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ORIGINAL ARTICLE

Can intravesical prostatic protrusion predict bladder outlet obstruction even in men with good flow?

Alvin Lee [a], Han Jie Lee [a], Kok Bin Lim [b], Hong Hong Huang [a], Henry Ho [a,*], Keong Tatt Foo [a]

[a] *Department of Urology, Singapore General Hospital, Singapore*
[b] *Urology Centre, Raffles Hospital, Singapore*

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Abstract *Objective:* Men with benign prostate hyperplasia (BPH) with good urinary flow may still have bladder outlet obstruction (BOO). Intravesical prostatic protrusion (IPP) has been shown to be able to predict BOO. We aim to investigate the use of IPP to predict BOO in men with good urinary flow.
Methods: One hundred and fourteen consecutive men (>50 years old) presenting with lower urinary tract symptoms suggestive of BPH were recruited in 2001 and 2002. They were evaluated with serum prostate specific antigen (PSA), uroflowmetry and transabdominal ultrasound measurement of IPP and prostate volume (PV). Pressure-flow urodynamic studies were performed on all men and BOO was defined by BOO index > 40. Men with $Q_{max} \geq 12.0$ mL/s were considered to have good flow.
Results: Among the 114 men, 61 patients had good urinary flow. Their median age, PV and Q_{max} were 66 years, 32.9 mm^3 and 14.5 mL/s respectively. 14/61 (23.0%) patients had BOO and their distribution of IPP were as follows: Grade 1 – 0/20 (0%) obstructed, Grade 2 – 6/22 (27.3%) and Grade 3 – 8/19 (42.1%). Sensitivity of Grade 2/3 IPP for BOO was 100% while specificity of Grade 3 IPP was 76.6%. The area-under-curve (AUC) for IPP was greater than that for PV (0.757 *vs.* 0.696).
Conclusion: Even in men with good flow, high grades of IPP were more likely to have BOO and hence, may be a useful adjunct to predict BOO.

* Corresponding author.
E-mail address: henry.ho.s.s@sgh.com.sg (H. Ho).
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1. Introduction

Benign prostate enlargement (BPE) is a common cause of bladder outlet obstruction with increasing incidence in men over 50 years of age [1]. Urodynamic study is the international gold standard for diagnosis of bladder outlet obstruction (BOO), but its routine use has been limited by its invasive nature [2]. Currently, several markers identified to be of useful significance in the evaluation of BOO include uroflowmetry, post-void residual urine (PVR), prostate volume (PV), prostate-specific antigen (PSA) and intravesical prostatic protrusion (IPP) [3,4].

Uroflowmetry studies have become established as a non-invasive and routine investigation in men suspected to have BPE. However, peak urinary flow rate (Q_{max}) has limited sensitivity and specificity for BOO depending on the cut-off used [5]. A threshold value of Q_{max} of 10 mL/s has good specificity but poor sensitivity for BOO while a threshold value of Q_{max} of 15 mL/s has good sensitivity but poor specificity [6].

Anatomical configuration of the prostate in the form of IPP has been proven to have good correlation to BOO [2,3]. Studies have shown that the grade of IPP is able to predict success of trial without catheter [7,8], efficacy of α-blocker therapy [9] and clinical progression [10]. In this study, we aim to investigate the use of IPP to predict BOO in men with good urinary flow rate.

2. Patients and methods

From November 2001 to November 2002, 114 consecutive men older than 50 years presenting with lower urinary tract symptoms (LUTS) suggestive of BPE were recruited. Their evaluation included digital rectal examination, uroflowmetry (Q_{max}) and serum PSA measurement.

