Ultrasound Assessment of Detrusor Thickness in Men—Can it Predict Bladder Outlet Obstruction and Replace Pressure Flow Study?

Thomas M. Kessler,* Rolf Gerber, Fiona C. Burkhard, Urs E. Studer and Hansjörg Danuser

From the Department of Urology, University of Bern, Bern, Switzerland

Purpose: We estimated the diagnostic accuracy of ultrasound detrusor thickness measurement for BOO and investigated whether this method can replace PFS for the diagnosis of BOO in some patients with lower urinary tract symptoms.
Materials and Methods: Detrusor thickness was measured by linear ultrasound (7.5 MHz) at a filling volume of greater than 50% of cystometric capacity in 102 men undergoing PFS for LUTS. All patients with prior treatment for bladder outlet obstruction and those with underlying neurological disorders were excluded from analysis. Detrusor thickness was correlated with PFS data. Obstruction was defined according to the Abrams-Griffiths nomogram.
Results: Detrusor thickness was significantly higher ($p < 0.0001$) in obstructed (61 cases, median detrusor thickness 2.7 mm, IQR 2.4 to 3.3) compared to unobstructed (18 cases, median detrusor thickness 1.7 mm, IQR 1.5 to 2) as well as equivocal (23 cases, median detrusor thickness 1.8 mm, IQR 1.5 to 2.2) cases. A weak to medium Spearman correlation was found between detrusor thickness and PFS parameters. For a diagnosis of BOO, detrusor thickness of 2.9 mm or greater had a positive predictive value of 100%, a negative predictive value of 54%, specificity of 100% and sensitivity of 43%. ROC analysis revealed that detrusor thickness had a high predictive value for BOO with an AUC of 0.88 (95% CI 0.81–0.94).
Conclusions: In men with LUTS without prior treatment and/or neurological disorders, ultrasonographically assessed detrusor thickness 2.9 mm or greater has a high predictive value for BOO and can replace PFS for the diagnosis of BOO. However, this cutoff value needs to be validated in a larger study population.

Key Words: ultrasonography, urodynamics, diagnosis, sensitivity and specificity

BOO is the generic term for obstruction during voiding and is characterized by increased detrusor pressure and reduced urinary flow rate.[1] The established gold standard for the diagnosis of BOO is the PFS.[2,3] However, PFS is an invasive procedure and aside from specialized centers its routine use is limited by personnel and financial resources. Thus, a noninvasive, quick, inexpensive and easily available diagnostic tool with a high specificity and sensitivity for determining BOO would be ideal. Before the era of urodynamics clinicians correlated a thickened or trabeculated detrusor with infravesical obstruction in men with LUTS. Although the clinical relevance of these observations has waned, recent studies suggested that assessment of bladder[4] or detrusor thickness[5] by transabdominal ultrasonography may be a useful parameter for diagnosing BOO. Therefore, we estimated the diagnostic accuracy of ultrasound detrusor thickness measurement for BOO and investigated whether this method can replace PFS for the diagnosis of BOO in some patients with LUTS.

Submitted for publication July 14, 2005.
* Correspondence: Department of Urology, University of Bern, 3010 Bern, Switzerland (telephone: 0041 31 632 20 45; FAX: 0041 31 632 21 81; e-mail: tkessler@gmx.ch).

PATIENTS AND METHODS

Patients

A consecutive series of 102 men with LUTS without prior pharmacological or surgical treatment and/or neurological disorders undergoing further investigation with PFS and ultrasound detrusor thickness measurement were evaluated prospectively. All patients completed the I-PSS questionnaire.

Test Methods

PFS was performed as the generally accepted reference standard for the diagnosis of BOO.[2,3] Urodynamics were done according to the "good urodynamic practices" recommended by the International Continence Society.[6] Patients were divided into unobstructed, equivocal and obstructed categories according to the Abrams-Griffiths nomogram.[7,8] Following PFS the bladder was filled by the transurethral catheter with greater than 50% of the cystometric capacity taking into account that detrusor thickness decreases continuously during the first 50% of bladder capacity but remains constant thereafter.[5] Anatomical structures of the anterior abdominal and bladder wall were identified suprapubically using a 7.5 MHz linear array ultrasound probe in the horizontal direction at low magnification. Mucosa, submucosal and subserosal tissues of the bladder are represented as thin hyperechogenic layers on either side of the hypoechogenic detrusor. At maximum magnification (accuracy in measurement 0.1 mm), the middle hypoechogenic layer representing the anterior detrusor was measured at 2

DOI:10.1016/S0022-5347(06)00316-8

or more different sites and consequently the mean value was used for further calculation. PFS (reference standard) and ultrasound detrusor thickness measurement (index test) were performed unblinded by the same physician. During the recruitment period from March 2002 to November 2004, the reference standard and index test were executed and read by 3 residents experienced in urodynamic and ultrasound investigation. Analysis of the reproducibility and validity of ultrasound detrusor thickness measurement was performed on 23 randomly selected patients with 3 consecutive measurements made by the same resident and 3 separate measurements obtained by 3 different residents.

