THE ASEAN JOURNAL OF RADIOLOGY
ISSN 2672-9393

Original Article

The study of relationships between bladder volume and intravesical prostatic protrusion on transabdominal ultrasound in patients with benign prostatic hyperplasia

Watinee Suwankesa, M.D.
From Department of Radiology, Rayong Hospital, Rayong, Thailand.
Address correspondence to W.S. (email: mmwatineesuwankesa@gmail.com)

Received 6 November 2025; revised 11 December 2025; accepted 11 January 2026
doi:10.46475/asean-jr.v27i1.994

Abstract

Background: Benign prostatic hyperplasia (BPH) is a common cause of lower urinary tract symptoms (LUTS) in aging men, primarily resulting from bladder outlet obstruction (BOO). Intravesical prostatic protrusion (IPP), assessed by transabdominal ultrasonography, has emerged as a reliable and non-invasive imaging marker reflecting the degree of BOO. However, IPP measurements may vary depending on bladder volume (BV), and the optimal filling level for consistent evaluation remains uncertain.

Objective: To examine the relationships between IPP, BV, prostate volume (PV), post-void residual urine (PVR), and symptom severity (IPSS) in patients with BPH.

Materials and Methods: A prospective cohort study was conducted at Rayong Hospital, Thailand, from May to October 2025. Fifty-four men aged ≥50 years with clinically diagnosed BPH underwent four standardized transabdominal ultrasound scans: three for BV, PV, and IPP, and one for PVR. Baseline IPSS was recorded. Pearson correlation and group comparisons were performed, with statistical significance defined as $p < 0.05$. The study was approved by Rayong Hospital Ethics Committee (RYH REC No. E016/2568), and written informed consent was obtained from all participants before data collection.

Results: The mean age of participants was 69.4 ± 8.9 years, with mean PV and PVR of 64.5 ± 31.1 mL and 91.8 ± 80.9 mL, respectively. IPP showed significant positive correlations with PV ($p = 0.007$) and PVR ($p < 0.001$), but not with BV ($p = 0.762$) or IPSS ($p = 0.887$). Patients with Grade 3 IPP had the largest PV and highest PVR ($p = 0.038$ and $p = 0.016$).

Conclusion: IPP was significantly associated with PV and PVR but not with IPSS. Measurements were most consistent at bladder volumes of 200–299 mL, highlighting this range as the optimal filling level for reproducible and accurate IPP assessment in clinical practice.

Keywords: Benign prostatic hyperplasia, Bladder volume, Intravesical prostatic protrusion, Prostate volume, Post-void residual.

Introduction

Benign prostatic hyperplasia (BPH) is a nonmalignant enlargement of the prostate gland caused by abnormal proliferation of stromal and epithelial cells. It is one of the most common urological conditions in aging men and a major cause of progressive lower urinary tract symptoms (LUTS). Globally, BPH affected approximately 94 million individuals in 2019 compared with 51 million in 2000 [1]. The lifetime prevalence is estimated at 26.2% (95% CI: 22.8–29.6%), increasing markedly with age [2]. The global disease burden continues to rise, particularly in low- and middle-income countries [1]. In Thailand, data from the Bureau of Policy and Strategy, Ministry of Public Health, reported 113,552 inpatient cases of BPH in 2023, which is equivalent to 174.47 cases per 100,000 population [3].

Prostate enlargement leads to urethral compression and bladder outlet obstruction (BOO), resulting in LUTS such as hesitancy, a weak urinary stream, incomplete emptying, urgency, frequency, and nocturia. Severe cases may develop complications such as bladder stones, hematuria, and recurrent urinary tract infections [4]. Clinical evaluation typically includes history taking, physical examination, urinalysis, and assessment using the International Prostate Symptom Score (IPSS), which categorizes symptom severity as mild (0–7), moderate (8–19), or severe (20–35) [5].

