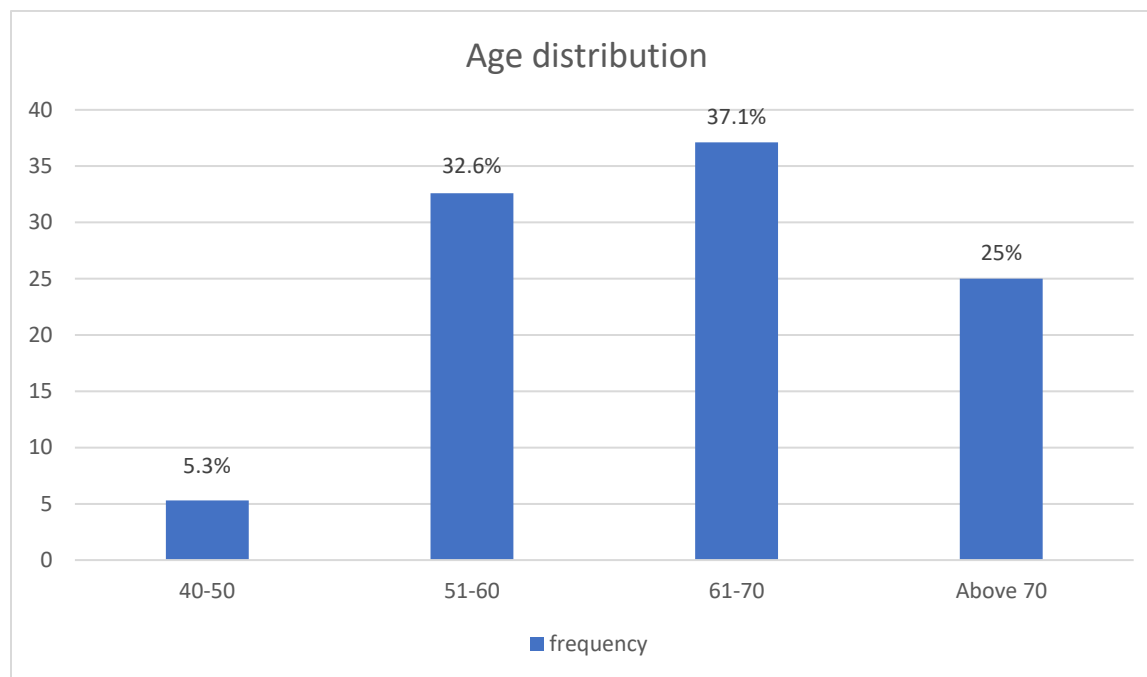


Figure 1: Age distribution of study participants

Multivariate analysis showed that pre-void urine volume and prostate volume independently predicted IPP; there was a 0.016mm decrease in average IPP for every 1ml increase in pre-void urine volume (95% CI -0.006; -0.026,  $p = 0.002$ ). For a unit increase in prostate volume, the average IPP increased by 0.101mm (95% CI 0.060; -0.142,  $p < 0.001$ ). There was no significant correlation between IPP and post-void urine ( $p = 0.15$ ), as shown in Table III.

## Discussion

Symptomatic BOO from prostatic enlargement, one of the commonest disease conditions affecting older men worldwide, is associated with progressive prostate gland enlargement as men age. [4, 5] This was corroborated in this study, where the patients aged above 70 years (84.6%) had the highest number of cases with prostate volume above 40mls while those between 40 and 50 years (42.9%) had the least number of cases with prostate volume above 40mls.

Table I: Association between Intravesical Prostatic Protrusion and other ultrasound scan parameters studied

Variables	Grade 1 Median (IQR)	Grade 2 Median (IQR)	Grade 3 Median (IQR)	p-value	Pairwise comparison
Age (years)	61.0 (56.0; 64.0)	64.0 (56.5; 70.0)	66.5 (60.5; 72.0)	0.005	1<3
PoVR urine (ml)	34.0 (17.0; 77.2)	78.0 (11.9; 142.0)	91.1 (27.0; 128.3)	0.052	1>3
PrVR urine (ml)	355.0 (222.0; 453.0)	360.0 (237.0; 494.0)	221.4 (131.4; 317.7)	0.001	2>3
Prostate volume (ml)	44.0 (35.2; 61.9)	57.7 (40.0; 66.0)	64.1 (51.6; 92.5)	0.003	1<3
Bladder wall thickness (mm)	3.70 (3.00; 4.40)	4.50 (3.40; 5.15)	3.78 (3.00; 5.00)	0.095	?

