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Bladder Outlet Obstruction

Diagnostic Accuracy of Noninvasive Tests to Evaluate Bladder Outlet Obstruction in Men: Detrusor Wall Thickness, Uroflowmetry, Postvoid Residual Urine, and Prostate Volume

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Abstract

Objectives: The aim of this prospective study was to compare the diagnostic accuracy of detrusor wall thickness (DWT), free uroflowmetry, postvoid residual urine, and prostate volume (index tests) with pressure–flow studies (reference standard) to detect bladder outlet obstruction (BOO) in men.

Methods: During a 2-yr period, men older than 40 yr with lower urinary tract symptoms and/or prostatic enlargement had the following tests: ultrasound measurements of DWT, free uroflowmetry (Q_{max}, Q_{ave}), postvoid residual urine, and prostate volume. Pressure–flow studies were used to divide obstructed from nonobstructed bladders.

Results: One hundred sixty men between 40–89 yr of age (median: 62 yr) were included in the study; 75 patients (46.9%) had BOO according to pressure–flow studies. The results of all investigated index tests differed significantly between obstructed and nonobstructed men. DWT was the most accurate test to determine BOO: the positive predictive value was 94%, specificity 95%, and the area under the curve of ROC analysis 0.93. There was an agreement of 89% between the results of DWT measurement and pressure–flow studies.

Conclusions: Measurements of DWT can detect BOO better than free uroflowmetry, postvoid residual urine, or prostate volume. In clinical routine, DWT measurements can be used to judge BOO noninvasively.

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1. Introduction

Benign prostatic hyperplasia (BPH) is one of the most common benign diseases in men that can lead to benign prostatic enlargement (BPE), lower urinary tract symptoms (LUTS), and/or bladder outlet obstruction (BOO). One third to one half of men with histologic signs of BPH also have a prostate volume of more than 25 ml (BPE), and up to 28% have moderate to severe LUTS [1,2]. The majority of men seek medical help because of bothersome LUTS [3]. BOO was detected in about 60% of the symptomatic and 52% of the asymptomatic men with BPH [4,5]. No clear association between LUTS, BPE, and BOO has been found so far [6,7]. Therefore, each parameter of this disease has to be evaluated separately. Quantification of prostate size, by digitorectal examination or (transrectal) ultrasound measurement, and LUTS, by history or International Prostate Symptom Score (IPSS) questionnaire, is quick and simple. Evaluation of BOO is more difficult. Until now, only pressure–flow studies were able to determine BOO accurately. However, pressure–flow studies are invasive, expensive, and time consuming. In clinical routine, measurements of free uroflowmetry, postvoid residual urine, and prostate volume are used to estimate BOO in men with BPH.

Studies in artificially obstructed animal bladders revealed a significant enlargement of the bladder wall attributable to smooth muscle cell hypertrophy, fibrocyte hyperplasia, and collagen deposition in the detrusor [8]. These experimental findings were confirmed in humans with BOO [8,9]. The detrusor wall can be visualized with ultrasound technology very well; consequently, measurements of detrusor wall thickness (DWT) have been used lately to diagnose BOO in men with BPH [10–12]. In a recently published meta-analysis of all available noninvasive tests for BOO evaluation, ultrasound measurements of DWT or bladder weight were the only promising methods with a good evidence base to support their use in entering clinical practice after further evaluation [13]. Until now, no study had prospectively investigated the diagnostic accuracy of DWT measurements together with other clinical routine tests in one group of patients, and no study had been conducted according to the recommendations of the STARD initiative (Standards for Reporting of Diagnostic Accuracy) [14]. Therefore, the aim of our study was to prospectively evaluate the diagnostic accuracy of DWT measurements, free uroflowmetry, postvoid residual urine, and prostate volume (index tests) in one group of patients with clinical BPH to diagnose BOO defined by pressure–flow analysis (reference standard).

