Original Article

Ultrasonographic Intravesical Prostatic Protrusion in Men with Benign Prostatic Hyperplasia in Southwest Nigeria

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Abstract

Objectives: To study the relationship between sonographically measured intravesical prostate protrusion and international prostate symptoms score (IPSS), as well as prostate volume, in men with benign prostatic hyperplasia at a single health facility. **Materials and Methods:** This was a cross-sectional observational study of one hundred men (age >40 years) diagnosed with benign prostatic hyperplasia. Their International Prostate Symptoms Score (IPSS) was assessed using the standardised IPSS instrument. Abdominal ultrasound was done to measure the intravesical prostatic protrusion (IPP), while prostate volume was estimated transabdominally and transrectally. Correlations between parameters were quantified with Spearman's correlation test. P ≤ 0.05 was statistically significant. **Results:** The mean age was 62.84 ± 9.0 years (Range =42–79 years). The mean IPSS was 20.99 ± 6.42 (range of 5–30). Seventy-three percent of the men in this study had intravesical prostatic protrusion on ultrasound. The mean IPP was 13.0 ± 4.0 mm. Of the 73 men with IPP, 17 (23.3%), 29 (39.7%), and 27 (37%) had grade I, grade II and grade III IPP, respectively. The mean transabdominal prostate volume (TPVA) and transrectal prostate volume (TPVT) were 71 ± 14 ml and 69 ± 13 ml, respectively. IPP had a statistically significant positive correlation with all the other parameters. The strongest correlation (very high correlation) was with the TPVA (r=0.797, $P < 0.0001$), followed by a moderate correlation with the IPSS (r =0.513, $P < 0.0001$). TPVT, transition zone volume, transition zone index, presumed circle area ratio, and quality of life score yielded slightly weaker moderate correlation with IPP, while IPP correlated weakly with age. **Conclusion:** IPP correlated well with multiple clinical and sonographic parameters. It correlated better with TPVA than TPVT.

Keywords: *Benign prostatic hyperplasia, international prostate symptom score, intravesical prostate protrusion, lower urinary tract symptoms, prostate volume, ultrasound*

Introduction

Recently, clinical benign prostatic hyperplasia (BPH) has been defined as prostatic adenoma(ta) causing a spectrum of bladder outlet obstruction which might eventually impair renal and vesical excretory functions.[1,2]

Male lower urinary tract symptoms (LUTS) could present with obstructive or voiding symptoms (diminished urine stream, dysuria, hesitancy, terminal dribbling, reduced urine stream, splitting urine stream, straining to void, and intermittency), irritative or storage symptoms (urgency, urge incontinence, frequency, nocturia), and post-micturition symptoms (sensation of incomplete voiding, post-micturition dribbling). Benign prostatic hyperplasia, urethral stricture, and prostatic carcinoma are the leading causes of LUTS.[3-5] The International Prostate Symptoms Score (IPSS), Iversen score, Madsen score, Boyarsky score, and Danish prostatic symptom score are validated for assessing the severity of lower urinary tract symptoms, but the IPSS is the preferred instrument in men.[6]

There were 94 million prevalent cases of benign prostatic hyperplasia worldwide in 2019, which represents a 70.5% increase compared to the 51·1 million cases in the year 2000.[7] Globally, the disease burden of BPH is greater than that of all other male genitourinary disorders put together. The prevalence of BPH over a person's lifetime ranges from 22.8 to 29.6%.[8]

In Nigeria, there were 305,000 (range = 224,000 – 413,000) cases in the year 2000, which had increased by 36.3% (33.3 - 40.4%) to 415,000 (range = 308,000 – 566,000) cases by 2019.[7] Local community-

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based studies yielded a BPH prevalence of 23.7% - 25.3%,[9] while hospital-based studies reported a much high prevalence rate of 71.3% - 92%.[10,11] Approximately 27% of all cases of obstructive uropathy in our environment are attributable to BPH.[12] The predisposing factors for BPH include non-modifiable (Age, family history, Black race) and modifiable (Obesity, cardiovascular diseases, sedentary lifestyle, type 2 diabetes mellitus, dyslipidemia, hormonal imbalance, etc.) risk factors.[13,14]

With the refined definition mentioned above, clinical benign prostatic hyperplasia is now easier to discriminate from other less common aetiologies of male lower urinary tract symptoms (LUTS) using relatively simple and non-invasive transabdominal sonographic parameters: intravesical prostatic protrusion and prostate volume.[1,2]

