ORIGINAL ARTICLE

The relationship between intravesical prostatic protrusion and pressure flow study findings in patients with benign prostate obstruction/lower urinary tract symptoms


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KEYWORDS
Benign prostate hyperplasia; Ultrasound; Urodynamic study

PALABRAS CLAVE
Hiperplasia benigna de próstata; Ecografía; Estudio urodinámico

Abstract
Objectives: To evaluate the relationship between intravesical prostatic protrusion (IPP) on transrectal ultrasonography (TRUS) and pressure-flow study (PFS) findings in patients with benign prostatic obstruction/lower urinary tract symptoms (BPO/LUTS).

Materials and methods: Between March 2006 and August 2009, we reviewed medical records of 87 patients who underwent TRUS and PFS for the evaluation of their LUTS. The patients were classified by the IPP vertical degree: less than 5 mm (group A), 5–10 mm (group B), over than 10 mm (group C). The extent of bladder outlet obstruction (BOO) was calculated as the bladder outlet obstruction index (BOOI) by the PFS. The obstruction was defined as the BOOI over 40.

Results: Mean age was 71.1 years, and mean IPP vertical was 8.23 mm. The IPP vertical showed significant correlation with prostate volume (r = 0.688, P < 0.001) and transitional zone volume (TZV) (r = 0.645, P < 0.001), but there was no correlation between IPP and International Prostate Symptom Score (IPSS), maximal flow rate, post-voided residual urine (PVR) and BOOI. The IPP transverse was significantly correlated with BOOI (r = 0.213, P = 0.048).

Conclusions: The IPP vertical showed significant correlation with prostate volume and transitional volume, but not with severity of symptom, quality of life, and parameters of PFS. However, the IPP transverse on TRUS was correlated with BOOI.

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Resumen
Objetivos: Evaluar la relación entre el grado de protrusión prostatica intravesical (PPI) vertical en la ecografía transrectal (ETR) y los hallazgos del estudio de presión-flujo en pacientes con obstrucción prostática benigna/síntomas del tracto urinario inferior (OP/STUI).

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Material y métodos: Entre marzo de 2006 y agosto de 2009, se revisaron los registros médicos de 87 pacientes a los que se les realizó ETR y EPF para la evaluación de los STUI. Se clasificó a los pacientes por el grado de PPI vertical: menos de 5 mm (grupo A), 5-10 mm (grupo B), y más de 10 mm (grupo C). El grado de obstrucción de la salida vesical se calculó como el índice de obstrucción de la salida vesical (IOSV) en el EPF. La obstrucción se definió como el IOSV por encima de 40.

Resultados: La media de edad fue de 71,1 años y la PPI vertical media fue de 8,23 mm. La PPI vertical mostró una correlación importante con el volumen prostático \( r = 0,688, p < 0,001 \) y el volumen de la zona transicional (VZT) \( r = 0,645, p < 0,001 \), pero no hubo correlación entre la PPI y la Puntuación Internacional de los Síntomas Prostáticos, la tasa máxima de flujo, la orina residual tras la micción y el IOSV. La PPI transversal estaba considerablemente correlacionada con el IOSV \( r = 0,213, p = 0,048 \).

Conclusiones: La PPI vertical mostró una correlación importante con el volumen de la próstata y el volumen de transición, pero no con la gravedad de los síntomas, la calidad de vida y los parámetros del EPF. Sin embargo, la PPI transversal en ETR guardaba correlación con el IOSV.

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Introduction

Benign prostatic enlargement is a common cause of BOO in men older than 50 years. There is a significant positive correlation between the LUTS and the presence of BOO. The LUTS can be caused by various pathologies, such as benign prostatic hyperplasia (BPH), detrusor overactivity, and detrusor underactivity. Because of the complex etiological aspect, the identification of BOO is important in treating patients with LUTS. Validated symptom scores and quality of life questionnaire are used in patient’s assessment, but they are of limited diagnostic and prognostic use. The multichannel PFS remains the gold standard diagnostic method for identifying BOO. However, the PFS is an invasive and uncomfortable procedure for the patients, and it is time consuming and expensive. The PFS also caused herna, urinary tract infection, and difficulty in urination. Thus, variable non-invasive diagnostic methods included PVR, prostate volume, ultrasound-estimated detrusor thickness and bladder weight, and uroflowmetry attempted to define BOO. Though the uroflowmetry and PVR measurement are simple first-line investigations which can raise or lower the suspicion of BOO, they cannot make a definitive diagnosis either.