PoVR - Post-Void Residual; PrVR - Pre-void Residual

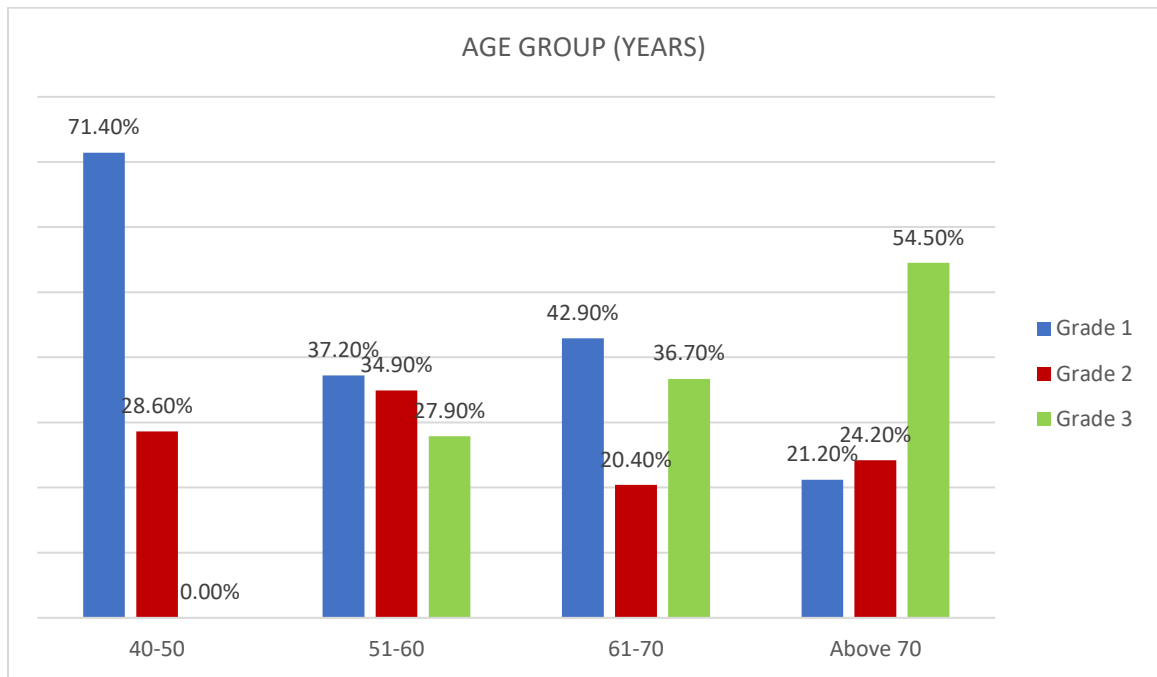


Figure 2: Age distribution of Intravesical Protrusion among participants

This is similar to findings from a previous study by Reis *et al.* [8] in Brazil, which concluded that increasing age coincides with the period of symptomatic benign prostatic enlargement following hyperplasia of the prostatic stroma.

In the present study, the severity of IPP increased with age as IPP grade III was recorded among most patients above 70 years. This is similar to

the findings of Wang *et al.* [9] and Aganovic *et al.* [10], and this may be attributed to the fact that the intravesical portion of the prostate gland becomes more prominent with advancing age. On the contrary, Lieber *et al.* [11] showed no significant relationship between IPP and age. These variations may be attributed to different characteristics of ethnic populations.

Bladder Outlet Obstruction is usually followed by a compensatory increase in bladder wall thickness (BWT) due to smooth muscle hypertrophy and decomposition of connective tissue. [5] The present study showed a weak

relationship between IPP and bladder wall thickness. Despite the high prostatic volume, less than one-quarter had bladder wall thickness above 5mm.