2. Methods

2.1. *Patients and study design*

From 1 January 2000 until 31 December 2001, each new patient aged 40 yr or older with clinical BPH, LUTS, and/or prostate volume greater than 25 ml was recruited from the urologic outpatient department of the University Hospital Hannover. All men with α-blockers, 5α-reductase inhibitors, urinary retention, prior lower urinary tract or pelvic surgery, evident prostate carcinoma, or a neurologic deficit were excluded from the study. Everyone who met the inclusion criteria was willing to participate in the prospective study, which was conducted according to the regulations of the local ethics committee. Study design, terminology, and presentation of the results followed the recommendations of the STARD initiative (Fig. 1) [14]. All tests were performed at the urologic outpatient department of the University Hospital Hannover during two visits.

2.2. *Index tests*

At the first visit, a comprehensive patient history was taken, and the IPSS questionnaire was used to quantify LUTS. Digitorectal examination was performed to exclude men with palpable prostate cancer and to judge the prostate size for study inclusion in asymptomatic men (IPSS $\leq$ 7). All men with a PSA concentration of more than 4 μg/l were excluded from the study (n = 8). Participants who met the inclusion criteria were asked to drink water until they felt the strong desire to void. When their bladders were full, DWT was measured at the anterior bladder wall with the use of a 7.5-MHz linear ultrasound array [9]. The technique of DWT measurement has been described earlier [9,11,15]. With a magnification factor of the ultrasound picture of 9.8, the adventitia, detrusor, and mucosa were identified (Fig. 2). Afterwards, all men performed a free uroflowmetry, and the maximal (Q_{max}) and average urinary flow (Q_{ave}) rates were quantified. Postvoid residual urine was measured immediately after voiding with a 3.5-MHz curved ultrasound array, and prostate volume was determined with a 7.5-MHz transrectal ultrasound probe (all ultrasound measurements were done by M.O. with Sono-DIAGNOST360 [Philips Medical Systems, Eindhoven, The Netherlands]). The baseline characteristics and results after initial evaluation of the patients are listed in Table 1.

2.3. *Reference test*

At the second visit 1–3 wk after initial presentation, all patients had a computer urodynamic investigation (Ellipse; ANDROMEDA Medical Systems, Taufkirchen, Germany), which was performed by experienced residents according to the ''good urodynamic practice'' standard of the International Continence Society (ICS) [16]. The investigators of the urodynamic studies were blinded to the results of the index tests. BOO was determined by pressure–flow analysis with the use of the CHESS classification [17]. The fields A1, A2, and B1 were considered as nonobstruction and all other fields as obstruction. Men with obstructed and nonobstructed bladders were divided on the basis of the pressure–flow analysis, which served as the reference standard for BOO.