IPP is a morphological change due to excessive growth of the median and lateral lobe of the prostate into the bladder. The strongest correlation was observed between the IPP measured by trans-abdominal ultrasonography (TAUS) and the prostate volume. The IPP and the TAUS may be useful, noninvasive predictors of urodynamically ascertained BOO, as well as predictors of a trial without catheter success for men with acute urinary retention. The objective of this study was to define the predictive value of the IPP measured by TRUS for diagnosing BOO in patients with benign prostate hyperplasia.

Materials and methods

From March 2006 to August 2009, we conducted a single center study of relationship between the IPP measured by TRUS and PFS in first-visit patients with BPO/LUTS. After our institutional review board approval, 87 patients who underwent PFS for the evaluation of their LUTS were enrolled in this study. All the patients did not receive alpha-blocker for their LUTS. Routine initial evaluation for male LUTS in our Department included past history, digital rectal examination with neurological examination, urinalysis, serum creatinine and prostate specific antigen, IPSS and quality of life, uroflowmetry, PVR and TRUS. Patients with acute urinary retention, bladder stone, upper tract complications, malignancy including prostate cancer, and neurological conditions such as cerebrovascular dysfunction and Parkinson disease were excluded from this study.

We assessed the IPP and prostate volume by transrectal ultrasound (Sonaco 9900, Medison, Korea Republic) when the bladder volume was 150–200 ml. The prostate volume was measured using the prostate ellipse formula with 7.5 Hz endorectal probe. After measuring the prostate volume, the IPP was checked on the midsagittal plane. The IPP vertical was measured by vertical distance from the tip of the protrusion to the circumference of the bladder at the base of the prostate gland, and the IPP transverse was measured by transverse distance of the circumference of the bladder at the base of the prostate gland (Fig. 1). The grades of the IPP vertical were divided into three groups: group A <5 mm, group B 5–10 mm, group C >10 mm. All the TRUS were performed by experienced urologists.

The multichannel urodynamic studies, with a PFS (Duet Logic G2 manometer, Medtronic-Dantec, Denmark) were performed according to the recommendation of the International Continence Society Good Urodynamic Practices protocol. The extent of the BOO was calculated as the BOOI: BOOI = detrusor pressure at \( Q_{\text{max}} \) \( − 2Q_{\text{max}} \). A BOOI of >40 indicates definite obstruction, 20–40 is equivocal and <20 indicates no obstruction.

All statistical analyses were performed using the SPSS version 13.0 for Windows (SPSS Inc., Chicago, USA). Data distribution was not normal, and nonparametric tests were used. Differences in clinical and urodynamic characteristics among groups were evaluated by the Kruskal–Wallis test and Mann–Whitney U-test. The correlations were quantified by Spearman rank correlation coefficient. A 5% level of significance was used for all statistical testing.
Results

In all, 87 patients with LUTS were assessed and entered into the study. The mean age was 71.7 years, and the mean prostate specific antigen was 3.1 ng/ml. The mean prostate volume was 38.9 ml and the mean IPSS was 23.5. The mean maximal flow rate was 8.5 ml/s and the mean PVR was 84.2 ml. The mean IPP vertical was 8.2 mm and the mean IPP transverse was 27.6 mm.