Transabdominal ultrasound scan by a single operator (F.K.T.) measured the IPP, PV and PVR. The method of measurement for IPP and grading system was as previously reported [11]. The degree of IPP was measured in millimeters perpendicularly from the intravesical edge of the prostate to the base of the bladder in the mid-sagittal plane, by transabdominal ultrasound (Fig. 1) [12]. The extent of IPP was classified as Grade 1 = 5 mm or less, Grade 2 = greater than 5—10 mm and Grade 3 = greater than 10 mm. As a general rule, the IPP is to be measured with the bladder slightly distended with 100—200 mL of urine [11]. The exclusion criteria included previous lower urinary tract or pelvic surgery, previous pelvic trauma, radiation therapy, diabetic cystopathy or neurological bladder with voiding dysfunction. Patients with raised PSA underwent transrectal ultrasound guided prostate biopsy to exclude malignancy before inclusion. Those with incomplete datasets were excluded from statistical analysis.

Pressure-flow urodynamic studies (UDS) were performed on all patients according to the ICS recommendations. The extent of BOO was calculated using the BOO index (BOOI of $>$40 indicates definite obstruction, 20—40 is equivocal and $<$20 indicates no obstruction).

Complete datasets of IPP and BOOI were available in 112 of the patients. In our study, we are looking at patients with $Q_{max} \geq 12.0$ mL/s which we will be referencing as a good flow.

Statistical analysis was performed using SPSS version (IBM, Chicago, IL, USA). Any significant differences in median were analysed using Kruskal—Wallis test while correlations were analysed using Spearman's rho (r_s). Differences are significant if $p < 0.05$. Local Domain Specific Review Board ethics approval was granted (Reference: 2012/311/D).

3. Results

Sixty-one patients had $Q_{max} \geq 12.0$ mL/s. Their median age was 66 years (range: 53—83 years). The median Q_{max} was 14.5 mL/s (range: 12.1—30.7 mL/s), median PVR was 49.4 mL (range: 8—120 mL), and median PV was 32.9 mm^3. Their IPP grade is distributed as follows: 20 had Grade 1 IPP (0—5 mm), 22 had Grade 2 IPP (6—10 mm) and 19 had Grade 3 IPP ($>$10 mm). PV, detrusor pressure (at peak flow) and BOOI were all significantly different between grades 1 to 3 IPP (Table 1).

Of the patients with $Q_{max} \geq 12.0$ mL/s, only 14/61 (23.0%) of them had BOO, 28/61 (45.9%) had equivocal BOOI

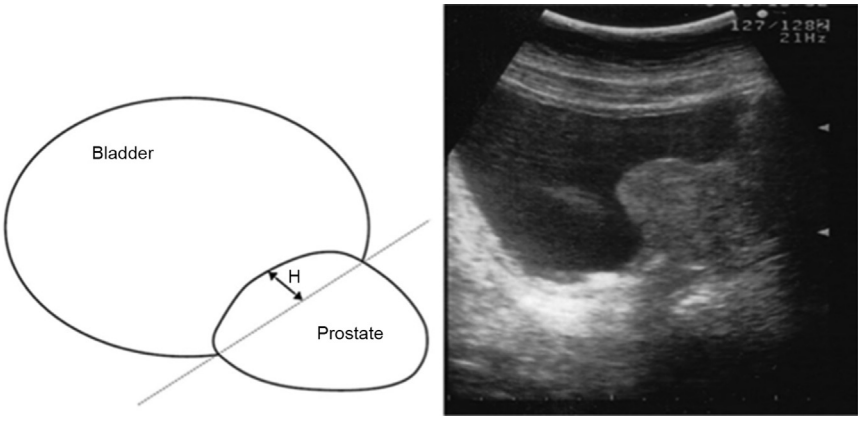

Figure 1 Measurement of intravesical prostatic protrusion (IPP). The vertical distance between the point of highest protrusion to the base of the bladder in the sagittal view using transabdominal ultrasonography. Reproduced with permission of the authors [12].

Table 1 Patient characteristics and urodynamic parameters based on IPP grade.