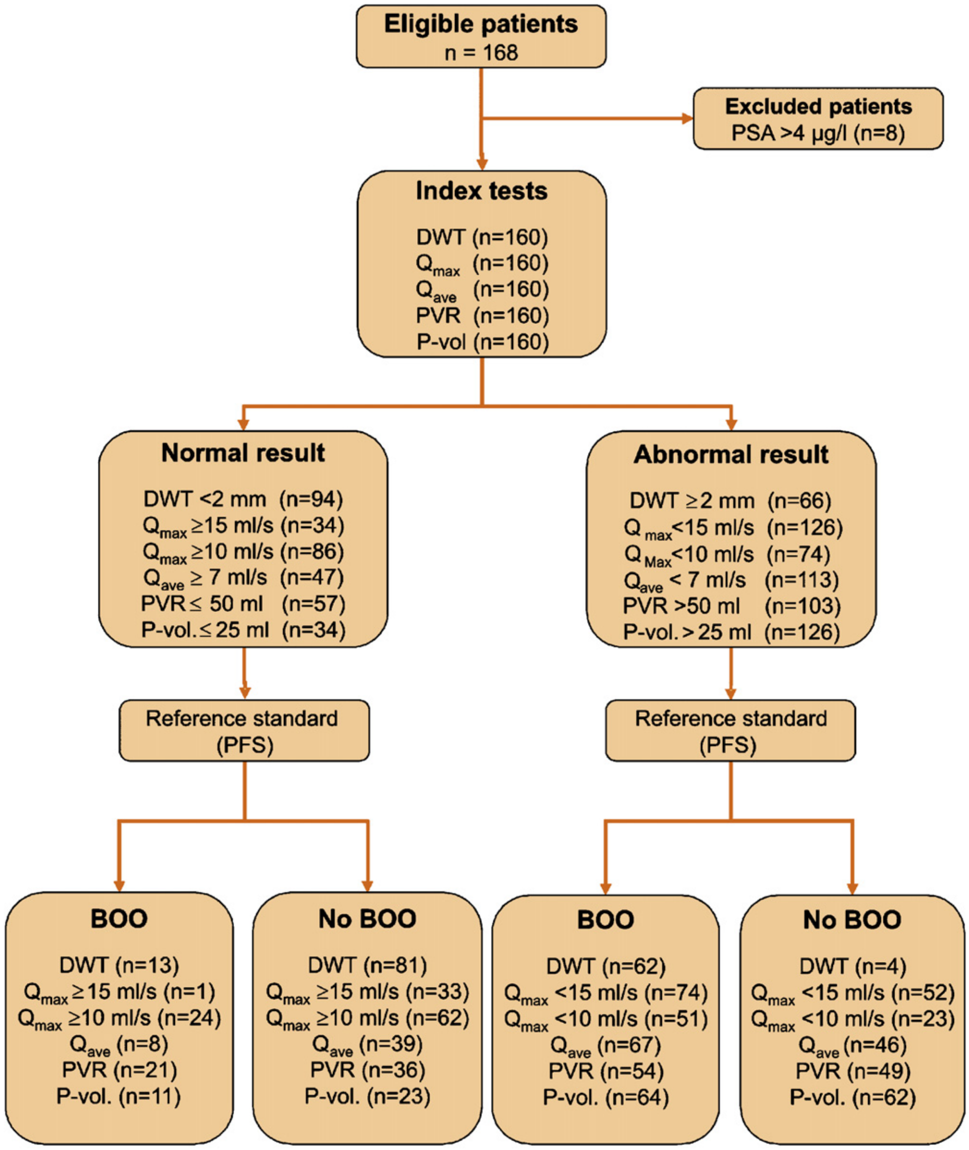

Fig. 1 – Study design and distribution of test results. DWT = detrusor wall thickness; Q_{max} = maximum urinary flow; Q_{ave} = average urinary flow; PVR = postvoid residual urine; P-vol. = prostate volume; PFS = pressure–flow study; BOO = bladder outlet obstruction.

2.4. *Statistical analysis*

Because the data were unevenly distributed, median values including their 25th and 75th percentiles were calculated for the baseline data of the patients and the results of the index tests. The differences in results between index tests and the reference test were analyzed with the Mann-Whitney *U* test. A *p* value equal to or below 0.05 was considered significant. Positive and negative predictive values, sensitivity, specificity, accuracy, and the likelihood ratio of a positive or negative test result (Table 2) were calculated for DWT, Q_{max}, Q_{ave}, postvoid residual urine, and prostate volume. For the index tests, clinical cutoff values for BOO determination were used and defined before the start of the study [18]. The diagnostic accuracy was also calculated for a cutoff value of $Q_{max} < 10$ ml/s [19]. DWT $\geq$ 2 mm served as a cutoff value to detect BOO because a previous study demonstrated that this value most accurately distinguishes between obstructed and unobstructed bladders [11]. Receiver operator characteristic (ROC) curves were produced to visualize, and calculation of the area under the curve (AUC) was used to describe the diagnostic characteristics of the index tests to diagnose BOO. The Statistical Package for the Social Sciences, version 12.0.2 (SPSS Inc, Chicago, IL, USA) was used for the statistical analysis.