The sonographically visible intravesical prostate protrusion (IPP) is caused by the enlargement of the median and or lateral lobes of the prostate gland into the urinary bladder neck.[15,16] This prostatic protrusion results in a "ball-valve" type of obstruction, which is worsened by subsequent forceful bladder contractions.[15] The IPP is measured on a midline longitudinal/sagittal view of a comfortably full bladder (about 200 ml) as the perpendicular distance (in millimeters) between the innermost intravesical protrusion of the prostate (prostatic tip) and the bladder neck.[1] IPP has a 100% specificity and 100% positive predictive value for diagnosing prostate adenoma.[1] It also correlates strongly with bladder outlet obstruction index measured by pressure flow studies.[6]

Maximum intravesical prostate protrusion (IPP) is obtained when the urinary bladder is comfortably distended, as stated above, with an inverse relationship between intravesical prostate protrusion and increasing urinary bladder volume beyond 200 ml.[17]

The purpose of this study was to assess the prevalence of IPP in men with BPH-related lower urinary tract symptoms and to determine its relationship with the International Prostate Symptoms Score (IPSS), transabdominal ultrasound prostatic volume, and transrectal ultrasound prostate parameters.

Materials and Methods

This prospective, descriptive cross-sectional study was conducted on 100 men, aged 40–90 years, with diagnosis of BPH by the Urologist, who were enrolled consecutively from the Urology clinic of the Obafemi Awolowo University teaching hospitals complex, Ile-Ife, Osun State, Nigeria. The study was approved by the Ethics and Research Committee of the hospital. Written informed consent was obtained from all the participants.

The study included individuals who were diagnosed with BPH based on clinical history of LUTS, digital rectal examination, prostate specific antigen <4ng/ml, and transabdominal prostatic volume >30 ml (or grams or cm^3). Patients with the following conditions were excluded from the study: prostate or bladder cancer, prostatitis, in-dwelling catheter, bladder calculi, urethral stricture, neurogenic bladder, acute urinary retention, history of transurethral resection of the prostate or previous urinary tract surgery, and anal stenosis or previous extensive rectal surgery.

The age, weight, height, body mass index (BMI), and PSA values of the participants were recorded. International Prostatic Symptoms Score and quality of life score were assessed using the standardized IPSS questionnaire. The IPSS is based on the answers to seven questions concerning urinary symptoms and one question concerning quality of life. Each question concerning urinary symptoms allows the patient to choose one out of six answers indicating increasing severity of the symptoms. The answers are assigned points from 0 to 5. The total score ranges from 0 - 35 (i.e., asymptomatic to very symptomatic) and the symptoms stratified into Mild (symptom score < 7), Moderate (symptom score = 8–19), Severe (symptom score = 20–35).[18]

The sonographic measurements were carried out with a Mindray® model DC-7 ultrasound machine (Shenzhen Mindray Bio-medical Electronics, Nanshan, Shenzhen, China). A transrectal biplanar transducer (frequency = 5.0 – 10.0 MHz) was used for transrectal scan of the prostate gland, while a curvilinear transducer (frequency = 3.5 – 5.0 MHz) was used for the transabdominal ultrasound scan of the prostate.

Transabdominal (100–200 ml of urine to measure IPP, then full bladder for TPVA) and transrectal (with empty bladder) prostate ultrasonography were performed in accordance with previously described standard techniques.[8,19,20] The urine volume was calculated on orthogonal views of the urinary bladder using the prolate ellipsoid formula: Volume (ml) = superior-inferior length (height) x anteroposterior (depth) x transverse (width) diameters.[21,22]

The longitudinal diameter (LD), anteroposterior diameter (APD), and transverse diameter (TD) of the prostate were measured. The transabdominal total prostate volume (TPVA) at full bladder volume, transrectal total prostate volume (TPVT), and the transition zone volume (TZV) were calculated using ellipsoid formula (0.523 x LD x APD x TD). The transitional zone index (TZI = TZV/TPVT) and the presumed circle area ratio (PCAR) were also calculated.[8,19]

On transabdominal ultrasound, the intravesical prostatic protrusion (IPP) was measured with 100–200 ml of urine in the bladder. A midline longitudinal/sagittal image of the urinary bladder neck and the prostate was obtained. In those with protruding median lobe, the IPP was measured (in millimeters) from the protruding prostatic tip to the to the circumference of the urinary bladder at the base of the

prostate gland [Figure 1]. The IPP was graded as follows: Grade I: < 5 mm; Grade II: 5 -10 mm; Grade III: > 10 mm.[6]

The examinations were carried out by the same investigator to eliminate inter-observer variability. All sonographic measurements were taken thrice and the mean values were recorded for each subject, to ensure accuracy of the measurements and reduce intra-observer variation.

