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Role of Intravesical Prostatic Protrusion in Predicting Lower Urinary Tract Symptoms in Men with Benign Prostatic Enlargement: Hospital Based Prospective Comparative Study

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ABSTRACT

Introduction: Intravesical prostatic protrusion (IPP) reflects the degree of prostatic protrusion into the bladder and may serve as a non-invasive marker of obstruction in benign prostatic enlargement (BPE). We tend to evaluate the association of IPP with lower urinary tract symptoms (LUTS) and compare predictive performance with prostate size for obstruction-related outcome in patients.

Methods: Hospital-based prospective study was conducted from October to December 2025 and included 380 men aged >50 years presenting with LUTS attributed to BPE. IPP and prostate size were measured on trans abdominal ultrasound. Symptoms were assessed using the International Prostate Symptom Score (IPSS), quality-of-life (QoL) score, Peak flow rate (Qmax) and post-void residual urine (PVR). A bladder outlet obstruction (BOO) surrogate outcome was defined as Qmax <=10 mL/s and/or PVR >=100 mL.

Results: Mean age and prostate size was 65.04 years and 43.6 g respectively. Mean IPP was 6.3 ± 4.2 mm. IPP was positively correlated with IPSS (rho=0.366, p<0.001), QoL (rho=0.315, p<0.001), and PVR (rho=0.270, p<0.001), and inversely correlated with Qmax (rho=-0.301, p<0.001). Mean IPSS increased across IPP grades (9.4, 12.5, and 16.2 for grades 1-3). BOO surrogate was present in 121/380 (31.8%) and increased across IPP grades (23.3%, 33.6%, 46.2%). IPP demonstrated higher discrimination for BOO surrogate than prostate size (AUC 0.621 vs 0.578).

Conclusion: Higher IPP correlates significantly with greater LUTS, poorer QoL, lower urinary flow rate and larger residual urine. Hence, it is a better predictor of LUTS and BOO than prostate volume in men with BPE

Keywords: *Benign prostatic hyperplasia; Intravesical prostatic protrusion; IPSS; Lower urinary tract symptoms; Post-void residual urine; Uroflowmetry*

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INTRODUCTION

Benign Prostatic Hyperplasia (BPH) is a progressive disease with increasing incidence in men over 50 years-of-age. In Asia, the incidence of lower urinary tract symptoms (LUTS) secondary to benign prostate enlargement is estimated to be between 14–59%, with increasing severity in older men. [1] Pressure-flow study is the reference standard for diagnosing bladder outlet obstruction (BOO), but it is invasive and can be associated with hematuria, urinary tract infection, and difficulty in urination, so it is not feasible in all patients. [2,3] Because of this, non-invasive assessment methods are being explored, and ultrasound-based parameters have shown promise. [4,5,6]

Intravesical prostatic protrusion (IPP) occurs as the prostate expands into the bladder, commonly due to median lobe enlargement with or without lateral lobe enlargement. IPP can be measured transrectally or trans abdominally, and trans abdominal measurement correlates well with trans rectal assessment when bladder volume is less than 400 ml. [7] IPP has been used as a non-invasive marker in men with BPH/BPE, including prediction of trial without catheter outcomes and evaluation of BOO risk. [5,6,8]

From this study we aim to compare the diagnostic value of IPP with prostate volume in predicting the LUTS in patients with BPH. We want to know the predictive performance of IPP and Prostate volume for BOO surrogate outcome in patient with BPH.

METHODS

This was a hospital-based prospective comparative study conducted in the Department of Urology, Nepal. Data were collected from October 2025 to December 2025 of patients visting in Urology OPD. Ethical approval was obtained from the Institutional Review Committee (IRC)/730 of Manipal College of Medical Sciences. Informed consent was obtained from all participants prior to enrollment. Inclusion criteria was men aged >50 years presenting to the urology outpatient department with LUTS attributed to BPH/BPE. Exclusion criteria was suspected/diagnosed prostate cancer, previous prostate/urethral surgery, bladder stones/diverticulum, per urethral catheter in situ, BPH with urethral stricture, and neurogenic bladder.

Eligible patients were evaluated with history and examination including IPSS and IPSS-QoL, followed by DRE and brief neurological examination. Trans abdominal ultrasonography (TAUS) was performed by an experienced radiologist to measure prostate size, IPP, and post-void residual urine (PVRU). IPP was measured as the vertical distance from the tip of the protruding prostate to the base of the urinary bladder in the sagittal plane. Uroflowmetry was done to measure Qmax, followed by TAUS measurement of PVRU.