Although BOO can be clinically suspected based on LUTS and physical examination, the gold standard for confirming BOO is a pressure–flow urodynamic study, which objectively evaluates the relationship between detrusor pressure and urinary flow [6]. However, urodynamic testing is invasive, time-consuming, uncomfortable for patients, and not routinely performed in many clinical settings [7]. These limitations have increased interest in noninvasive surrogate markers of BOO, among which intravesical prostatic protrusion (IPP) has shown promising diagnostic value.

Among several sonographic parameters, intravesical prostatic protrusion (IPP), defined as the vertical distance from the tip of the prostate protruding into the bladder to the bladder neck, has emerged as a reliable indicator of BOO and disease progression [8]. IPP is generally classified as <5 mm, 5–10 mm, or >10 mm [9], and higher grades are associated with more severe obstruction and an increased likelihood of requiring surgical intervention [8,10]. Measurement of IPP using transabdominal ultrasonography provides a rapid, noninvasive, and cost-effective method for evaluating BOO [11].

The accuracy of IPP measurement depends on bladder volume (BV). A sufficiently filled bladder provides an optimal acoustic window for ultrasound imaging, whereas an underfilled bladder may yield unreliable results [12]. Previous research, such as the study by Yuen et al. [12], demonstrated that IPP values tend to decrease as bladder volume increases, with the most accurate measurements obtained when the BV is between 100 and 200 mL. Furthermore, IPP has been shown to correlate with IPSS, prostate volume (PV), maximum urinary flow rate (Qmax), and post-void residual urine volume (PVR), reflecting disease severity [13].

However, evidence regarding the optimal bladder volume for accurate IPP measurement remains limited, particularly in routine clinical practice. Therefore, this study aims to investigate the relationships between IPP, BV, PV, and PVR among patients with BPH at Rayong Hospital.

Materials and methods

Study Design and Setting

This prospective cohort study was conducted at Rayong Hospital, Thailand between May and October 2025. This study aimed to investigate the relationship between IPP, BV, PV, and PVR in patients diagnosed with BPH. The study protocol was reviewed and approved by the Rayong Hospital Ethics Committee (RYH REC No. E016/2568).

Study Population and Sample Size

The study population comprised male patients aged ≥50 years who were diagnosed with BPH and demonstrated intravesical prostatic protrusion on ultrasonography. The required sample size was estimated using a single-proportion formula, based on a previously reported BPH prevalence of 16.67% among men in a suburban Nigerian population [14], as no robust local prevalence data were available. Wayne's formula [15] was applied:

$$n = \frac{z_{1-\alpha/2}^2 \; P\,(1-P)}{d^2}$$

where n is the required sample size, $Z_{1-\alpha/2}$ is the standard normal deviate corresponding to the desired confidence level, P is the expected prevalence, and d is the allowable margin of error. Assuming a 95% confidence level ($Z_{1-\alpha/2}$ = 1.96), an expected prevalence of P = 0.167, and a precision of d = F0.10, the calculated minimum sample size was approximately 53. We, therefore, aimed to recruit at least 54 participants, which was achieved in the present study.