The distribution of the various clinical parameters according to the BOOI is shown in Table 1. Fifty patients (57.5%) had BOO defined as a BOOI > 40 in PFS. Prostate volumes were 27.6 ml, 32.6 ml, and 42.8 ml in patients with non-obstruction, equivocal, and obstruction in PFS, respectively ($P = 0.011$). The TZVs were 12.3 ml, 14.9 ml, and 22.2 ml in patients with non-obstruction, equivocal, and obstruction in PFS, respectively ($P = 0.009$). The IPP transverse were 22.9 mm, 25.5 mm, and 29.5 mm in patients with non-obstruction, equivocal, and obstruction in PFS, respectively ($P = 0.160$). The IPP verticals were 5.9 mm, 7.8 mm, and 8.7 mm in patients with non-obstruction, equivocal, and obstruction in PFS, respectively ($P = 0.317$) (Table 1).

The prostate volume and TZV were significantly increased according to the IPP vertical. The prostate volumes were 28.4 ml, 35.5 ml, and 52.1 ml in each group. The TZVs were 12.0 ml, 18.2 ml, and 27.5 ml in each group. The BOOI also increased in group C, but it did not reach statistical significance: 42.9 in group A, 50.1 in group B, and 51.8 in group C ($P = 0.081$). Other clinical parameters were not different between the groups (Table 2).

There was a significant correlation between the IPP vertical and the prostate volume (Spearman’s Rho = 0.688, $P < 0.001$). The IPP vertical was also significantly correlated with the TZV (Spearman’s Rho = 0.645, $P < 0.001$). However, no significant correlations were noted between the IPP vertical and the IPSS (Spearman’s Rho = 0.188, $P = 0.081$) (Fig. 2). There was a significant correlation between the IPP transverse and the prostate volume (Spearman’s Rho = 0.610, $P < 0.001$), and the TZV (Spearman’s Rho = 0.585, $P < 0.001$). And the IPP transverse was significantly correlated with the BOOI (Spearman’s Rho = 0.213, $P = 0.048$). However, no significant correlation was noted between the IPP transverse and the IPSS (Spearman’s Rho = 0.240, $P = 0.825$) (Fig. 3).

Discussion

The BOO is a common cause of LUTS in elderly men over 50 years. LUTS can be caused by various etiologies. The identification of BOO from other pathologies, such as detrusor overactivity or detrusor underactivity, is an important step to accurately treat men with LUTS. The multichannel PFS is the gold standard for diagnosing BOO and underlying mechanisms of LUTS. Even though the PFS is essential for the evaluation of the BOO before invasive treatment is considered, many clinicians skip the PFS as they consider it is invasive, time-consuming and expensive.4 Thus, several attempts have been made to date to diagnose BOO by non-invasive methods.

The uroflowmetry and PVR by ultrasonography are simple first-line methods for identifying BOO. Men with BOO have

Table 1 The distribution of clinical parameters according to bladder outlet obstruction index.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total (n = 87)</th>
<th>Pressure flow study</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Non-obstruction</td>
<td>Equivocal</td>
</tr>
<tr>
<td></td>
<td>(n = 10)</td>
<td>(n = 18)</td>
<td>(n = 59)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>71.1 ± 8.2</td>
<td>70.0 ± 10.3</td>
<td>69.1 ± 7.6</td>
</tr>
<tr>
<td>PSA (ng/ml)</td>
<td>3.1 ± 3.1</td>
<td>3.28 ± 3.8</td>
<td>1.98 ± 2.3</td>
</tr>
<tr>
<td>Prostate volume (ml)</td>
<td>38.9 ± 18.2</td>
<td>27.6 ± 13.9</td>
<td>32.6 ± 16.7</td>
</tr>
<tr>
<td>T-zone volume (ml)</td>
<td>19.5 ± 12.0</td>
<td>12.3 ± 7.3</td>
<td>14.9 ± 7.9</td>
</tr>
<tr>
<td>MFR (ml/s)</td>
<td>8.5 ± 6.4</td>
<td>9.7 ± 9.2</td>
<td>7.9 ± 3.9</td>
</tr>
<tr>
<td>Post-voided residual urine volume (ml)</td>
<td>84.2 ± 95.6</td>
<td>87.5 ± 80.2</td>
<td>74.0 ± 92.0</td>
</tr>
<tr>
<td>QoL score</td>
<td>4.2 ± 0.94</td>
<td>4.40 ± 0.84</td>
<td>4.11 ± 0.92</td>
</tr>
<tr>
<td>IPSS</td>
<td>23.5 ± 7.5</td>
<td>29.4 ± 6.2</td>
<td>21.1 ± 7.8</td>
</tr>
<tr>
<td>IPP transverse (mm)</td>
<td>27.6 ± 10.7</td>
<td>22.9 ± 7.4</td>
<td>25.5 ± 10.0</td>
</tr>
<tr>
<td>IPP vertical (mm)</td>
<td>8.2 ± 5.5</td>
<td>5.9 ± 3.7</td>
<td>7.8 ± 6.0</td>
</tr>
</tbody>
</table>

