

Relationships between Prostatic Volume and Intravesical Prostatic Protrusion on Transabdominal Ultrasound and Benign Prostatic Obstruction in Patients with Lower Urinary Tract Symptoms

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Abstract

Introduction: The objective of this study is to determine the relationships between prostatic volume (PV) and intravesical prostatic protrusion (IPP) with benign prostatic obstruction (BPO). **Materials and Methods:** A total of 408 males (aged 50 years and above) who presented with lower urinary tract symptoms (LUTS) suggestive of benign prostatic hyperplasia (BPH) were recruited. All had International Prostate Symptoms Score (IPSS), quality of life (QOL) index, uroflowmetry (Qmax) and postvoid residual urine (PVR) measured by transabdominal ultrasonography (TAUS). The PV and the degree of IPP were also measured by TAUS in the transverse and sagittal planes respectively. The PV is classified as Grade a, (20 ml or less), Grade b, (more than 20 ml to 40 ml) and Grade c, (more than 40 ml), while the IPP is graded as Grade 1 (5 mm or less), Grade 2 (more than 5 mm to 10 mm) and Grade 3 (more than 10 mm). **Results:** There was a fair positive correlation between the PV and IPP (Spearman, $r_s = 0.62$, $P < 0.001$) with important clinical exceptions. There was negative correlation between the PV and Qmax ($r_s = -0.20$, $P = 0.022$), IPP and Qmax ($r_s = -0.30$, $P < 0.001$). PV and IPP were good predictors of BPO. However, IPP was slightly better (r_s of -0.30 vs -0.20) than PV. **Conclusion:** PV is related to IPP with important clinical exceptions. IPP is a better predictor of BPO than PV.

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Key words: Benign prostatic hyperplasia, Prostate volume

Introduction

Benign prostatic hyperplasia (BPH) is one of the commonest diseases of ageing men. It can be associated with bothersome lower urinary tract symptoms (LUTS) that affect quality of life and it causes structural and functional changes in the bladder. Previous clinical guidelines had emphasised on managing symptoms; however current thinking is that the prevention of progression of BPH is also important.¹ Progression depends not only on the size but also the shape of the prostate adenoma which causes obstruction, hence, the importance of studying the relationship between prostate volume (PV) and the intravesical prostatic protrusion (IPP). IPP which distorts the funneling effect of the bladder neck can be considered to represent the shape of the prostate. The severity of LUTS suggestive of BPH correlates poorly with benign prostatic obstruction (BPO).²⁻⁵ Differences in

the mean symptom index score in men with and without BPO were not statistically significant. Although pressure flow studies and voiding urethral pressure profilometry are reliable means of identifying BPO, they are not routinely performed for ageing men with LUTS suggestive of BPH. This is because urodynamic studies are acknowledged to be relatively complex, invasive and not cost-effective. The other non-invasive methods have not been effective for predicting BPO.⁶

The correlation of PV and BPO has been extensively investigated. It was generally accepted that there was weak correlation of PV with BPO. However, several recent studies indicated a stronger correlation between PV and BPO than previously reported.⁶⁻⁹ It had also been shown in our earlier study that the IPP was strongly correlated with BPO, 21% of the prostate with Grade 1 (defined by a IPP of equal or less

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than 5 mm) were obstructed, while for Grade 3 (defined by a IPP of more than 10 mm), 94% were obstructed on pressure flow study.¹⁰ Ochiai et al⁷ emphasised the importance of bladder weight and prostatic configuration in determining BPO, using transrectal ultrasound. Steele, Kuo and Ockrim et al^{6,8,9} used transrectal ultrasound to measure PV and configuration for predicting BPO. The transrectal approach is inconvenient and uncomfortable to patients. It may be unsuitable or unacceptable as an initial routine assessment tool to most patients.

Bedside ultrasound has been routinely used for evaluating the anatomical size (PV) and configuration (IPP) of the prostate gland and assessing postvoid residual urine (PVR) of patients with LUTS suggestive of BPH in our institution since 1997.¹⁰⁻¹⁵ In this study, we retrospectively investigated the relationship between PV and IPP and their relationship with BPO in patients who presented with LUTS.