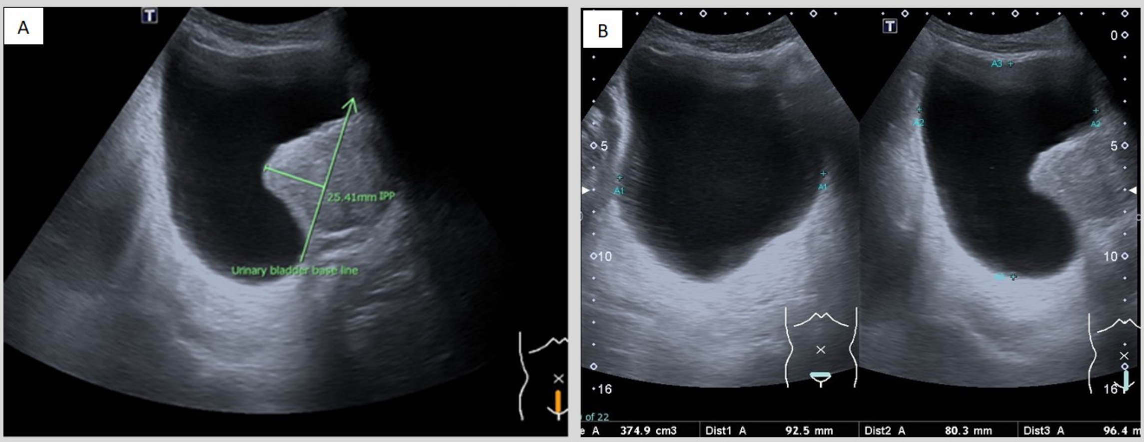
Inclusion and Exclusion Criteria

Participants were recruited from male patients aged ≥50 years [16-18] who had been clinically diagnosed with benign prostatic hyperplasia (BPH) by attending physicians as part of routine care. For the inclusion, the presence of intravesical prostatic protrusion (IPP) was subsequently confirmed by the radiologist investigator using transabdominal ultrasonography. Exclusion criteria included a history of lower urinary tract surgery, prostate or bladder malignancy, bladder stones, indwelling catheter use, a neurogenic bladder, neurological disorders (e.g., stroke, Parkinson's disease), chronic kidney disease with fluid restriction, inability to provide informed consent, or inability to complete the ultrasound procedure.

THE ASEAN JOURNAL OF RADIOLOGY
ISSN 2672-9393

Study Procedure

After obtaining informed consent, demographic data and clinical information—including age and the IPSS were recorded. Each participant underwent four standardized transabdominal ultrasonography (US) examinations using the same ultrasound device operated by a radiologist. Participants were instructed to empty their bladder before the first scan and then consume 500 mL of water. The first scan was performed 30 minutes later to assess BV, PV, and IPP. Participants subsequently consumed an additional 500 mL of water, followed by a second scan after another 30 minutes or earlier if they experienced a strong urge to void. The third scan was performed at a similar interval, and BV, PV, and IPP were recorded in all three scans. After the third measurement, participants were instructed to void, and the fourth scan was performed immediately afterward to measure PVR. Each examination session took approximately two hours per participant. All ultrasound measurements were performed with participants in the supine position. BV, PV, and IPP—defined as the vertical distance from the tip of the prostate protruding into the bladder to the bladder neck—were measured in millimeters (Figure 1). Radiologic data were stored digitally and subsequently extracted for statistical analysis. Primary outcomes included BV, PV, PVR, IPSS, and IPP.



A: Measurement of intravesical prostatic protrusion (IPP) **B:** Measurement of bladder volume (BV)

Figure 1. *Transabdominal ultrasound showing measurement of IPP and BV.*

Statistical Analysis

Descriptive statistics were used to summarize participant characteristics. Continuous variables (e.g., BV, PV, PVR) were presented as mean ± standard deviation (SD), while categorical variables (e.g., IPSS severity, IPP grade) were expressed as frequencies and percentages. Pearson correlation analysis was applied to examine the relationships among BV, PV, PVR, IPSS, and IPP. To compare IPP measurements across different bladder volumes, paired t-tests were performed. Missing paired-volume data were handled using pairwise deletion; analyses involving IPP–bladder volume pairs included only participants with complete measurements for the respective filling levels. No data imputation was performed. Statistical significance was set at $p < 0.05$. Data analysis was performed using STATA version 16 (StataCorp, College Station, TX, USA).

Results

A total of 54 male patients with BPH were included in the study. The mean age was 69.37 ± 8.90 years, with an average body mass index (BMI) of 23.37 ± 3.60 kg/m^2. The mean PV was 64.49 ± 31.14 mL, and the mean PVR was 91.76 ± 80.89 mL. The average IPSS was 15.37 ± 10.34, with 27.8% of patients classified as having mild symptoms, 31.5% as moderate, and 40.7% as severe (Table 1).