Parameters	IPP grade			Total ($n = 61$)	p-Value
	Grade 1 ($n = 20$)	Grade 2 ($n = 22$)	Grade 3 ($n = 19$)		
Age (year)[a]	63 (56–66)*	67 (59–71)*	72 (65–76)*	66 (58–73)	0.017
Q_{max} (mL/s)[a]	14.7 (12.5–20.0)	14.5 (13.2–20.0)	14.5 (13.5–17.7)	14.5 (13.4–18.6)	0.962
PV (mm^3)[a]	20.5 (16.0–26.5)*	29.4 (25.8–45.8)*	51.8 (43.6–75.0)*	32.9 (22.2–49.3)	<0.001*
PVR (mL)[a]	37.0 (23.5–61.8)	55.7 (33.7–72.5)	49.6 (34.3–66.4)	49.4 (30.5–68.2)	0.175
P_{det} at peak flow (cmH_2O)[a]	43.5 (29.5–53.8)*	51.0 (36.5–70.5)*	67.0 (60.0–75.0)*	54.0 (36.0–68.0)	<0.001*
BOOI[a]	5.5 (−3.0–25.9)*	18.9 (−0.5–41.0)*	35.2 (23.8–46.0)*	23.8 (1.1–37.7)	0.001*
Detrusor instability, n (%)	8 (40.0)	12 (54.5)	10 (52.6)	30 (49.2)	0.601

*$p < 0.05$, Kruskal–Wallis test between the 3 grades of IPP.
[a] Values shown as median (interquartile range). BOOI, bladder outlet obstruction index; IPP, intravesical prostatic protrusion; PV, prostate volume; PVR, post void residual urine; Q_{max}, peak urinary flow rate.

and 19/61 (31.1%) had no BOO. BOO was seen in 8/19 (42.1%) of Grade 3 IPP prostates and in none of those with Grade 1 IPP (Table 2). Table 3 depicts the sensitivity, specificity, positive and negative predictive value of higher grades of IPP in identifying BOO.

There was good positive correlation between IPP and PV. The correlation coefficient between IPP and PV is 0.747 ($P < 0.001$). Both PV and IPP were positively correlated to BOOI. However, IPP had better correlation ($r_s = 0.497$, $P < 0.001$) (Fig. 2A) than PV ($r_s = 0.318$, $P = 0.013$) to BOOI (Fig. 2B). This trend was also observed between PV and IPP with BOO (BOOI > 40) ($r_s = 0.280$, $P = 0.030$ and $r_s = 0.391$, $P = 0.002$, respectively). Based on receiver-operator curves (ROC), area-under-curve (AUC) for IPP was greater than the AUC for PV (0.757, $P = 0.005$ *vs.* 0.696, $P = 0.031$) (Fig. 3).

4. Discussion

IPP in BPH occurs as the prostate enlarges into the bladder along the plane of least resistance, resulting in various anatomical configurations that were recognised in gross specimens by Randall in the early 20th century [13]. IPP can be caused by an enlarging median and/or lateral lobes of the prostate. It is postulated that IPP causes distortion of the bladder neck which then disrupts laminar flow and funneling, leading to dynamic obstruction [12]. The measurement of IPP via transabdominal ultrasound is simple, non-invasive and can provide useful information on BOO [10], success of trial without catheter [7,8] and clinical progression [10]. In our previous analysis, we have shown that IPP is a better predictor of BOO, compared to PV and PSA [3]. While IPP has been proven to be a good predictor of obstruction [4], this is the first study to our knowledge that endeavored to investigate the use of IPP to predict BOO in men with good urinary flow.

UDS remains the gold standard of diagnosis of BOO [2]. However, its use is limited by its invasive nature and confers undesirable morbidity such as gross hematuria, urinary retention, urinary tract infection and pain [14]. Uroflowmetry is another useful clinical parameter which can help in the clinical evaluation of BPH. It is a function of bladder contractility and bladder outlet resistance and thereby only measure the functional status of the lower urinary tract, rather than being a direct marker of obstruction. Reynard et al. [6] proposed the use of 10 mL/s as a cut-off to reduce the number of unobstructed men undergoing prostatectomy, such that the results of surgery could be improved by selecting a threshold which is highly specific and with a high positive predictive value for BOO. However, at this cut-off, sensitivity is low at merely 47%, meaning that 53% of men with BOO have flow rates above 10 mL/s. Bladder outlet resistance can be overcome at higher detrusor pressures to produce good flow, which could possibly explain why men with obstruction can still have relatively good urinary flow.