Materials and Methods

Patients' Eligibility

An approval from the SingHealth Centralised Institutional Review Board was sought with a waiver of informed consent (CIRB Ref: 2012/311/D). A total of 408 consecutive male patients, aged 50 years and older who presented with LUTS suggestive of BPH between July 1997 and December 2003 were recruited in this study. Patients with a known history of previous lower urinary tract surgery, prostatic cancer, neurological disease such as cerebral vascular accidents and Parkinsonism were excluded.

Evaluations

The International Prostate Symptoms Score (IPSS) was used to assess the severity of LUTS and quality of life (QOL) index was used to evaluate if the symptoms were bothering the patients. Medical history taking and physical examination were performed. Digital rectal examination (DRE) was performed to exclude prostate cancer, and a neurological examination was performed to exclude neurogenic bladder dysfunction.

The patients were next assessed by bedside transabdominal ultrasonography (TAUS) with 3.5 MHz curvilinear probe (Ausonics Opus-257310). The PV was measured by TAUS in the transverse plane. It has been shown in our earlier study that TAUS measurement of PV correlated well with transrectal measurement when bladder volume is less than 400 ml.¹² The PV was classified as Grade a (20 ml or less), Grade b (more than 20 ml to 40 ml), and Grade c (more than 40 ml). The bladder capacity was approximately 150 ml to 250 ml before the extent of IPP was measured. The degree of IPP was graded by measuring the vertical distance from intravesical protruding prostatic tip to the imaginary bladder neck line in the midline sagittal plane.¹⁰⁻¹¹ The degree of IPP was classified as follows: Grade 1: 5 mm or less; Grade 2: more than 5 to 10 mm; Grade 3: more than 10 mm (Fig. 1).

After TAUS assessment, uroflowmetry was then performed to assess Qmax (peak flow rate). PVR was then measured by TAUS. To accurately measure PVR, repeated estimation of PVR was performed for patients

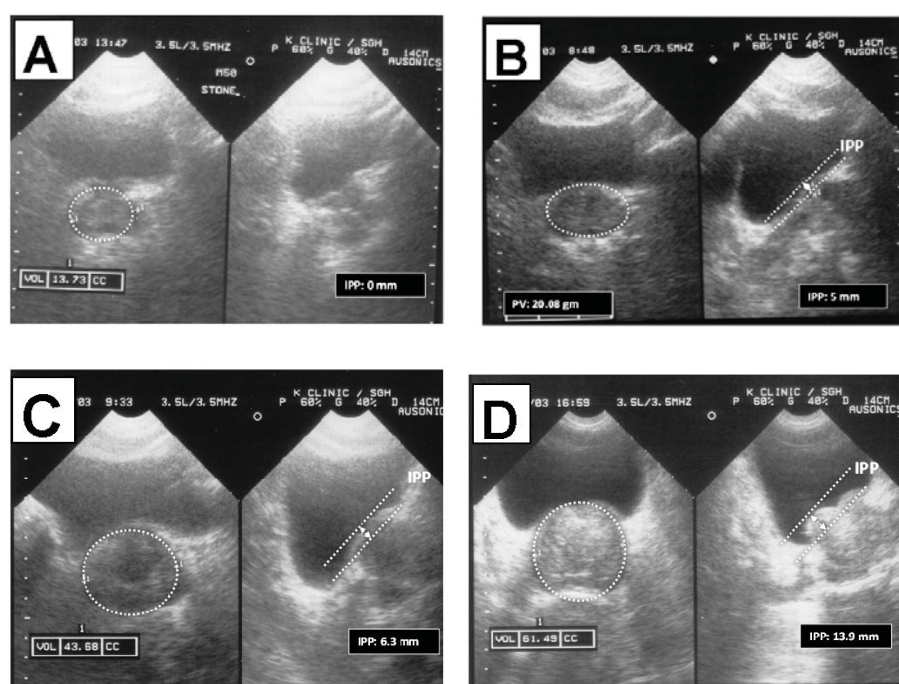


Fig 1. Grading according to intravesical prostatic protrusion (IPP). Slide A shows a normal prostate, slide B shows Grade 1, slide C shows Grade 2, and slide D shows Grade 3.