Table 1. *General characteristics of the study population (n=54).*

Baseline characteristics	Mean	SD
Age (years)	69.37	8.90
Weight (kg)	65.06	11.89
Height (cm)	166.62	7.38
Body mass index (kg/m^2)	23.37	3.60
Prostate volume (mL)	64.49	31.14
Post-void residual urine volume (mL)	91.76	80.89
IPSS	15.37	10.34
Severity of lower urinary tract symptoms (IPSS), N%		
Mild (0-7)	15	27.78
Moderate (8-18)	17	31.48
Severe (19-35)	22	40.74

Correlation between IPP and Clinical Parameters

The degree of IPP demonstrated a significant positive correlation with PV (r = 0.365, p = 0.007) and PVR (r = 0.490, p < 0.001). However, there was no significant correlation with BV (r = –0.042, p = 0.762) or IPSS (r = 0.020, p = 0.887) (Table 2).

Table 2. *Correlation between IPP and BV, PV, PVR, and IPSS.*

Variables	Correlation coefficient	p-value
Bladder volume (BV, mL)	-0.042	0.762
Prostate volume (PV, mL)	0.365	0.007*
IPSS	0.020	0.887
Post-void residual urine (PVR, mL)	0.490	<0.001*

**p < 0.05 indicates statistical significance.*

Comparison among IPP Grades

Significant differences were found in median PV (p = 0.038) and PVR (p = 0.016) among the three IPP grades. Patients with Grade 3 IPP showed the largest PV and the highest residual urine volume. No significant differences were observed in BV (p = 0.528) or IPSS (p = 0.745) (Table 3).

Table 3. *Comparison of BV, PV, PVR, and IPSS among IPP grades.*

Variables	IPP, Median (IQR)			p-value
	Grade 1	Grade 2	Grade 3	
BV (mL)	225.97 (225.27-237.53)	249.07 (214.40-277.48)	244.37 (185.90-268.23)	0.528
PV (mL)	48.60 (34.90-50.13)	49.57 (36.42-59.47)	76.23 (43.80-100.20)	0.038*
PVR (mL)	17.50 (8.90-42.60)	57.95 (28.50-107.00)	67.50 (53.50-189.40)	0.016*
IPSS	18.00 (2.00-24.00)	17.00 (9.00-23.00)	13.00 (5.00-23.00)	0.745

Effect of BV on IPP Measurement

When stratified by BV, IPP was significantly correlated with BV only in the range of 50-199 mL (r = 0.348, p = 0.011), while no significant correlations were observed at higher BV (Table 4).

Table 4. *Correlation between IPP and BV.*

Bladder volume (mL)	Correlation coefficient	p-value
50-199	0.348	0.011*
200-299	0.055	0.711
≥ 300	-0.092	0.548

**p < 0.05 indicates statistical significance.*

Relationship between IPP Grade and BV Levels

Further analysis stratified by IPP grades revealed that the correlation between IPP and BV varied by both IPP grade and the bladder filling level (Table 5). For Grade 3 IPP (>10 mm), a strong and statistically significant positive correlation was found when BV was between 50–199 mL (r = 0.640, p = 0.003). In contrast, Grade 1 (<5 mm) and Grade 2 (5–10 mm) IPP showed no statistically significant correlation across any BV range. No significant correlations were found for any IPP grade when BV exceeded 200 mL.

Table 5. *Correlation between IPP grades and BV levels.*

Bladder volume (mL)	Intravesical Prostatic Protrusion					
	Grade 1 (<5 mm)		Grade 2 (5-10 mm)		Grade 3 (>10 mm)	
	r	p-value	*r*	p-value	*r*	p-value
50 - 199	0.278	0.594	0.362	0.069	0.640	0.003*
200 - 299	0.135	0.829	0.038	0.874	-0.108	0.623
≥300	0.167	0.753	-0.202	0.381	-0.195	0.439

**p-value < 0.05, r = correlation coefficient.*

Comparison of IPP at Different BV

Among the 46 participants who had IPP measured at two bladder filling levels (V1: 50-199 mL and V2: 200-299 mL), the mean difference in IPP was 0.22 mm, which was not statistically significant (p = 0.540), as shown in Table 6. Similarly, among 43 participants with paired measurements at V1 (50-199 mL) and V3 (≥300 mL), no significant difference was observed (mean difference = 0.18 mm, p = 0.647). In contrast, a statistically significant difference was observed in 39 participants who had IPP measured at moderate (V2: 200-299 mL) and high (≥300 mL) bladder volumes (mean difference = 0.70 mm, p = 0.045), as shown in Table 6.