Patients were grouped by IPP grade:

Grade I: <5 mm

Grade II: 5–10 mm

Grade III: >10 mm

Prostate volume was classified as:

Grade a: <20 ml

Grade b: 20–40 ml

Grade c: >40 ml

A BOO surrogate definition was used: PVRU ≥100 ml was considered significantly obstructed. [9] and Qmax ≤10 ml/sec was considered a marker of significant obstruction. [10,11] Urodynamic pressure-flow study was not performed because it is invasive and not feasible for all patients in outpatient practice.

Sample size calculation: The sample size for the study period was calculated at a 95% confidence interval with a 5% margin of error. Based on previous studies, the proportion of BPH after age 50 was taken as 50%. Using these parameters ($Z = 1.96$, $p = 0.50$, and allowable error = 0.05), the minimum required sample size was calculated to be 384.

RESULTS

A total of 380 participants were included. Baseline clinical characteristics are summarized in Table 1. Spearman correlation of IPP with key clinical variables is shown in Table 2.

Table 1: Baseline clinical characteristics (n=380)

Variable	Mean	Median	SD	Min	Max
Age (years)	65.04	65.00	9.19	50.00	84.00
Prostate size (g)	43.64	39.35	20.67	15.00	117.10
IPP (mm)	6.32	5.80	4.20	0.00	18.60
IPSS	11.97	12.00	7.29	0.00	34.00

QoL	2.06	2.00	1.59	0.00	6.00
Qmax (mL/s)	17.48	17.40	6.00	5.00	41.00
PVR (mL)	92.07	57.50	118.22	0.00	982.00

A total of 380 men were included with a mean age of 65.04±9.19 years. The mean prostate size was 43.64±20.67 g and mean IPP was 6.32±4.20 mm, with a wide range of IPP values (0.00–18.60 mm). The mean symptom score (IPSS) was 11.97±7.29, and mean QoL score was 2.06±1.59. The mean Qmax was 17.48±6.00 mL/s, and mean PVR was 92.07±118.22 mL, showing high variability in residual urine.

Table 2: Spearman correlation of IPP (mm) with clinical variables (n=380)

Variable	Spearman rho	P value
Age (years)	0.154	0.003
IPSS	0.366	<0.001
QoL	0.315	<0.001
Qmax (mL/s)	-0.301	<0.001
PVR (mL)	0.270	<0.001

IPP showed a significant positive correlation with symptom burden and residual urine: IPSS ($\rho=0.366$, $p<0.001$), QoL ($\rho=0.315$, $p<0.001$), and PVR ($\rho=0.270$, $p<0.001$). IPP showed a significant negative correlation with peak flow rate (Qmax) ($\rho=-0.301$, $p<0.001$), indicating worse flow with increasing protrusion. Age had a weak but significant positive correlation with IPP ($\rho=0.154$, $p=0.003$).

Table 3: Clinical parameters by IPP grade

IPP grade	n	IPSS (mean± SD)	QoL (mean± SD)	Qmax (mL/s) (mean± SD)	PVR (mL) (mean± SD)
1	163	9.42 ± 6.62	1.53 ± 1.45	19.52 ± 5.65	66.81± 68.12
2	137	12.52 ± 7.06	2.24 ± 1.55	16.61 ± 6.01	89.03 ± 93.84
3	80	16.24 ± 6.82	2.84 ± 1.54	14.83 ± 5.31	148.76 ± 194.39

Clinical severity worsened progressively with increasing IPP grade. Mean IPSS increased from 9.42±6.62 (Grade 1) to 12.52±7.06 (Grade 2) and 16.24±6.82 (Grade 3), while QoL similarly worsened from 1.53±1.45 to 2.24±1.55 and 2.84±1.54 across Grades 1–3. Objective voiding parameters also deteriorated: mean Qmax declined from 19.52±5.65 mL/s (Grade 1) to 16.61±6.01 mL/s (Grade 2) and 14.83±5.31 mL/s (Grade 3), and mean PVR increased from 66.81±68.12 mL to 89.03±93.84 mL and 148.76±194.39 mL, respectively.