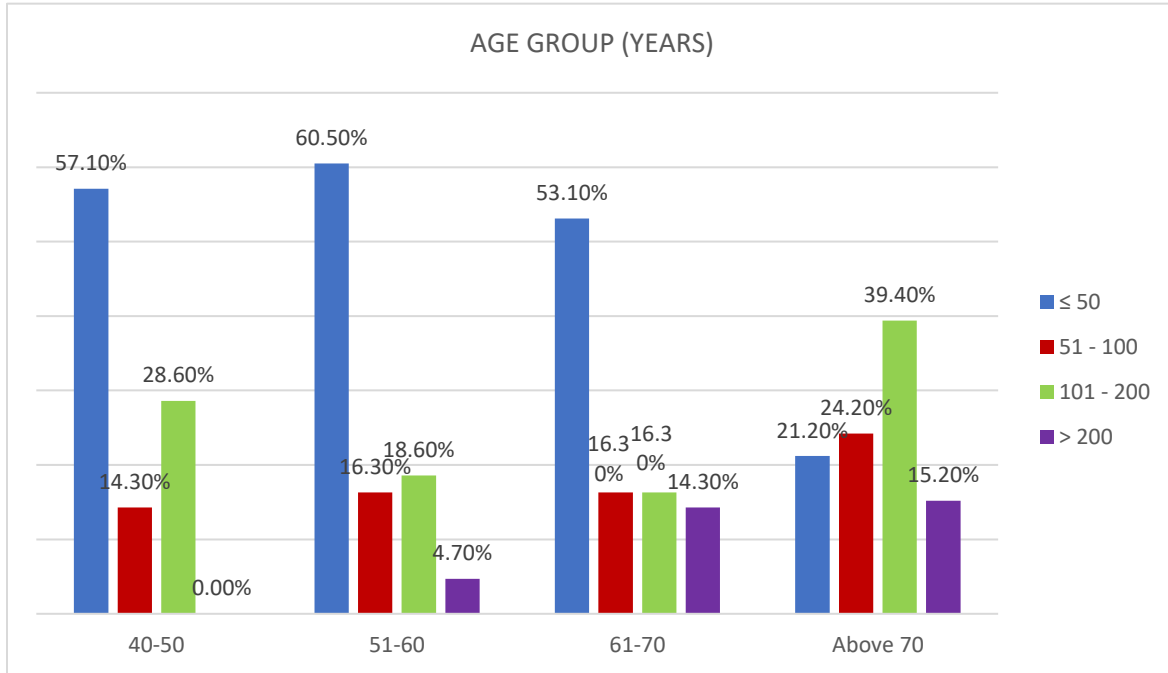


Figure 3: Age distribution of post-void urine retention among participants

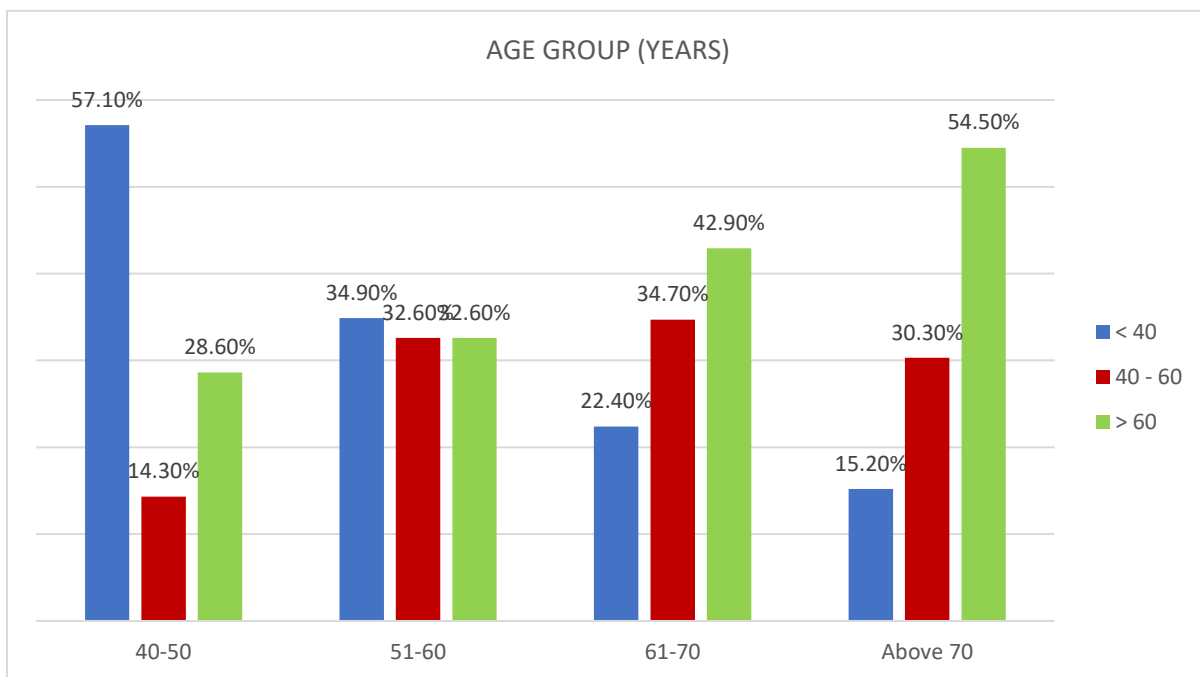


Figure 4: Age distribution and prostatic volume among Participants

**Table II: Correlation between age and ultrasound scan parameters**

<i>Variables</i>	<i>Correlation coefficient</i>	<i>p-value</i>
Intravesical Prostatic Protrusion (mm)	0.260	0.003
Post-void Residual Volume (ml)	0.240	0.006
Pre-void Urine Volume (ml)	-0.204	0.019
Prostate Volume (ml)	0.221	0.011
Bladder Wall Thickness (mm)	0.187	0.032

**Table III: Multivariate analysis of the factors associated with Intravesical Prostatic Protrusion in symptomatic Bladder Outlet Obstruction**

<i>Variables</i>	<i>B</i>	<i>95% CI</i>	<i>p-value</i>
Age (years)	0.088	-0.086, 0.262	0.321
Post-void Residual Volume (ml)	0.010	-0.004, 0.025	0.157
Pre-void Urine Volume (ml)	-0.016	-0.026, -0.006	0.002
Prostate Volume (ml)	0.101	0.060, 0.142	<0.001
Bladder Wall Thickness (mm)	-0.098	-1.051, 0.855	0.840

This is similar to the findings of Fadi *et al.* [12], who postulated that an increase in bladder wall thickness may result from smooth muscle hypertrophy and increased collagen deposition in the bladder wall. They opined that the BWT dimension is volume-dependent; BWT decreases rapidly during the initial 200ml bladder filling. Afterwards, it becomes relatively constant, with all parts of the bladder wall uniformly thick. Therefore, with increasing post-void urine volume, the bladder wall thickness reduces.

Lieber *et al.* [11] described a trend for men with an increase in prostate volume to have IPP of 10mm or greater, subsequently leading to obstruction as evidenced by increased post-void urine volume. This finding is corroborated in the present study, where 54.5% of patients above 70 years had prostate volume greater than 60mls. They also had the highest proportion (54.5%) of Grade III IPP and significant post-void urine above 100mls

in 54.6%. Undang *et al.* [13] correlated intravesical prostatic protrusion with post-void residual (PoVR) urine volume in the studied patients and reported a significant relationship between IPP and PoVR urine in BPH patients. They showed that the greater the IPP, the greater the volume of residual urine post-micturition, depicting an increase in bladder outlet obstruction.