Table 6. *Comparison of IPP at different bladder volume levels.*

Comparison of volume groups	Mean difference in IPP (mm)	p-value
V1 vs V2	0.22	0.540
V1 vs V3	0.18	0.647
V2 vs V3	0.70	0.045*

Bladder volume groups: V1 = 50-199 mL, V2 = 200-299 mL, V3 ≥300 mL.

Discussion

This prospective cohort study included 54 male patients diagnosed with benign prostatic hyperplasia (BPH) who demonstrated intravesical prostatic protrusion (IPP) on transabdominal ultrasonography. The results showed that IPP was significantly and positively correlated with prostate volume (PV) and post-void residual (PVR), but not with bladder volume (BV) or the International Prostate Symptom Score (IPSS). Further analyses revealed that the correlation between IPP and BV was significant only at lower bladder filling levels (50-199 mL) and disappeared at higher volumes. However, when comparing IPP measurements across different BV ranges, the largest median IPP values were observed at BV between 200-299 mL, suggesting that this range may provide the most stable and representative measurements.

The present study demonstrated significant correlations between IPP, PV, and PVR. The positive correlations observed between IPP and PV ($r = 0.365$, $p = 0.007$) and between IPP and PVR ($r = 0.490$, $p < 0.001$) indicate that higher IPP values are associated with increased residual urine and a greater degree of bladder outlet obstruction. These findings are consistent with several previous studies, which have shown that patients with IPP > 10 mm are more likely to experience moderate-to-severe BOO and to have higher residual urine volumes compared with those with smaller IPP values [19-24], a recent review confirmed that IPP is a more accurate predictor of BOO than prostate volume alone [13]. From a pathophysiological perspective, protrusion of the prostate into the bladder, particularly the median lobe, exerts a "ball-valve" effect that mechanically narrows the bladder outlet. This mechanism increases voiding resistance, leading to incomplete emptying and elevated PVR. Chronic obstruction may subsequently result in detrusor hypertrophy and long-term urinary retention [10,25].

However, the present study found no significant correlation between IPP and IPSS, which contrasts with previous study reporting a significant association between IPP and symptom severity as measured by IPSS [26]. This discrepancy may be explained by differences in patient characteristics and symptom evaluation methods. Our cohort primarily consisted of elderly patients attending a general hospital ultrasound service, many of whom had comorbidities such as diabetes mellitus or neurologic disorders. These conditions can impair detrusor contractility and bladder sensation, leading to a dissociation between symptom perception (e.g., weak stream, frequency) and the degree of mechanical obstruction caused by IPP.

Regarding bladder volume, no overall correlation was found between IPP and BV across all filling levels, consistent with previous reports by Yuen et al. [12] and Brakohiapa et al. [27], which emphasised that bladder distension can influence the apparent length of IPP on ultrasonography. In our study, IPP showed a significant positive correlation with BV only at lower filling levels (50-199 mL), particularly among patients with Grade 3 protrusion, reflecting a dynamic effect in which IPP increases proportionally as the bladder fills. However, this correlation disappeared at higher volumes, indicating that further bladder filling does not substantially alter IPP measurements. To identify the optimal range for clinical assessment, we compared IPP measurements between the higher bladder volumes (V2: 200-299 mL and V3: ≥300 mL), for which no significant correlation was observed. Among these, measurements at V2 (200-299 mL) yielded higher mean IPP values than those at V3, suggesting that this intermediate bladder volume provides the most stable and representative assessment of prostatic protrusion.