Table 1. The Baseline Clinical Characteristics (n = 408)

	Mean	Median	Standard Deviation	Minimum	Maximum
Age (years)	64	63	9	50	90
Prostate size (gm)	34	30	18	6	98
IPSS	12	10	7	0	34
QOL	3	3	1	0	6
Qmax (ml/sec)	12	11	5	1	41
PVR (ml)	54	34	69	5	1000

IPSS: International Prostate Symptoms Score; PVR: Postvoid residual urine; Qmax: Peak flow rate; QOL: Quality of life

Table 2. The Correlation of PV with Age, IPSS, IPP, Qmax, PVR, QOL (n = 408)

PV*	r_s	P Value
Age (years)	0.30	<0.001
IPSS	-0.03	0.612
IPP	0.62	<0.001
Qmax (ml/sec)	-0.20	0.022
PVR (ml)	0.16	0.004
QOL	0.08	0.157

*PV is related to age and IPP but not to IPSS and QOL

IPP: Intravesical prostatic protrusion; IPSS: International Prostate Symptoms Score; PV: Prostatic volume; PVR: postvoid residual urine; Qmax: peak flow rate; QOL: Quality of life

with abnormally high volume during the same visit or subsequent visit. Persistent PVR of 100 ml or greater would be suspected to be significantly obstructed.¹³ Also, we selected a cutoff value for urine flow rate of 10 ml/sec or below as a surrogate of obstruction.^{15,16}

Statistical Analysis

We used the SPSS 17.0 software for the statistical analysis. The Spearman correlation r_s , chi-square and one-way ANOVA tests were used as appropriate.

Results

The baseline clinical characteristics of this cohort (n = 408) are shown in Table 1. The correlations between total PV and age, IPSS, QOL, IPP, Qmax, and PVR are illustrated in Table 2. There was a weak correlation between PV and age ($r_s = 0.30$, $P < 0.001$), Qmax ($r_s = -0.20$, $P = 0.022$) and PVR ($r_s = 0.16$, $P = 0.004$). The scatterplot showed a linear regression between PV and IPP (Fig. 2). The correlation between PV and IPP was fairly strong ($r_s = 0.62$, $P < 0.001$). However, there was no significant correlation of PV with IPSS ($r_s = -0.03$, $P = 0.612$) and QOL ($r_s = 0.08$, $P = 0.157$).

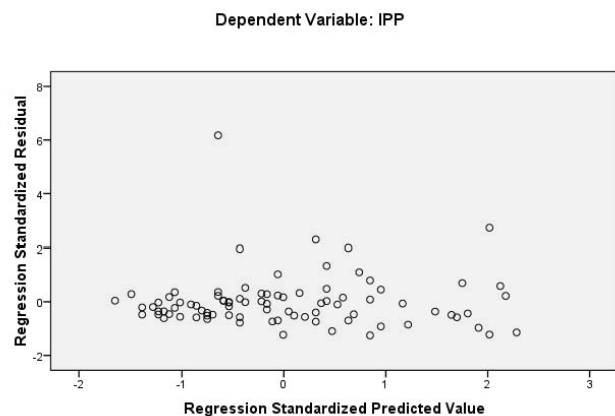


Fig. 2. Scatterplot showing the correlation between prostatic volume (PV) and intravesical prostatic protrusion (IPP).

The good relationship between PV and IPP can also be shown with chi-square tests ($\chi^2 = 129.212$, $P < 0.001$) (Fig. 3). The small prostate of 20 ml or less were mainly distributed in Grade 1, 20 ml to 40 ml prostate in Grade 2, >40 ml prostate in Grade 3.

The correlation of the combined classification PV with IPP (grade) and mean uroflow rate is shown in Table 3. The definition of BPH grade is a combination of the degree of IPP and the PV, e.g. Grade 1a corresponds to a patient with IPP of Grade 1 and a PV of Grade a. There were negative correlations between PV and average Qmax ($r_s = -0.20$, $P = 0.022$), IPP and average Qmax ($r_s = -0.30$, $P < 0.001$). One-way ANOVA test showed that mean Qmax was significantly lower for higher degree of IPP ($F = 18.075$, $P < 0.001$).