Table 4: IPP grade and BOO surrogate outcome

IPP grade	Not obstructed (n)	Obstructed (n)	Total	Obstructed (%)
1	125	38	163	23.3
2	91	46	137	33.6
3	43	37	80	46.2
Total	259	121	380	31.8

Overall, BOO surrogate (Qmax ≤10 mL/s and/or PVR ≥100 mL) was present in 121/380 (31.8%) participants. The prevalence of obstruction increased stepwise across IPP grades: 23.3% in Grade 1, 33.6% in Grade 2, and 46.2% in Grade 3. This shows that higher IPP grades are associated with a substantially higher likelihood of clinically relevant obstruction by non-invasive criteria.

Table 5: Combined grade (IPP grade + prostate size grade) and mean Qmax (mL/s)

No. of cases (% of total)	Combined grade	Mean Qmax (mL/s)	Mean Qmax within IPP grade (mL/s)
23 (6.1)	1a	21.32	
102 (26.8)	1b	19.65	19.52
38 (10.0)	1c	18.08	
3 (0.8)	2a	18.37	
60 (15.8)	2b	17.25	16.61
74 (19.5)	2c	16.01	
2 (0.5)	3a	19.45	
6 (1.6)	3b	15.28	14.83
72 (18.9)	3c	14.66	

Grade 1 is <5mm IPP; Grade 2 is 5-10 mm IPP and Grade 3 is >10mm IPP. On the basis of prostate volume we divided a= prostate size <20ml; b = prostate size 20-40ml and c = prostate size >40ml. When patients were stratified by both IPP grade and prostate size grade, Qmax generally decreased as IPP severity increased, supporting that IPP contributes to reduced flow across different prostate size categories.

Within Grade 1, mean Qmax decreased from 21.32 (1a) to 19.65 (1b) and 18.08 (1c); within Grade 2, Qmax decreased from 18.37 (2a) to 17.25 (2b) and 16.01 (2c); within Grade 3, most patients were in 3c (n=72) with the lowest Qmax (14.66 mL/s). The small subgroup 3a (n=2) had a higher Qmax (19.45 mL/s), which is likely influenced by the very small sample size, but overall the pattern supports worsening flow with higher IPP grades even within the same prostate size group.

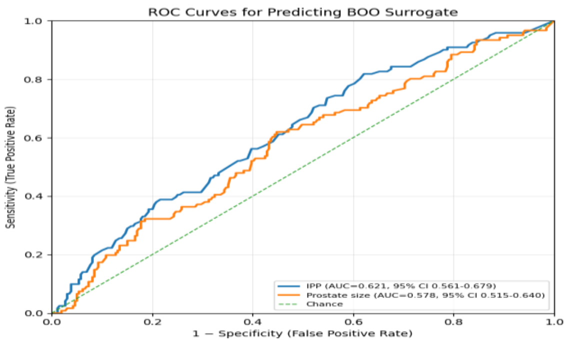

Figure 1: ROC curve for predicting BOO surrogate (Qmax ≤10 and/or PVR ≥100)

In ROC analysis, IPP demonstrated higher discrimination for BOO surrogate than prostate size. The AUC for IPP was 0.621 (95% CI 0.559–0.680) compared with 0.578 (95% CI 0.516–0.642) for prostate size. This suggests that IPP performs modestly better than gland size alone in identifying patients with BOO surrogate by non-invasive criteria.

DISCUSSION

In this study of 380 men with benign prostate enlargement (BPE), intravesical prostatic protrusion (IPP) showed a consistent and clinically relevant relationship with both symptom burden and objective voiding measures. Based on IPP grading, Grade I, Grade II and Grade III were present in 42.9%, 36.1% and 21% of patients, respectively. As shown in Table 3, increasing grade was associated with higher IPSS and poorer quality of life, while Uroflowmetry and residual urine parameters worsened. As shown in Table 4, the proportion of patients classified as obstructed increased stepwise with IPP grade. Correlation analysis further demonstrated a positive relationship with IPSS, QoL and PVR, and a negative relationship with Qmax, indicating that higher protrusion is associated with greater symptom severity and poorer voiding function which is shown in Table 2. Moreover, discrimination for obstruction was better with protrusion than with prostate volume on ROC analysis (AUC 0.621 vs. 0.578) as shown in Figure 1. These findings suggest that protrusion provides clinically meaningful variation in BPE-related LUTS beyond what is explained by gland size alone.

The association between increasing protrusion grade and worsening voiding measures in this cohort can be explained by the underlying bladder neck mechanics of intravesical protrusion. As the prostate (commonly the median lobe) projects into the bladder lumen, it can behave as a ball-valve at the bladder outlet and disrupt normal funneling of the bladder neck, increasing urethral resistance during voiding. [12] With stronger detrusor contraction, a transient channel may form between lobes, but this may paradoxically accentuate the ball-valve effect and further impair effective emptying. [13] This provides a plausible basis for the stepwise decline in flow and rise in residual urine seen with higher grades, and supports the concept that protrusion reflects configuration and functional obstruction risk beyond prostate bulk alone.