3. Results

One hundred sixty men between 40–89 yr of age (median: 62 yr) participated in this study. Thirteen men (8.1%) had BPE (>25 ml) without LUTS (IPSS $\leq$ 7), 34 men (21.3%) had LUTS (IPSS > 7)

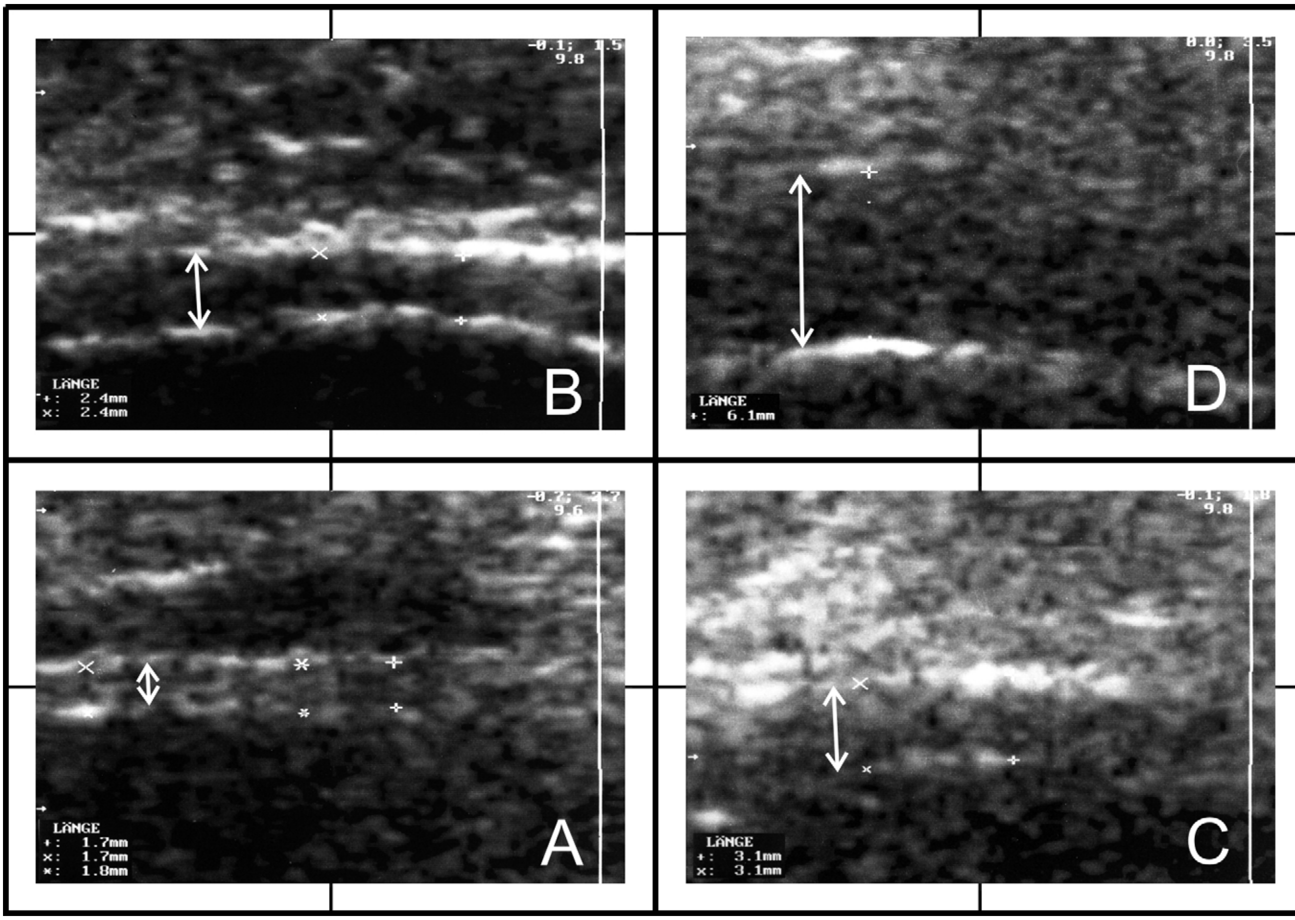

Fig. 2 – Ultrasound measurements of DWT. The mucosa (lower line) and adventitia of the bladder (upper line) appear hyperechogenic; the hypoechogenic area between those lines represents the detrusor and DWT (↕). The figure shows DWT measurements of four BPH patients (all 9.8 enlarged). (A) No BOO (A1, DWT 1.7–1.8 mm). (B–D) Varying degrees of BOO ([B] B3 obstruction with a DWT of 2.4 mm; [C] C1 obstruction with a DWT of 3.1 mm; [D] D4 obstruction with a DWT of 6.1 mm). DWT = detrusor wall thickness; BPH = benign prostatic hyperplasia; BOO = bladder outlet obstruction.

without BPE, and 113 men (70.6%) had both BPE and LUTS. On the basis of the pressure–flow analysis, the prevalence of BOO in this study population was 46.9% (75 of 160). DWT, Q_{max}, Q_{ave}, postvoid residual urine, and prostate volume all differed significantly between nonobstructed and obstructed bladders (Table 3). However, there were no significant differences between age, IPSS value, or bladder filling at the time of DWT measurement.

Patient inclusion and distribution of the tests results are shown in Fig. 1. Diagnostic accuracy data are shown in Table 4. Calculation of the positive predictive values demonstrated that 94% of patients with DWT $\geq$ 2 mm had BOO, whereas the other

Table 1 – Baseline data of the patients and test results after initial evaluation with noninvasive or minimally invasive tests