The data obtained were analysed using the IBM SPSS Statistics for Windows, version 20 (IBM Corp., Armonk, N.Y., USA). Data Normality was tested with the Kolmogorov-Smirnov's test. Continuous variables were presented as mean ±Standard deviation (SD) and ranges, while categorical variables were presented as frequencies and proportions. The relationship between variables was tested using Spearman's correlation for non-parametric data. The strength of the correlation coefficients was grade as follows: r = 0 – 0.2: very low/negligible and probably meaningless correlation; r = >0.2 – 0.4: low correlation; r = >0.4 – 0.6: moderate correlation; r = >0.6 – 0.8: high correlation; r = >0.8 – 1.0: excellent/very high correlation.[23] At 95% confidence interval, *P* values ≤ 0.05 was considered statistically significant.

Results

A total of 100 men with BPH were studied. Their mean age was 62.84 ± 9.0 years (Range = 42–79 years) [Table 1]. The age subgroups were as follows: 40–49 years (10; 10%), 50–59 years (26; 26%), 60–69 years (36; 36%), and 70–79 years (28; 28%).

The mean transabdominal total prostate volume was 71 ± 14 ml (range = 48–97 ml), while the mean transrectal total prostate volume was 69 ± 13 ml (range = 46–96 ml). The summary statistics of the other variables are shown in [Table 1].

The mean IPSS of all the participants was 20.99 ± 6.42 (range = 5 – 30). Mild, moderate, and severe IPSS were recorded in 10 (10%), 31 (31%), and 59 (59%) participants, respectively [Table 2]. Furthermore, the mean IPSS by age group were 14 ± 6.6 (40–49 years), 21 ± 6.0 (50–59 years),

Table 1: Clinical and sonographic characteristics of the study population

Parameters	Mean± SD	Range
Age (Years)	62 ± 9.0	42–79
TPVT (ml)	69 ± 13	46–96
TZV (ml)	54 ± 15	29–83
TPVA (ml)	71 ± 14	48–97
TZI	0.8 ± 0.1	0.6–0.9
IPP (mm)	13.0 ± 4.0	10.0–20.0
PCAR	0.8 ± 0.7	0.6–0.9
QOLS	3.7 ± 0.8	2.0–5.0

IPP=Intravesical Prostatic Protrusion; PCAR=Presumed Circle Area; QOLS=Quality of Life Score; TPVA=Transabdominal Total Prostate Volume; TPVT=Transrectal Total Prostate Volume; TZI=Transition Zone Index; TZV=Transition Zone Volume

Table 2: International prostate symptoms scores (IPSS) of the participants

Symptoms	Frequency	Percentage
Mild	10	10
Moderate	31	31
Severe	59	59
Total	100	100