BOO was estimated using a non-invasive approach. The BOO surrogate was defined as Qmax ≤10 mL/s and/or PVRU ≥100 mL. Using this definition, obstruction prevalence increased across grades. Su Hwan Shin et al. assessed the relationship between BOO and protrusion grades using the Bladder Outlet Obstruction Index (PdetQmax − 2×Qmax, where Pdet is detrusor pressure at peak flow and Qmax is peak flow). They reported that protrusion greater than 5.5 mm was significantly associated with bladder outlet obstruction. [14] Their findings align with this cohort, where obstruction was positively related to protrusion, PVR, and prostate volume; among these, protrusion showed better predictive performance for obstruction. Delin Wang et al. and S J Chia et al. similarly reported that protrusion had better predictive value for BOO. [6,15] Wang et al. also noted that Grade 3a prostates (high protrusion but low volume) tended to be most obstructed, whereas Grade 1c prostates (large size with mild protrusion) were less frequently obstructed. [15] Alvin Lee et al. reported that even in men with good flow, higher grades of protrusion were more likely to have BOO. They found that both prostate volume and protrusion were positively correlated, but protrusion showed a stronger association than volume. [16]

Although protrusion and prostate volume were strongly correlated in this cohort (rho≈0.75), the clinical value of measuring protrusion is in identifying the direction and functional relevance of growth, not simply the bulk of the prostate. Two men can have similar volumes yet very different degrees of intravesical protrusion and, consequently, different obstruction probability. This concept is consistent with studies indicating that protrusion can predict BOO even after accounting for volume and other office-based variables. [17]

Although prostate volume and protrusion are related, predictive analyses suggest that protrusion provides additional information beyond gland size alone. On ROC analysis, protrusion showed better discrimination for BOO surrogate than prostate volume (AUC 0.621 vs. 0.578), while prostate volume and age were not significant after adjustment. This finding also supports the other study; for instance, Lim et al. similarly demonstrated that IPP has more diagnostic observation for obstruction compared to the prostate volume they reported a higher area under the curve (AUC 0.772 vs. 0.637). [17] Furthermore, Shin et al. also showed this pattern, confirming that IPP gave a higher AUC value than total prostate volume (AUC 0.759 vs. 0.746) when identifying clinically relevant bladder outlet obstruction. [14] This supports the concept that configuration (intravesical protrusion) may be more functionally relevant than bulk when assessing obstruction risk.

The International Prostate Symptom Score (IPSS) is one of the ideal instruments used to grade baseline LUTS severity. Here, increasing protrusion grade was associated with a rise in mean IPSS, suggesting that larger intravesical protrusion corresponds to higher symptom burden. Agbo et al., who observed a significant positive correlation between protrusion and IPSS (rho = 0.808), along with a negative correlation with Qmax (rho = -0.519). [18] Similarly, Hamza et al. identified protrusion as a reliable predictor of LUTS severity by IPSS and reported good correlation with other surrogates of bladder outlet obstruction. [19] In contrast, Hou et al. reported no linear correlation between protrusion and either IPSS or Qmax. This may be explained by bladder volume at the time of measurement: too little urine (volume <100 mL) can overestimate protrusion, while bladder volume >400 mL can underestimate it, thereby affecting accuracy. In addition, the subjectivity of IPSS—depending on patient perception and symptom tolerance—may contribute to a null relationship in some studies. In this context, protrusion remains a valuable objective anatomical marker that adds to BOO assessment when used alongside symptom scores.

Peak flow rate (Qmax) showed a clear negative relationship with protrusion. Mean Qmax declined across grades (19.52 mL/s in grade 1, 16.61 mL/s in grade 2, and 14.83 mL/s in grade 3). Correlation analysis also demonstrated a statistically significant negative association (Spearman rho −0.30, $p<0.001$). This suggests that larger intravesical protrusion is associated with more pronounced outlet obstruction, resulting in substantial reduction in peak urinary flow rate. Wang et al. reported that Qmax demonstrated a stronger correlation with protrusion (rho = -0.30) than with prostate volume (rho = -0.20), suggesting that intravesical protrusion may be more relevant in analyzing urinary flow limitation than gland size alone. [15] Importantly, Alvin Lee et al. highlighted that despite having good flow, 23.0% of men in their study still had BOO (16), supporting the use of protrusion as an adjunct marker even in men with relatively good urinary flow.

