Ultrasound Assessment of Intravesical Prostatic Protrusion and Detrusor Wall Thickness—New Standards for Noninvasive Bladder Outlet Obstruction Diagnosis?

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Abbreviations and Acronyms

BOOI = bladder outlet obstruction index

BPH = benign prostatic hyperplasia

BPO = bladder prostatic obstruction

DRE = digital rectal examination

DWT = detrusor wall thickness

IPP = intravesical prostatic protrusion

I-PSS = International Prostate Symptom Score

LR = likelihood ratio

LUTS = lower urinary tract symptoms

PFS = pressure flow study

PH = prostate height

PMUO = minimal urethral opening pressure

PV = prostate volume

PVR = post-void residual urine

Qmax = maximum free flow rate

URA = urethral resistance algorithm

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Study received local independent ethics committee approval.

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Purpose: We evaluated the accuracy of detrusor wall thickness and intravesical prostatic protrusion, and the association of each test to diagnose bladder prostatic obstruction in patients with lower urinary tract symptoms.

Materials and Methods: We enrolled in the study 100 consecutive patients with lower urinary tract symptoms due to benign prostatic hyperplasia. Baseline parameters were International Prostate Symptom Score, prostate volume, urinary flow rate, intravesical prostatic protrusion, detrusor wall thickness, Schaefer obstruction class, minimal urethral opening pressure and the urethral resistance algorithm bladder outlet obstruction index. A ROC curve was produced to calculate AUC and evaluate the diagnostic performance of intravesical prostatic protrusion, detrusor wall thickness and prostate volume for bladder prostatic obstruction.

Results: We noted a highly significant correlation between intravesical prostatic protrusion and the bladder outlet obstruction index (Spearman's $\rho = 0.49$, $p = 0.001$), and Schaefer obstruction class (Spearman's $\rho = 0.51$, $p = 0.001$). A highly significant correlation was also observed for detrusor wall thickness and the bladder outlet obstruction index (Spearman's $\rho = 0.57$, $p = 0.001$), detrusor wall thickness and Schaefer obstruction class (Spearman's $\rho = 0.432$, $p = 0.02$). On multivariate analysis intravesical prostatic protrusion and detrusor wall thickness were the only parameters associated with bladder prostatic obstruction ($p = 0.015$). The AUC for intravesical prostatic protrusion was 0.835 (95% CI 0.756–0.915) and for detrusor wall thickness it was 0.845 (95% CI 0.78–0.91). The association of intravesical prostatic protrusion and detrusor wall thickness produced the best diagnostic accuracy (87%) when the 2 tests were done consecutively.

Conclusions: Suprapubic ultrasound of detrusor wall thickness and intravesical prostatic protrusion is a simple, noninvasive, accurate system to assess bladder prostatic obstruction in patients with lower urinary tract symptoms due to benign prostatic hyperplasia.

Key Words: prostate, prostatic hyperplasia, urinary bladder neck obstruction, diagnostic imaging, ultrasonography

LOWER urinary tract symptoms may include voiding and/or storage urinary symptoms, and be considered a consequence of BPO with its related effect on detrusor function.[1–6] Urodynamics with PFS have been considered the gold standard to evaluate and grade BPO and detrusor contrac-

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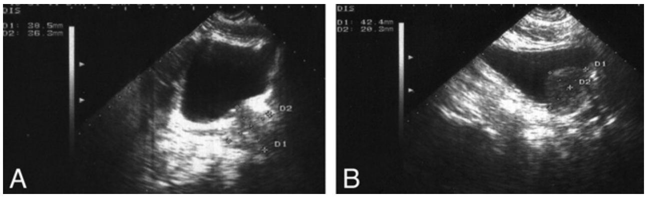

Figure 1. Sagittal suprapubic ultrasound shows 2 prostates with similar volume but with no intravesical protrusion (*A*) and with 20 mm lateral lobe protrusion (*B*).

tility. Urinary flow rate measurement is considered a useful initial diagnostic assessment in patients with LUTS but low Qmax does not distinguish obstruction from decreased detrusor contractility.[1,4,5] However, PFS is considered an invasive procedure with possible side effects that make its routine clinical use debatable.[7,8] Some groups also consider that PFS cost and invasiveness are not justified by its clinical advantages.[7–9] Thus, several attempts have been made to date to diagnose BPO by noninvasive methods.[10]

Recently the 2 ultrasound derived measurements DWT and IPP were separately proposed as useful noninvasive parameters to predict BPO in patients with LUTS.[10–14] We evaluated the accuracy of DWT and IPP, and the association of each to diagnose BPO in men with LUTS due to BPH.