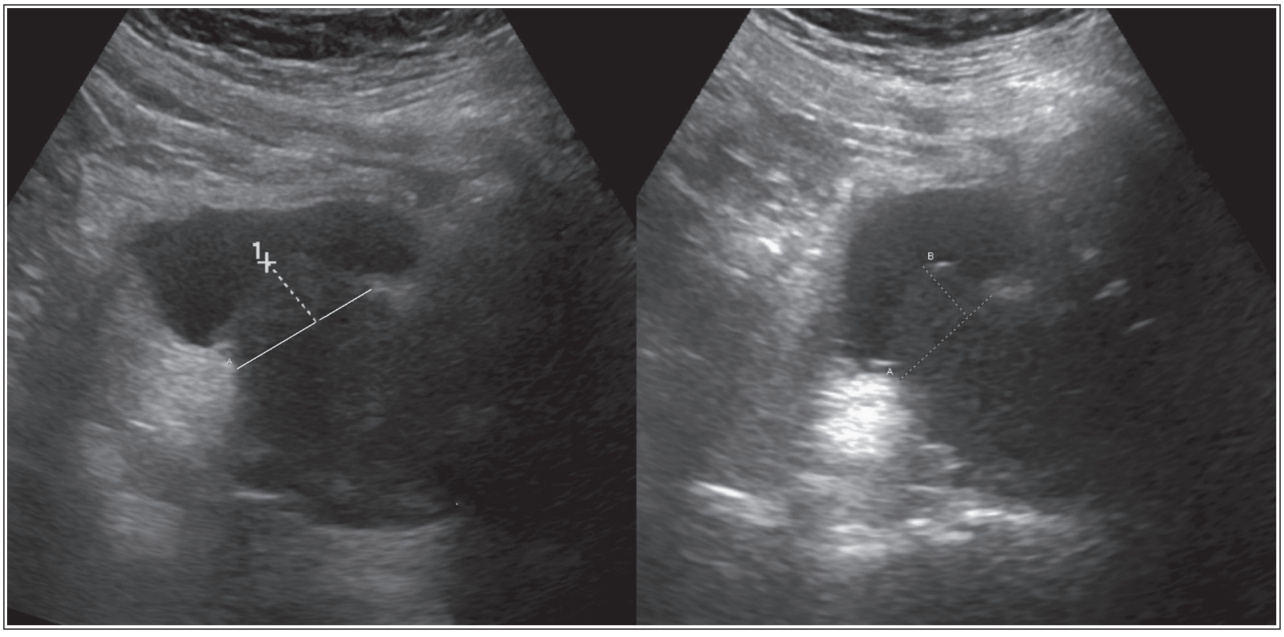

Figure 1: Transabdominal ultrasound measurement of Intravesical Prostatic Protrusion in two different men with benign prostatic hyperplasia as the distance between the tip of the prostate's protrusion into the bladder and the bladder neck

Table 3: Clinical and Ultrasound parameters by age group

Parameters	40-49 (N=10)	50-59 (N=26)	60-69 (N=36)	70-79 (N=28)	t	*P* value
IPP (mm)	16.0 ± 5.0	13.0 ± 5.0	12.0 ± 4.0	11 ± 4.0	8.001	**0.046**
TPV (ml)	60 ± 10	60 ± 10	67 ± 15	77 ± 9.0	14.441	**0.002**
TPVT (ml)	43 ± 11	43 ± 11	52 ± 15	61 ± 10	14.197	**0.003**
TZI	0.7 ± 0.1	0.7 ± 0.1	0.7 ± 0.1	0.8 ± 0.0	13.359	**0.004**
PCAR	0.7 ± 0.1	0.8 ± 0.1	0.8 ± 0.1	0.8 ± 0.1	10.220	**0.017**
IPSS	14 ± 6.6	21 ± 6.0	20 ± 5.8	24 ± 5.7	18.331	**0.005**
QOLS	3.2 ± 0.6	3.7 ± 0.7	3.7 ± 0.7	4.0 ± 0.9	7.575	**<0.001**
TPVA (ml)	62 ± 11	71 ± 14	68 ± 15	78 ± 9.6	12.685	**0.002**

t= Kruskal Wallis test statistics

IPP=Intravesical Prostatic Protrusion; PCAR=Presumed Circle Area; QOLS=Quality of Life Score; TPVA=Transabdominal Total Prostate Volume; TPVT=Transrectal Total Prostate Volume; TZI=Transition Zone Index; TZV=Transition Zone Volume

Table 4: Intravesical Prostatic Protrusion (IPP) grades in the study population

Grade	Frequency	Percent
I	17	23.3%
II	29	39.7%
III	27	37.0%
Total	73	100

20 ± 5.8 (60–69 years), and 24 ± 5.7 (70–79 years) [Table 3]. [Table 3] shows the summary statistics of the other variables by age group.

Intravesical prostate protrusion (IPP) was seen in 73 (73%) men. Of these 73, 17 (23.3%), 29 (39.7%), and 27 (37%) had grade I, grade II, and grade III IPP, respectively [Table 4]. The IPP distance ranged from 10 mm to 20 mm, with a mean of 13.0 ± 4.0 mm [Table 1].

In [Table 5], the mean age of the 29 participants with grade II IPP (67 ± 9.1 years) was significantly higher than that of men with grade III IPP (64 ± 8.6 years), while those with grade III IPP also had a significantly higher mean age than the grade I IPP subgroup (60 ± 6.5 years). Moreover, the grade II IPP subgroup had the highest IPSS, TPVT, TPVA, and QOLS. In contrast, the grade III IPP subgroup had the highest TZV. Grade II IPP and grade III IPP subgroups had essentially the same TZI and PCAR [Table 5].