Quality of life was assessed using the IPSS quality-of-life question score from 0–6 (delighted to terrible), where a higher score indicates worse LUTS-related quality of life. Quality of life worsened as grade increased: QoL rose from 1.53 in grade I to 2.24 in grade II and 2.84 in grade III, suggesting a shift toward poorer QoL with increasing protrusion. This is clinically important because it reflects global health-related QoL beyond symptom count alone. [20] Consistent with this, a community-based LUTS study reported day-to-day disruption: Kant et al. found that 50.6% of men reported it affected daily functioning, including limiting fluid before sleep or travel and avoiding places without toilet access. [21] Recent clinical data similarly show that increasing LUTS severity (higher IPSS) is associated with poorer QoL across multiple domains, highlighting psychosocial consequences of symptom burden. [22] Disease-specific instruments also support this relationship: the modified BPH-specific QoL scale correlates significantly with total IPSS and the IPSS QoL question, validating the IPSS-QoL item as an important indicator of symptom-related bother in BPH/LUTS research. [23]

Baseline PVRU was 92.07±118.20 mL, and it increased with increasing grades (mean PVRU 66.81 mL in grade I, 89.03 mL in grade II, and 148.76 mL in grade III). Protrusion showed a statistically significant positive correlation with PVRU (Spearman $\rho=0.270$, $p<0.001$). Practically, men with more pronounced intravesical protrusion tended to retain more urine after voiding, consistent with worsening functional outflow resistance and impaired emptying as severity increases. Prior studies reported similar findings. Hamza et al. measured PVRU during ultrasound-based protrusion assessment and found a significant positive correlation, reinforcing that increasing protrusion is associated with greater urinary retention after voiding. [19] More recently, Bulbul et al. introduced a three-dimensional protrusion volume measurement and found that protrusion volume independently correlated with post-void residual volume, suggesting that the "bulk" of intravesical protrusion may capture impaired bladder emptying even better than linear protrusion length alone. [24] Clinically, rising PVRU with higher grades may help identify men at risk of progression and complications of urinary stasis, such as worsening retention, supporting closer follow-up and earlier BOO-directed management. Since PVRU alone has limited specificity and can vary with hydration, voided volume, and bladder contractility, it should not be used in isolation; combining PVRU with Qmax, symptoms, and trans abdominal ultrasonography provides a more reliable picture of obstructive physiology.

These findings support incorporating intravesical prostatic protrusion measurement into routine initial assessment of men with LUTS due to benign prostatic enlargement. Because BOO surrogate prevalence increased progressively from grade I to grade III (23.3%, 33.6% and 46.2%), alongside rising PVRU and falling Qmax, protrusion can serve as a simple, non-invasive risk stratification marker at first presentation. Practically, patients with higher grades (especially grade III) may be flagged early as a higher-risk group for clinically relevant obstruction and incomplete emptying, prompting closer monitoring and earlier escalation of management when symptoms persist or objective measures deteriorate. In addition, protrusion demonstrated better discrimination for BOO surrogate than prostate volume and remained independently associated with BOO surrogate, suggesting it adds clinically meaningful information beyond gland size alone when prioritizing patients for further evaluation or definitive BOO-directed treatment. [18] We also did Spearman correlation test for total prostate size with necessary clinical parameter to compare with IPP. Total prostate size showed correlation with symptom scores IPSS (rho = 0.471, $p<0.001$) and QoL (rho = 0.402, $p<0.001$). But if we look at objective parameters of urine blocking, intravesical prostatic protrusion (IPP) has more strong correlation. IPP shows more negative correlation with peak flow rate (rho = -0.301, $p<0.001$) than prostate size (rho = -0.279, $p<0.001$). Also IPP has higher positive correlation with post void residual urine (rho = 0.270, $p<0.001$) than prostate size (rho = 0.256, $p<0.001$). This comparison shows how prostate shapes inside bladder neck plays main role in blocking urine flow than the size alone.

CONCLUSIONS

IPP was significantly associated with worse LUTS, poorer quality of life, reduced urinary flow, higher residual urine, and a higher likelihood of BOO surrogate. IPP is a practical ultrasound parameter and more informative than prostate size alone when evaluating men with BPE.

CONFLICT OF INTEREST

None

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None

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