Collectively, these findings indicate that bladder volume exerts a biphasic influence on the stability of IPP measurements. At lower bladder volumes, partial filling elevates the bladder base, which reduces the apparent degree of intravesical protrusion as the bladder neck is pushed upward, resulting in lower IPP values. As filling increases and the bladder becomes adequately distended, the bladder wall stretches and the bladder base flattens, allowing the median lobe to project more prominently into the bladder lumen, thereby increasing the measured IPP. This dynamic shift is consistent with prior observations that bladder distension alters prostate–bladder geometry and affects the reproducibility of ultrasonographic measurements[13,28]. Once the bladder reaches a sufficiently distended state, further increases in volume induce minimal additional geometric change, explaining why the correlation between IPP and bladder volume becomes negligible at higher filling levels. Similar findings in pelvic imaging studies have shown that bladder filling modifies the relative position of pelvic organs, including the prostate, emphasizing the importance of standardized bladder conditions for consistent measurements[29]. Taken together, these considerations support the use of an intermediate filling range—particularly 200–299 mL—as a clinically reliable and representative condition for obtaining stable IPP measurements.

The strengths of this study include its prospective design and the standardized assessment of IPP at multiple bladder volumes, which minimizes measurement variability and enables the evaluation of volume-related effects. Nevertheless, several limitations should be acknowledged. This was a single-center study with a relatively small overall sample size, and the distribution of patients across IPP grades and IPSS severity categories was unequal, which may have reduced the statistical power of subgroup analyses and limited the reliability of group comparisons. In addition, all ultrasound measurements were performed by a single operator. Although this approach ensured consistency and minimized intra-operator variability, the use of a single operator may have introduced some degree of operator-related variability, as minor differences in probe positioning, pressure, or insonation angle could affect IPP measurements. Unequal subgroup sizes—particularly the smaller number of patients in certain IPP grades—may also have increased variability in group estimates, reducing the precision of statistical comparisons. These factors, together with recruitment from a single tertiary hospital, may limit external validity, as the findings may not fully represent broader populations with different demographic or clinical characteristics. Finally, IPP measurement using transabdominal ultrasonography is inherently subject to technical variability, including differences in bladder-filling physiology and patient-specific anatomic factors, which may further influence measurement consistency.

Future studies should include larger, multicenter cohorts with more balanced group sizes, employ standardized BV ranges (preferably 200–299 mL), incorporate urodynamic parameters or clinical outcomes such as treatment response and surgical intervention rates, and involve multiple operators with formal evaluation of interobserver agreement to enhance methodological rigor and external validity.

Conclusion

In conclusion, IPP showed significant positive correlations with prostate volume and post-void residual volume but not with patient-reported IPSS. Although IPP increased with bladder filling at lower volumes (50-199 mL), measurements were most consistent and reflective of true prostatic protrusion at 200-299 mL. These findings highlight the value of standardizing bladder-filling protocols within this intermediate range during transabdominal ultrasonography, thereby improving measurement reliability and reinforcing IPP as a practical, non-invasive indicator of anatomical obstruction and urinary retention risk in men with BPH.

Competing Interest
The author declares no competing interest.

Acknowledgements
The author would like to express sincere gratitude to Dr. Piromsiri Koosakul, Radiologist and Head of the Department of Radiology, Rayong Hospital, and Dr. Janejira Chumcheon, Radiologist, Diploma of the Thai Subspecialty Board of Advanced Diagnostic Body Imaging, for their expert guidance and valuable advice throughout this study. The author also gratefully acknowledges Dr. Phanpon Leelahawong, Urologist, Rayong Hospital, for his kind assistance with the diagnosis and management of benign prostatic hyperplasia (BPH), as well as for providing valuable information regarding the International Prostate Symptom Score (IPSS). Finally, the author wishes to thank the patients who participated in this study.

References

1. GBD 2019 Benign Prostatic Hyperplasia Collaborators. The global, regional, and national burden of benign prostatic hyperplasia in 204 countries and territories from 2000 to 2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Healthy Longev 2022;3:e754–76. doi: 10.1016/S2666-7568(22)00213-6.