Despite having good flow, 23.0% of the men in our study still had BOO. In our analysis of men with good flow, we found that IPP still had better correlation to both BOO and BOOI compared to PV. Furthermore, the AUC for IPP was greater than PV, suggesting that it is a better predictor of BOO. Higher grades of IPP (Grade 2/3) have good sensitivity

Table 2 Distribution of UDS results based on IPP.

IPP grade	Obstruction (BOOI >40) n (%)	Equivocal (BOOI 20–40) n (%)	No obstruction (BOOI <20) n (%)	Total, n
Grade 1	0 (0.0)	13 (65.0)	7 (35.0)	20
Grade 2	6 (27.3)	11 (50.0)	5 (22.7)	22
Grade 3	8 (42.1)	4 (21.1)	7 (36.8)	19
Total	14 (23.0)	28 (45.9)	19 (31.1)	61

BOOI, bladder outlet obstruction index; IPP, intravesical prostatic protrusion; UDS, urodynamic studies.

Table 3 Evaluation of accuracy of IPP in identifying BOO.

Statistics	Grade 2/3 IPP	Grade 3 IPP
Sensitivity	100 (76.7–100)	57.1 (28.9–82.2)
Specificity	42.6 (28.3–57.8)	76.6 (62.0–87.7)
PPV	34.2 (20.1–50.6)	42.1 (20.3–66.5)
NPV	100 (83.0–100)	85.7 (71.5–94.5)

Values are presented as % with 95%CI in parentheses. BOO, bladder outlet obstruction; IPP, intravesical prostatic protrusion; PPV, positive predictive value; NPV, negative predictive value.

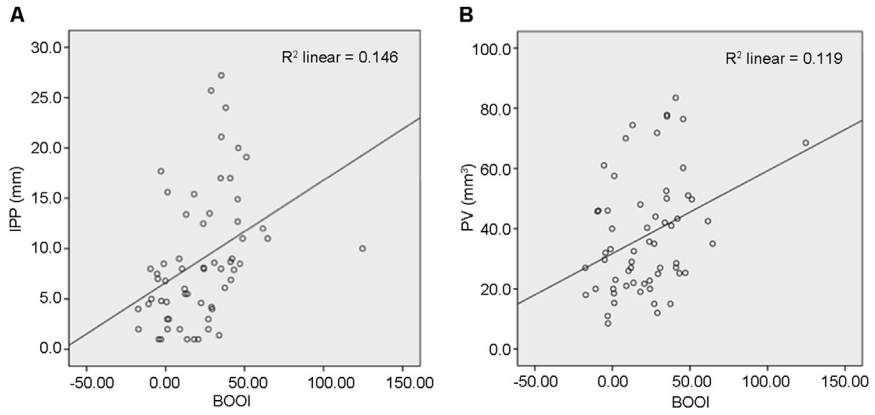

Figure 2 (A) Scatter plot of relationship between BOOI and IPP (r_s = 0.497) and (B) scatter plot showing relationship between BOOI and PV (r_s = 0.318). BOOI, bladder outlet obstruction index; PV, prostate volume; IPP, intravesical prostatic protrusion.

(100%) for BOO and good negative predictive value for BOO (100%). Grade 3 IPP also has good specificity for BOO (76.6%). This present study suggests that IPP could be a useful non-invasive adjunct to predict BOO in men with relatively good urinary flow. Identification of high grade (Grade 2/3) IPP as an anatomical, causative factor may help identify BOO in these men whose bladders are able to produce greater detrusor pressures to overcome infravesical obstruction. In clinical practice, urologists may assume that patients with good flow have no BOO. However, we want to highlight that in this group of patients, a significant IPP may confer a higher risk of having BOO and may warrant closer observation with possibly a lower threshold for intervention.