MATERIALS AND METHODS

From January 2001 to January 2002 each new patient 50 years old or older with LUTS due to BPH who presented to our outpatient clinic was prospectively enrolled. Not included in the study were men with neurological disorders, renal insufficiency, bladder stones, prostate cancer, urethral stricture, previous pelvic surgery, currently on α-blockers or 5α-reductase inhibitors, or with ultrasound evidence of a prostatic median lobe. The local independent ethics committee approved the study protocol and dedicated informed consent was obtained from all patients before enrolling. Patients were evaluated by I-PSS, digital rectal examination, uroflowmetry with PVR, bladder and prostatic suprapubic ultrasound, and PFS. The study was designed and done according to the Standards for Reporting of Diagnostic Accuracy initiative.[15]

Ultrasound Measurement

Suprapubic ultrasound was done with a 3.5 MHz convex probe and a 7.5 MHz linear probe when bladder volume was approximately 200 ml. DWT was measured using the 7.5 MHz linear probe in the horizontal direction at maximum magnification. Outer and inner detrusor muscle surfaces were identified by hyperechogenic lines corresponding to subserosal tissue and to bladder mucosa plus submucosal tissue, respectively. A minimum of 3 measurements was made of the anterior or lateral walls and averaged.[11,16] IPP[9] was assessed using a 3.5 MHz probe in the midsagittal plane and defined as the vertical distance in mm from the tip of the prostatic protrusion to bladder circumference at the prostate base (fig. 1). As proposed by Tan and Foo, patients were stratified into 3 groups by IPP grade, including grade I—IPP less than 5 mm, grade II—IPP between 5 and 10 mm, and grade III—IPP greater than 10 mm.[17] PH, and prostate width and depth were also calculated. PV was evaluated using the ellipsoid formula, $\pi/6 \times$ prostate width $\times$ height $\times$ depth. A single operator performed all ultrasound measurements (MC).

Urodynamics

Urodynamics were done according to International Consultation on BPH recommendations.[4] Qmax, detrusor pressure at maximum flow and PMUO were plotted on the 1993 version of the Schaefer nomogram to determine Schaefer class and URA.[18] BOOI was also calculated. The investigator responsible for urodynamics was blinded to ultrasound results. BPO was defined as BOOI 40 cm H_2O or greater.[4]

Statistical Analysis

Statistical analysis was done with SPSS® 12.0. Data distribution was not normal and nonparametric tests were used. Correlations were quantified by Spearman's rank correlation. Using binary logistic regression with the stepwise variable selection method independent variables were entered as continuous variables and investigated as BPO predictors, as assessed by PFS. ROC curves were produced to evaluate AUC, and the diagnostic performance of IPP, DWT, PV and PH for BPO. Diagnostic accuracy for BPO was calculated for IPP, DWT, PV and PH. The associated diagnostic accuracy of IPP and DWT was also evaluated. Differences in clinical and urodynamic characteristics among the groups were evaluated by the nonparametric Kruskal-Wallis test. Data are shown as the mean $\pm$ SD and $p < 0.05$ was considered statistically significant.

RESULTS

Table 1 lists mean characteristics of the 100 study patients. Of the men 26 were classified as unobstructed, including 21 with BOOI 20 cm H_2O or less,

Table 1. *Patient characteristics*

	Median	Mean ± SD (range)
Age	66	67 ± 8.2 (48–80)
Total prostate specific antigen (ng/ml)	3	2.6 ± 2 (0.4–8)
PV (cc)	40	53 ± 33 (20–200)
I-PSS	16	15 ± 8.2 (9–25)
Qmax (ml/sec)	10	8.5 ± 3.8 (2–18.2)
PVR (ml)	30	101 ± 85 (0–300)
Cystometric capacity (cc)	250	336 ± 103 (170–500)
Schaefer obstruction class	3	3 ± 1 (1–6)
URA (cm H_2O)	39	40 ± 18.2 (12–100)
PMUO (cm H_2O)	43	48 ± 24 (18–130)
BOOI	51	56 ± 35 (10–160)
IPP (mm)	12.5	11 ± 6 (0–23.7)
DWT (mm)	6.4	6.6 ± 2.1 (3.1–12)
PH (mm)	43	45.6 ± 11.8 (30–78)