The correlation of BPH grade (combination of IPP and PV) and obstruction (defined as Qmax of 10 ml/sec and below) is shown in Figure 4. There was a significant negative correlation between BPH grade and the Qmax of 10 ml/sec and below (χ^2 for trend = 32.2, $P < 0.001$). Seventy-nine percent of patients with Grade 1a prostates had Qmax of over 10 ml/sec (not obstructed), and 64% of patients with Grade 3c prostates had Qmax equal or less than 10 ml/sec (obstructed). However, Grade 3a prostates of small size

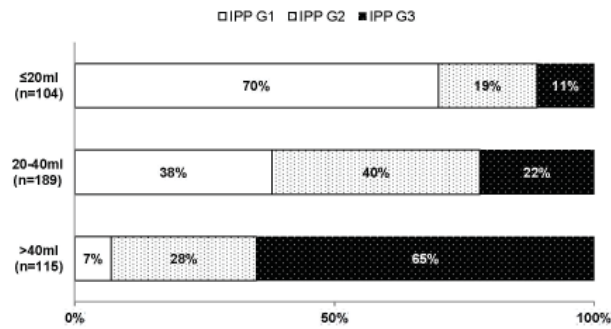


Fig 3. Bar chart showing the correlation between prostatic volume (PV) and intravesical prostatic protrusion (IPP), (n = 408). Note: IPP Grade 1: ≤5 mm; 2: >5 to 10 mm; 3: >10 mm. The percentages were the proportion of cases of each degree of IPP within each volume group (e.g. 73/104 = 70%).

but obvious IPP tended to be most obstructed at 82%. The Grade 1c prostates of large size but mild IPP prostate were rarely obstructed at 37%. Hence, IPP was a better predictor of bladder outlet obstruction (BOO) than PV.

Discussion

Using non-invasive evaluation techniques of TAUS and uroflowmetry, we evaluated correlation of PV, IPP and BPO. In our previous study, by using pressure flow studies, the results indicated that the IPP was a better and more reliable predictor of BPO than other variables.¹⁰ IPP was also a useful indicator for predicting the success of a voiding trial following acute urine retention (ARU).¹¹ In this study, our results further validated that IPP was indeed a better predictor of BPO. PV correlation with Qmax ($r_s = -0.20$, $P = 0.022$) is lower, compared to IPP correlation to Qmax ($r_s = -0.30$, $P < 0.001$). This study also showed that in

real life practice, any patient who presents with symptoms of BPH can be assigned a grade which is a combination of IPP (Grade 1, 2, 3) and PV (Grade a, b, c) (Fig. 1).

We found fairly strong correlation between PV and IPP ($r_s = 0.618$, $P < 0.001$) and a good consensus between PV and IPP. Seventy percent of patients with Grade 1 IPP had PV equal or less than 20 ml while 65% of patients with Grade 3 IPP had PV of more than 40 ml. There were, however, important exceptions. In our study, there were 11% (11/104) of patients with Grade 3 IPP having a PV of 20 ml or below, and 7% (8/115) of patients with Grade 1 IPP having PV of more than 40 ml (Table 3).

Using a cutoff value for Qmax ≤10 ml/sec as a surrogate for obstruction,¹⁵ our results showed significant negative correlation between various BPH grades (combination of IPP and PV), and obstruction ($\chi^2 = 43.101$, $P < 0.001$). In our study, we found that most of the patients with Grade 1a prostate were not obstructed (79%) (Qmax >10 ml/sec) while most patients with Grade 3c prostate were obstructed (64%) (Qmax ≤10 ml/sec). However, patients with Grade 3a prostate (small volume but obvious IPP) tend to be most obstructive with 82% having poor Qmax of equal or less than 10ml/sec. Patients with Grade 3a prostate had small total prostatic volume but had significant median lobe prostatic hyperplasia, resulting in ball-valve type of obstruction at bladder neck. On the other hand, patients with the Grade 1c prostate had large volume prostate but mild IPP were rarely obstructed; 63% of these patients had good uroflow with Qmax of more than 10ml/sec (Fig. 4).

Hence, our study once again showed a strong correlation between IPP and BPO. IPP is superior to PV in predicting BPO in patients who presented with LUTS. In our daily

Table 3. The Correlation of PV, IPP Grading with Average Qmax (n = 408)

No. of Cases (% of Total)	Grade*	Qmax (ml/sec)	Qmax Within Each IPP† Degree (ml/sec)	Total (%)
73 (18)	1a	14		
72 (18)	1b	13	14	153 (38)
8 (2.0)	1c	13		
20 (5)	2a	13		
75 (18)	2b	11	12	127 (31)
32 (8)	2c	11		
11 (3)	3a	8		
42 (10)	3b	11	10	128 (31)
75 (18)	3c	9		