All methods, definitions and units conform to the standards recommended by the International Continence Society.[1] In addition, as a study of diagnostic accuracy this article complies with the recommendations of the Standards for Reporting of Diagnostic Accuracy initiative.[9]

Statistical Analysis

Data are presented as median and IQR. Comparing unrelated samples, the Mann-Whitney U test was applied. The correlation between detrusor thickness and urodynamic parameters was estimated by Spearman's ρ. ROC curves were used to visualize the association between urodynamically proven BOO and measured predictors. The AUC was calculated to determine the strength of association considering an AUC of 0.5 to be no association and an AUC of 1.0 to be the best possible association. Because this study has an explorative status, no correction for multiple testing was applied. A p value of <0.05 was considered significant. Statistical analyses were performed in collaboration with the Department of Mathematical Statistics, University of Bern, Bern, Switzerland, using SPSS® 11.5.1.

RESULTS

The median age of the 102 men was 67 years (IQR 59 to 77). A total of 18 patients (18%) were unobstructed, 23 (22%) equivocal and 61 (60%) obstructed according to the Abrams-Griffiths nomogram. Median detrusor thickness for unobstructed, equivocal and obstructed cases was 1.7 (IQR 1.5 to 2), 1.8 (IQR 1.5 to 2.2) and 2.7 mm (IQR 2.4 to 3.3), respectively. The detrusor was significantly thicker in obstructed compared to unobstructed (p <0.0001) as well as in equivocal (p <0.0001) cases. There was no significant difference in detrusor thickness in unobstructed and equivocal cases (p = 0.79). Therefore, unobstructed and equivocal cases together were compared with the obstructed group (table 1). Significant differences between the 2 groups were found in I-PSS voiding symptoms, I-PSS quality of life, Pdet max, PdetQmax, Qmax, voided volume, post-void residual and detrusor thickness. However, only a weak to medium correlation was found between detrusor thickness and all parameters of the PFS (table 2).

TABLE 1. *Characteristics of patients with and without obstruction in the PFS according to the Abrams-Griffiths nomogram*

	Median No. No Obstruction (IQR)		Median No. Obstruction (IQR)		p Value
Age	66	(58–73)	70	(60–79)	0.11
I-PSS voiding symptoms*	9	(7–11)	13	(9–15)	0.0001
I-PSS storage symptoms†	8	(5–10)	9	(7–11)	0.06
I-PSS quality of life	3	(2–4)	4	(3–5)	0.01
Maximal cystometric capacity	430	(360–520)	340	(240–420)	0.0002
Pdet max (cm H_2O)	51	(37–59)	91	(78–110)	<0.0001
Pdet Qmax (cm H_2O)	42	(30–45)	81	(64–97)	<0.0001
Qmax (ml/sec)	9	(6–13)	5	(3–7)	<0.0001
Voided vol (ml)	330	(195–435)	110	(40–205)	<0.0001
Post-void residual (ml)	65	(15–140)	180	(110–278)	<0.0001
Detrusor thickness (mm)	1.7	(1.5–2)	2.7	(2.4–3.3)	<0.0001

* I-PSS voiding symptoms questions 1, 3, 5 and 6.
† I-PSS storage symptoms questions 2, 4 and 7.

TABLE 2. *Spearman correlation analysis between detrusor thickness and PFS parameters*

	Detrusor Thickness ρ
Pdet max	0.56
Pdet Qmax	0.57
Qmax	−0.38
Voided vol	−0.55
Post-void residual	0.38

All values p <0.0001.

Different cutoff values of detrusor thickness for diagnosis of BOO with the corresponding positive and negative predictive values, specificity and sensitivity are shown in table 3. Detrusor thickness of 2.9 mm or greater proved to be the best cutoff value to diagnose BOO (fig. 1). All 26 patients with a detrusor thickness of 2.9 mm or greater had obstruction while 41 of the 76 patients with less than 2.9 mm were in the unobstructed or equivocal group. Thus, detrusor thickness of 2.9 mm or greater results in a positive predictive value and specificity of 100%. In addition, ROC analysis (fig. 2) revealed that detrusor thickness is a good parameter for the diagnosis of BOO with an AUC of 0.88 (95% CI 0.81–0.94).

Analysis of ultrasound detrusor thickness measurement reproducibility and validity was performed on 23 randomly selected patients using 1-way ANOVA. We found an intraobserver variability (reproducibility) of 2% among 3 consecutive measurements made by the same resident and an interobserver variability (validity) of 4% among the measurements obtained by 3 different residents.

DISCUSSION

LUTS are one of the most common complaints in elderly men and benign prostatic hyperplasia is the most frequent underlying pathology. Before treatment PFS is the most reliable method to identify BOO in men, although the value of routine PFS before surgery has been questionned.[2,3] In addition, PFS is invasive, unpleasant for patients, costly, time-consuming and technically difficult with limited availability.

Consequently, efforts have been made to develop an easy, noninvasive and simple technique to identify patients with BOO, but with limited success so far. Kojima et al were the first to describe the use of ultrasound to calculate bladder weight as an indicator of BOO.[10,11] Bladder weight was estimated by ultrasonographic measurement of the thickness and volume of the bladder assuming the bladder formed a sphere. A cutoff estimated bladder weight value of 35 gm was suggested with a diagnostic accuracy of 86.2% in pre-