[Table 6] shows the relationship between intravesical prostate protrusion (IPP) and other evaluated parameters. IPP had a statistically significant positive correlation with all the other parameters. The strongest correlation (very high correlation) was with the transabdominal total prostate volume (r = 0.797, $P<0.0001$), followed by a moderate correlation with the IPSS (r = 0.513, $P<0.0001$). TPVT, TZV, TZI, QOLS, and PCAR yielded marginally weaker moderate correlation with IPP. IPP correlated weakly with age.

Discussion

Intravesical prostatic protrusion (IPP) has been investigated for multiple potential uses in urology. These include, interalia, diagnosis of bladder outlet obstruction, predictor of trial without catheter (TWOC), predictor of medical treatment effect, predictor of progression of BPH-related LUTS, is a risk factor for bladder stone in BPH, predictor of overactive bladder, predictor of prostate carcinoma, and predictor of early urinary continence recovery after laparoscopic radical prostatectomy.[24]

Ultrasonographic assessment of intravesical prostate protrusion (IPP) now plays an important role in the diagnosis of BPH. Multiple studies have shown that IPP, taken together with transabdominal total prostate volume (TPVA), correlates well with benign prostatic obstruction and the progression of the disease.[1,2,25-27]

The mean age of the study population was 62.84 ± 9.0 years. The seventh decade of life was also the mean age of subjects with BPH in multiple previous studies in this environment and elsewhere. Hamza *et al.* (63.7 years ± 8.9 years),[6] Agbo *et al.* (64.6 ± 10.2 years),[28] Aigbe *et al.* (68.12 ± 9 years),[29] Obiesie *et al.* (69.3 ± 10.6 years),[20] Mbouche *et al.* (63.17 ± 10.26 years),[30] Galeti *et al.* (65.94 ± 8.27 years),[31] and Tchaou *et al.* (66.63 ± 11.55 years)[32] documented mean age in the same range in Kaduna, Jos, Irrua, Nnewi, Cameroon, India, and Togo, respectively. The seventh decade of life coincides with the period of symptomatic benign prostatic enlargement following hyperplasia of the prostatic stroma.[3] The onset of BPH can occur as early as 25–30 years of age. The prevalence of histologically detectable BPH increases with age, such that by the sixth decade (age 51 to 60 years), it exceeds fifty percent.[33,34]

The mean IPP in this study was 13.0 ± 4.0 mm which lies within grade III IPP. This is similar to the findings of Hamza *et al.*,[6] Agbo *et al.*,[28] Oshagbemi *et al.*,[35] and Sigdel *et al.*[36] who reported mean IPP of 10.3 mm, 12.9 mm, 13.04 mm, and 14.6 mm, respectively. In contrast, the mean IPP of the study by Gopinath *et al.* (9.81 ± 5.1 mm)[37] and Galeti *et al.* (9.81 ± 5.41 mm)[31] which fell in the grade II IPP range. Differences in the severity of prostatic median and or lateral lobe enlargement in the subjects recruited is likely responsible for this disparity.

Seventy-three (73%) of the 100 subjects showed intravesical prostate protrusion (IPP) on ultrasound, while 27 (27%) had enlarged prostate glands without IPP. In the study by

Table 5: Clinical and ultrasound parameters compared by IPP grade

Parameters	IPP Grade I (N= 17)	IPP Grade II (N=29)	IPP Grade III (N=27)	df	t	*P* value
Age (years)	60 ± 6.5	67 ± 9.1	64 ± 8.6	2	9.088	**0.011**
IPSS	18 ± 6.9	25 ± 2.7	23 ± 5.5	2	19.838	**<0.0001**
TPVT (ml)	62 ± 12	79 ± 11	73 ± 13	2	18.767	**<0.0001**
TZV (ml)	44 ± 13	64 ± 11	83 ± 58	2	21.575	**<0.0001**
TZI	0.7 ± 0.1	0.8 ± 0.0	0.8 ± 0.1	2	25.619	**<0.0001**
PCAR	0.7 ± 0.1	0.8 ± 0.0	0.8 ± 0.1	2	23.696	**<0.0001**
QOLS	3.6 ± 0.5	4.3 ± 0.7	3.9 ± 0.7	2	9.133	**0.010**
TPVA (ml)	62 ± 11	81 ± 12	74 ± 13	2	21.093	**<0.0001**