IPP: Intravesical prostatic protrusion; PV: Prostatic volume; Qmax: Peak flow rate; QOL: Quality of life
*Grades 1, 2, 3 refer to the IPP grade: Grade 1: ≤5 mm; Grade 2: >5 to 10 mm; Grade 3: >10 mm. a,b,c refer to the size of the prostate: a: ≤20 grams; b: >20 to 40 grams; c: >40 grams. Thus Grade 1a refers to a prostate with IPP ≤5 mm with a size of ≤20 grams.
†Low IPP is associated with low PV 1a (18%). Moderate IPP is associated with moderate PV 2b (18%). High IPP is associated with large PV 3c (18%). However, there are exceptions with 2% in Grade 1c and 3% in Grade 3a. The higher the IPP, the lower the average Qmax.

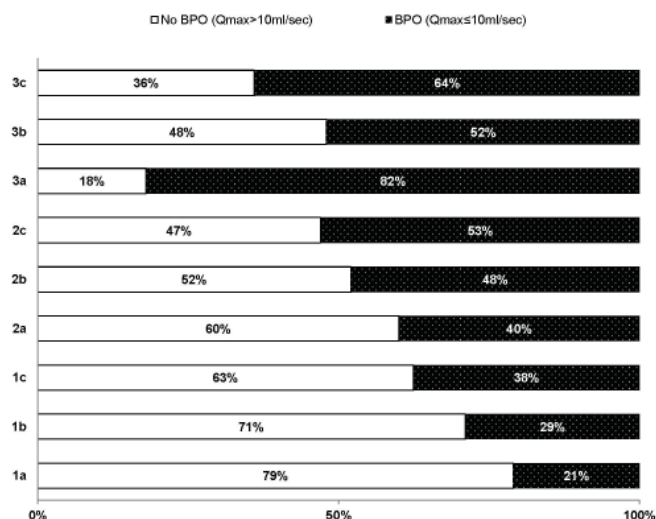


Fig 4. Bar chart showing the correlation between prostatic volume (PV) combined intravesical prostatic protrusion (IPP) and a cutoff value for peak flow rate (Qmax) of 10 or less ml/sec, n = 408. Note: BPO (benign prostatic obstruction) is defined as Qmax equal or less than 10ml/sec. Grade 3a is most obstructive and 1a is least obstructive. When IPP is 1 and 2, the degree of obstruction is related to the size. When IPP is Grade 3, then there is no correlation to the size, suggesting shape (IPP) is more important than size in causing obstruction.

clinical practice, we frequently encountered patients with large prostate volume who did not present with severe obstruction. Yet, some patients with small prostate volume can present with severe obstruction. Our results in this study will explain the reasons for that. Small prostate can have significant IPP due to median lobe hyperplasia, resulting in distortion of the funneling bladder neck, causing obstruction.

We have shown that IPP is also related to PV. IPP, with Qmax, helps to predict obstruction by BPH and therefore the progression of BPH (prostate adenoma) as well.¹⁷ IPP is useful in stratifying patients with LUTS at initial evaluation for further cost-effective management.

Our results would have important implications on patient management. Patients with Grade 3a prostate, being small, more obstructive would be better treated with surgery. While patients with Grade 1c prostate, being large and less obstructive, would be better treated medically with 5-alpha-reductase inhibitors (5-ARIs). Patients with Grade 3 IPP can confidently be diagnosed with obstruction before surgery. Only patients with low grade IPP, with poor flow, need further more invasive investigations such as pressure flow studies or flexible cystoscopy, if not responding to medical therapy and surgical treatment is contemplated.

The limitation of this study is the use of Qmax ≤ 10 ml/sec as a surrogate of obstruction. However, in clinical practice, it is not feasible to have pressure flow study on all our patients. It has been shown that 90% of patients with a

Qmax ≤ 10 ml/sec were obstructed on pressure flow study¹⁶ and this criterion is applied equally to IPP and PV in this analysis. Also, our previous study had already shown a strong co-relationship between IPP and BPO on pressure flow studies. The Spearman rho coefficient was 0.507 for IPP and 0.314 for PV. The receiver operator characteristic curve (ROC) for IPP was 0.77, compared to PV which was 0.637.¹⁸

Conclusion

We showed that PV and IPP are correlated with each other and with BPO, with important clinical exceptions. IPP is a better predictor of BPO than PV. IPP is easy to acquire and is non-invasive.

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