PSA: prostate specific antigen; T-zone: transitional zone; MFR: maximal flow rate; QoL: quality of life; IPSS: International Prostate Symptom Score; IPP: intravesical prostatic protrusions.
Table 2  The distribution of clinical parameters according to IPP vertical.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group A (n = 23)</th>
<th>Group B (n = 36)</th>
<th>Group C (n = 28)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>70.8 ± 7.8</td>
<td>70.9 ± 8.6</td>
<td>71.6 ± 8.4</td>
<td>0.924</td>
</tr>
<tr>
<td>PSA (ng/ml)</td>
<td>3.3 ± 3.6</td>
<td>2.9 ± 2.8</td>
<td>3.3 ± 3.2</td>
<td>0.870</td>
</tr>
<tr>
<td>Prostate volume (ml)</td>
<td>28.4 ± 13.8</td>
<td>35.5 ± 14.3</td>
<td>52.1 ± 18.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>T-zone volume (ml)</td>
<td>12 ± 7.8</td>
<td>18.2 ± 10.4</td>
<td>27.5 ± 12.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MFR (ml/s)</td>
<td>7.9 ± 4.3</td>
<td>9.8 ± 8.3</td>
<td>7.5 ± 4.8</td>
<td>0.309</td>
</tr>
<tr>
<td>Post-voided residual urine volume (ml)</td>
<td>95.3 ± 102.3</td>
<td>72.3 ± 89.2</td>
<td>85.1 ± 98.9</td>
<td>0.846</td>
</tr>
<tr>
<td>QoL score</td>
<td>4.3 ± 0.75</td>
<td>4.2 ± 1.02</td>
<td>4.1 ± 0.98</td>
<td>0.776</td>
</tr>
<tr>
<td>IPSS</td>
<td>25.7 ± 6.6</td>
<td>22.2 ± 7.9</td>
<td>23.4 ± 7.5</td>
<td>0.216</td>
</tr>
<tr>
<td>BOOI</td>
<td>42.9 ± 21.7</td>
<td>50.1 ± 20.5</td>
<td>51.8 ± 19.3</td>
<td>0.081</td>
</tr>
</tbody>
</table>

PSA: prostate specific antigen; T-zone: transitional zone; MFR: maximal flow rate; QoL: quality of life; IPSS: International Prostate Symptom Score; IPP: intravesical prostatic protrusions; BOOI: bladder outlet obstruction index.

a lower maximal flow rate than those with no obstruction, demonstrating a negative correlation of maximal flow rate with Schafer grade of obstruction. However, uroflowmetry cannot distinguish obstruction from impaired detrusor contractility as a cause of reduced flow. The PVR measured by ultrasound is a non-invasive method to indicate how completely a patient empties his bladder. Although the PVR occurs in some patients with BOO, the PVR is often a consequence of detrusor underactivity. On the other hand, Kang et al. showed that maximal flow rate and poor compliance were significant factors for predicting BOO in Korean men with LUTS.