IPP=Intravesical Prostatic Protrusion; PCAR=Presumed Circle Area; QOLS=Quality of Life Score; TPVA=Transabdominal Total Prostate Volume; TPVT=Transrectal Total Prostate Volume; TZI=Transition Zone Index; TZV=Transition Zone Volume
t= Kruskal Wallis test statistics

Table 6: Correlation between intravesical prostatic protrusion and other test parameters

Parameters	r	*P* value
Age (years)	-0.282	**0.005**
IPSS	-0.513	**<0.0001**
TPVT (ml)	-0.458	**<0.0001**
TZV (ml)	-0.453	**<0.0001**
TZI	-0.430	**<0.0001**
QOLS	-0.487	**<0.0001**
PCAR	-0.375	**<0.0001**
TPVA (ml)	-0.797	**<0.0001**

r = Spearman's correlation coefficient
IPP=Intravesical Prostatic Protrusion; PCAR=Presumed Circle Area; QOLS=Quality of Life Score; TPVA=Transabdominal Total Prostate Volume; TPVT=Transrectal Total Prostate Volume; TZI=Transition Zone Index; TZV=Transition Zone Volume

Gopinath *et al.*,[37] intravesical prostatic protrusion was present in 42.6% of patients. Of the 73 men with IPP in this study, 17 (23.3%), 29 (39.7%), and 27 (37%) had grade I, grade II and grade III IPP, respectively. In comparison, the percentages of patients with grade I, grade II and grade III IPP, respectively, were 28.2%, 24.4% and 47.4% by Oshagbemi *et al.*[35]; 7.9%, 32.7%, 59.4% by Eze *et al.*[38]; and 37.1%, 12.6%, 50.3% by Hamza *et al.*[6] The tally of the IPP subgroups differ between studies possibly because of the differences in the age, prostate volume, and median/lateral lobe enlargement of the recruited subjects. Furthermore, in the index study, a whopping 27 participants had BPH without IPP.

In this study, IPP had a statistically significant positive correlation with all the evaluated parameters. The strongest correlation (very high correlation) was with the transabdominal total prostate volume (r = 0.797, *P*<0.0001), followed by a moderate correlation with the IPSS (r = 0.513, *P*<0.0001). TPVT, TZV, TZI, QOLS, and PCAR yielded marginally weaker moderate correlation with IPP, while IPP correlated weakly with age. Similarly, other researchers reported significant correlations between IPP and multiple parameters; for example, Eze *et al.* (IPSS),[38] Gopinath *et al.* (TPVA),[37] Sigdel *et al.* (IPSS, TPVA, maximum flow rate, postvoid residual urine volume, PVR),[36] Hamza *et al.* (IPSS, Quality of life (QoL) score, PVR),[6] Shrestha *et al.* (IPSS, QoL score),[39] Wang *et al.* (TPVA, maximum flow rate),[40] Reddy *et al.* (TPVA, bladder outlet obstruction index),[41] and Lee *et al.* (TPVA, bladder outlet obstruction index).[42] The variability in various correlations with IPP could stem from lack of strict compliance with the urine volume at which IPP should be measured which eventually affects the grading of IPP and interobserver variability in studies that used more than one sonologist (including retrospective studies). IPP correlated better with transabdominal total prostate volume than transrectal total prostate volume likely because of the relatively narrow range of urine volume (100–200 ml) at which IPP is maximal, such that TPVA (measured at full bladder volume) and TPVT (measured with completely empty bladder) should expectedly diverge from the IPP minimally and moderately, respectively.

The limitations of this study include its hospital-based nature using a relatively small sample size. Furthermore, the cross-sectional study design makes to impossible to establish or debunk a direct causal relationship between BPH-related LUTS and IPP. Finally, we could not correlate IPP with uroflowmetry findings because the equipment was unavailable at the time of this study.

In conclusion, 73% of the men in this study had intravesical prostatic protrusion on ultrasound. IPP correlated with positively with TPVA, IPSS, TPVT, TZV, TZI, QOLS, and PCAR. IPP correlated better with transabdominal total prostate volume than transrectal total prostate volume.

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Conflicts of interest

There are no conflicts of interest.

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