2. Lee SWH, Chan EMC, Lai YK. The global burden of lower urinary tract symptoms suggestive of benign prostatic hyperplasia: a systematic review and meta-analysis. Sci Rep 2017;7:7984. doi:10.1038/s41598-017-06628-8.

3. Institute for Population and Social Research, Mahidol University. Thai Health 2023 : Thailand's Commitment in COP (Conference of Parties) & Responses to Climate Change [Internet]. Nakhon Pathom: Institute for Population and Social Research, Mahidol University with Thai Health Promotion Foundation; 2023 [cited 2025 Feb 11]. Available from: https://bps.moph.go.th/new_bps/sites/default/files/statistic53.pdf

4. Chunhakrai V, Santingamkun A, editors. Common urologic problems for medical student [Internet]. Bangkok: Thai Urological Association under The Royal Patronage; 2015. Thai. [cited 2025 Dec 26]. Available from: https://www.tuanet.org/wp-content/uploads/2020/06/07_Common-Urologic-Problems.pdf

5. Lerner LB, McVary KT, Barry MJ, Bixler BR, Dahm P, Das AK, et al. Management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline part I—initial work-up and medical management. J Urol 2021;206:806–17. doi:10.1097/JU.0000000000002183.

6. European Association of Urology. EAU Guidelines on Management of Male LUTS [Internet]. Arnhem (The Netherlands): EAU; 2013 [cited 2025 Feb 11]. Available from: https://uroweb.org/guidelines

7. Rosier PFWM, Schaefer W, Lose G, Goldman HB, Guralnick M, Eustice S, et al. International Continence Society good urodynamic practices and terms 2016: urodynamics, uroflowmetry, cystometry, and pressure-flow study. Neurourol Urodyn 2017;36:1243–60. doi:10.1002/nau.23124.

8. Eze BU. Intravesical prostatic protrusion as a predictor of need for surgical therapy in benign prostatic hyperplasia patients. EJMED [Internet]. 2023 [cited 2025 Dec 27]; 5:9–12. Available from: https://eu-opensci.org/index.php/ejmed/article/view/41746

9. Al Rashed AA, Isa QM, Mahdi A, Ebrahim M, Abdulaziz K, Hasan O, et al. Clinical outcomes of intravesical prostatic protrusion in patients with benign prostatic hyperplasia. Cureus 2024;16:e52541. doi:10.7759/cureus.52541.

10. Lee LS, Sim HG, Lim KB, Wang D, Foo KT. Intravesical prostatic protrusion predicts clinical progression of benign prostatic enlargement in patients receiving medical treatment. Int J Urol 2010;17:69–74. doi:10.1111/j.1442-2042.2009.02409.x.

11. Hossain AK, Alam AK, Habib AK, Rashid MM, Rahman H, Islam AK, et al. Comparison between prostate volume and intravesical prostatic protrusion in detecting bladder outlet obstruction due to benign prostatic hyperplasia. Bangladesh Med Res Counc Bull 2012;38:14–7. doi:10.3329/bmrcb.v38i1.10446.

12. Yuen JS, Ngiap JT, Cheng CW, Foo KT. Effects of bladder volume on transabdominal ultrasound measurements of intravesical prostatic protrusion and volume. Int J Urol 2002;9:225–9. doi:10.1046/j.1442-2042.2002.00453.x.

13. Gandhi J, Weissbart SJ, Kim AN, Joshi G, Kaplan SA, Khan SA. Clinical considerations for intravesical prostatic protrusion in the evaluation and management of bladder outlet obstruction secondary to benign prostatic hyperplasia. Curr Urol 2018;12:6–12. doi:10.1159/000447224.

14. Esomonu U, Obun C, Ude R, Igwe S, Esomchi C, Ogolekwu S. Prevalence of benign prostatic hyperplasia and prostate cancer among suburban residents in southern Nigeria. Afr J Urol 2024;30:66. doi:10.1186/s12301-024-00470-x.