The intravesical prostatic protrusion is a helpful predictor of BOO than prostate volume. [14-16] Hossain *et al.* [14] found that prostate volume and intravesical prostatic protrusion significantly correlated with bladder outlet obstruction in patients with BPH. However, they discovered that the correlation of IPP with PoVR was stronger than that of IPP with prostate volume. The present study, ironically, found a positive correlation between IPP and prostatic volume. The severity of BOO is usually assessed using the post-void urine volume. [17,18] The relationship



between IPP and PoVR urine volume in the present study showed a weak linear correlation, which was not statistically significant. Increasing IPP did not translate to significant PoVR urine volume in some subjects. Pre-void volume was introduced in this study, and there was a significant correlation between IPP and pre-void urine volume. This is not a common parameter in the evaluation of BOO. Therefore, further studies may be needed to evaluate its relevance.

## Conclusion

There is a positive relationship between IPP and prostate volume, and there is a suggestion that as patients age, the severity of IPP grade also increases. An association between pre-void urine volume and intravesical prostatic protrusion is also likely. Given the findings from this study, it is recommended that the sonographic measurement of IPP should be added to the assessment of patients presenting with BOO secondary to BPH. It is also essential to add the estimation of pre-void urine volume to post-void residual urine (PoVR) during prostate ultrasonography to give a more objective picture of how well the patient can empty his bladder.

**Authors' Contributions:** OO, AJA, OAO and SOB conceived and designed the study. OO and AI did data analysis and interpretation. OO and AJA drafted the manuscript while AJA, AI, OAO and SOB revised the draft for sound intellectual content. OAO and SOB approved the final version of the manuscript.

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