Bosch et al. demonstrated that the prostate volume was not useful for the prediction of BOO. However, the results of this study showed that male LUTS patients with BOO had a larger prostate volume and TZV. Our results suggest that

Figure 2  Relation between intravesical prostate protrusion vertical and other parameters. The prostate volume and transitional zone volume are correlated with intravesical prostate protrusion vertical.
the BOO was associated with prostate size, especially TZV. These results are consistent with the other Korean study. The TAUAS is a non-invasive method for identifying the BOO by measuring the IPP, detrusor wall thickness, and estimated bladder weight. Franco et al. suggested that suprapubic ultrasound of detrusor wall thickness and IPP are simple, noninvasive, accurate systems to assess bladder prostatic obstruction in patients with LUTS due to BPH.

The TAUAS measured the vertical distance from the tip of the prostatic protrusion to the circumference of the bladder at the base of the prostate gland in the midsagittal line. Lim et al. demonstrated that the prostate specific antigen, prostate volume and IPP correlate well with one another. And they suggested that the IPP, as a non-invasive clinical parameter, predicts BOO better than the prostate specific antigen and prostate volume. The TRUS measured the IPP vertical and transverse, also correlated with the prostate volume and TZV in this study. Chia et al. showed that a higher IPP grade was associated with a higher BOO index than lower grade IPP. Thus, they suggested that the IPP assessed by TAUAS is a better and more reliable predictor of BOO than the prostate volume, symptom severity, maximal flow rate, and PVR. Nose et al. also suggested that IPP grading correlated well the BOO index and the combination of the IPP grading, and Doppler urodynamic study may be a novel standard in the diagnosis of BOO in male patients. Keqing et al. showed that the BOO index was significantly higher and the incidence of acute urinary retention appeared more often in the significant IPP group. Thus, they suggested that the IPP is a useful predictor for evaluating the BOO and detrusor function. They also suggested that the significant IPP patients, especially those presenting with AUR, may benefit from early surgical intervention. Lieber et al. showed that, overall, 10% of men had an IPP of 10 mm or greater in their community-based study. They also showed that men with an IPP of 10 mm or greater were more likely to use medications for BPO/LUTS compared with those with an IPP lower than 10 mm. Lee et al. showed that a higher IPP grade is associated with a higher risk of clinical progression in benign prostate enlargement. Thus, they suggested that the IPP is a useful non-invasive predictor for clinical progression in benign prostate enlargement. In this study, the IPP vertical was not associated with the BOO index. However, the IPP transverse was correlated with the BOO index. It showed the IPP transverse is more important than the IPP vertical for evaluating the BOO in TRUS setting.

The IPP was measured by TRUS in this study, whereas the TAUAS was used in other studies. The TAUAS for evaluating the prostate is easily performed in patients with rectal pathologies that underwent rectal surgery. And it is a non-invasive method for the upper urinary tract. On the other hand, for TAUAS of the prostate, a filled bladder is essential. The loss of acoustic window (an empty bladder) makes measurement of the IPP difficult and unreliable. Yuen et al. showed that the
mean IPP decreases with increasing bladder volume. We measured the IPP by TRUS in this study. Although the TRUS is more invasive than the TAU, the TRUS is more accurate for the measurement of the IPP and a filled bladder is not essential. And the TRUS is very popular for the evaluation of the LUTS in Korea, even at private clinics.

This study has several limitations. First, in spite of the prospective study, the number of patients is small. The recruitment of patients was very difficult because the PFS is very uncomfortable and invasive. Although the BOOI was not statistically significantly correlated with the IPP vertical and transverse, the IPP vertical and transverse were increased in patients with BOO. It is possible that a statistically significant correlation between the IPP and the BOO would have been found if the number of patients in each group had been larger. Secondly, the TRUS is more invasive than the TAU. However, the TRUS gives more accurate information, and it is a popular tool for the evaluation of LUTS in Korea.

In conclusion, The IPP vertical measured by TRUS showed significant correlation with the prostate volume and TZV, but not with the severity of symptoms, quality of life, or BOOI. Nevertheless, the IPP transverse on TRUS was correlated with the BOOI. These conclusions might have implications for decision-making in patients with BPO/LUTS, especially invasive treatment. Further clinical research with a larger cohort is mandatory to confirm the relation between the BOOI and the IPP.

Conflict of interest

The authors declare that they have no conflict of interest.

References