15. Wayne DW. Biostatistics: a foundation for analysis in the health sciences. 7th ed. New York: John Wiley & Sons; 1995.

16. Iwenofu CA, Amu OC, Affusim EA, Nwachukwu CD, Anyimba SK. Correlation of intravesical prostatic protrusion with severity of lower urinary tract symptoms in men with symptomatic benign prostatic hyperplasia at University of Nigeria Teaching Hospital, Ituku-Ozalla Enugu. Niger J Med 2024;33:19–24. doi:10.4103/NJM.NJM_110_23.

17. Ruamcharoen S. Benign prostatic hyperplasia at Nakhon Phanom Hospital. Sanpasitthiprasong Med J 2021;35(1):1–12. Thai.

18. Wang D, Huang H, Law YM, Foo KT. Relationships between prostatic volume and intravesical prostatic protrusion on transabdominal ultrasound and benign prostatic obstruction in patients with lower urinary tract symptoms. Ann Acad Med Singap 2015;44:60–5.

19. Shin SH, Kim JW, Kim JW, Oh MM, Moon du G. Defining the degree of intravesical prostatic protrusion in association with bladder outlet obstruction. Korean J Urol 2013;54:369–72. doi:10.4111/kju.2013.54.6.369.

20. Lee A, Lee HJ, Lim KB, Huang HH, Ho H, Foo KT. Can intravesical prostatic protrusion predict bladder outlet obstruction even in men with good flow? Asian J Urol 2016;3:39–43. doi:10.1016/j.ajur.2015.10.002.

21. Kurnia IC, Ghinorawa T, Rochadi S. Correlation of PSA, PV, and IPP in detecting bladder outlet obstruction caused by prostate enlargement. Indones J Urol 2014; 21:1–6.

22. Tan YG, Teo JS, Kuo TLC, Guo L, Shi L, Shutchaidat V, et al. A systematic review and meta-analysis of transabdominal intravesical prostatic protrusion assessment in determining bladder outlet obstruction and unsuccessful trial without catheter. Eur Urol Focus 2022;8:1003–14. doi:10.1016/j.euf.2021.09.016.

23. Chia SJ, Heng CT, Chan SP, Foo KT. Correlation of intravesical prostatic protrusion with bladder outlet obstruction. BJU Int 2003;91:371–4. doi:10.1046/j.1464-410x.2003.04088.x.

24. Keqin Z, Zhishun X, Jing Z, Haixin W, Dongqing Z, Benkang S. Clinical significance of intravesical prostatic protrusion in patients with benign prostatic enlargement. Urology 2007;70:1096–9. doi:10.1016/j.urology.2007.08.008.

25. Foo KT. Pathophysiology of clinical benign prostatic hyperplasia. Asian J Urol 2017; 4:152–7. doi:10.1016/j.ajur.2017.06.003.

26. Sigdel G, Belokar W. Clinical significance of intravesical prostatic protrusion in patients with benign prostatic hyperplasia. J Univ Coll Med Sci 2015;3:6–10. doi:10.3126/jucms.v3i1.13248.

27. Brakohiapa EK, Botwe BO, Sarkodie BD. Prostate volume determination by transabdominal ultrasonography: does accuracy vary significantly with urinary bladder volumes between 50 to 400 mL? J Med Radiat Sci 2019 ;66:81-90. doi: 10.1002/jmrs.320.

28. Chauhan K, Ebner DK, Tzou K, Ryan K, May J, Kaleem T, et al. Assessment of bladder filling during prostate cancer radiation therapy with ultrasound and cone-beam CT. Front Oncol 2023;13:1200270. doi:10.3389/fonc.2023.1200270.

29. Hynds S, McGarry CK, Mitchell DM, Early S, Shum L, Stewart DP, et al. Assessing the daily consistency of bladder filling using an ultrasonic bladderscan device in men receiving radical conformal radiotherapy for prostate cancer. Br J Radiol 2011;84:813–8. doi:10.1259/bjr/50048151.