While UDS is clearly the only reliable method by which BOO can be diagnosed, our study shows that Q_{max} and IPP can provide good improvement in diagnostic power. In patients with Grade 1 IPP and good flow, benign prostate obstruction is very unlikely to be a cause of the patients' LUTS and hence clinicians should perform other investigations such as cystoscopy and urodynamic studies before considering invasive management for their patients. Furthermore, clinicians will be better able to identify and select men with BOO to undergo surgical resection of prostate, which could potentially result in more satisfactory post-operative outcomes [15]. Other non-invasive parameters such as detrusor wall thickness [16,17], prostatic urethral angle [18] and ultrasound-estimated bladder weight [19] have also been shown to predict BOO. However, most of these measurements are based on the consequences of BOO. An attractive quality of transabdominal ultrasonographic measurement of IPP is that it allows for evaluation of the prostate anatomy as a causative and predictive factor of bladder outlet obstruction before the onset of sequelae of BOO such as detrusor hypertrophy, bladder trabeculation with diverticulum as well as hydronephrosis with obstructive uropathy [14].

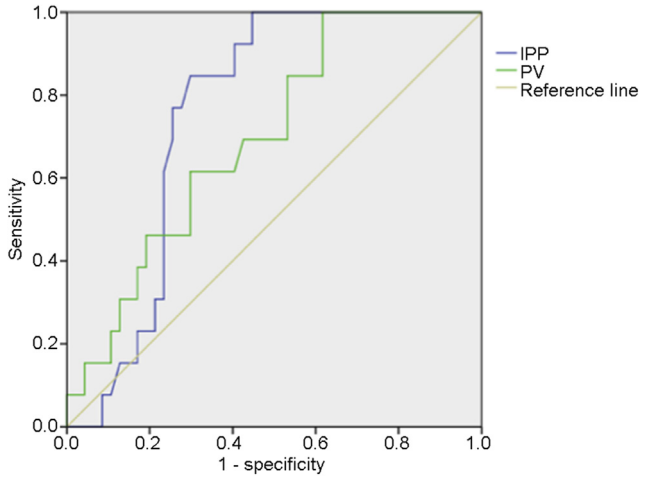

Figure 3 Receicer-operator characteristic curves of IPP and PV for BOO. BOO, bladder outlet obstruction; PV, prostate volume; IPP, intravesical prostatic protrusion.

Although our study is prospective and utilises UDS in the diagnosis of BOO, it is limited by its small sample size. IPP measurements via transabdominal ultrasound are affected by bladder volume at the time of measurement [11]. Unfortunately, we did not capture the bladder volume at which the IPP was measured in our analysis. However, we do have a general practice of measuring IPP when the bladder is sufficiently distended with about 100—200 mL of urine and this results in only minimal differences in the IPP measured [11]. A more significant source of error would be that of inter-observer variability in measurement. We have already reduced this variability by having a single, experienced operator to perform the measurements. Uroflowmetry findings also differ between voids and ideally, we could perform analysis using readings from multiple voids [20]. Symptom scores have been shown to correlate poorly with BOO by several studies and hence, this analysis was omitted [4,21—28].

In our study, we endeavoured to examine the use of IPP in men with $Q_{max} \geq 12.0$ mL/s in predicting BOO. Even with relatively good urinary flow, men with higher grades of IPP are more likely to have BOO. Conversely, patients with no or low grade IPP with good flow are unlikely to have BOO. Our present study provides more evidence that IPP measured via transabdominal ultrasound is a useful, non-

invasive adjunct in diagnosis, stratification and management of BPE in men.

Conflicts of interest

None of the contributing authors have any conflict of interest, including specific financial interests or relationships and affiliations relevant to the subject matter or materials discussed in the manuscript.

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