Parameter (unit)	Range	Median (25th–75th percentile)
Age (yr)	40–89	62 (59–70)
IPSS	2–30	15 (10–21)
DWT (mm)	0.8–8.4	1.7 (1.4–2.2)
Bladder filling at DWT measurement (ml)	250–1086	407 (304–540)
Q_{max} (ml/s)	2.7–35.4	10.2 (7.2–14.4)
Q_{ave} (ml/s)	1.5–20.7	5.1 (3.7–7.4)
Postvoid residual urine (ml)	0–670	100 (30–200)
Prostate volume (ml)	12–130	35 (28–48.5)

IPSS = International Prostate Symptom Score; DWT = detrusor wall thickness; Q_{max} = maximum urinary flow; Q_{ave} = average urinary flow.

Table 2 – Definitions of the test indicators used in this study

Test indicator	Definition
Positive predictive value (PPV)	Proportion of diseased among subjects with a positive test result
Negative predictive value (NPV)	Proportion of healthy among subjects with a negative test result
Sensitivity	Proportion of a positive test result among diseased subjects
Specificity	Proportion of a negative test result among healthy subjects
Accuracy	Proportion of correctly identified subjects
Likelihood ratio of a positive test result (LR^+)	Ratio of a positive test result among diseased subjects to the same result in the healthy: sensitivity/(1-specificity)
Likelihood ratio of a negative test result (LR^-)	Ratio of a negative test result among diseased subjects to the same result in the healthy: (1-sensitivity)/specificity

Table 3 – Comparison of men with obstructed or nonobstructed bladders

Parameter (unit)	Bladder outlet obstruction		*p* value
	NO (median [25th–75th percentiles])	**YES** (median [25th–75th percentiles])	
Age (yr)	62 (56–70)	63 (60–70)	0.051
IPSS	14 (10–20)	17 (11–22)	0.053
DWT (mm)	1.4 (1.3–1.7)	2.2 (2.0–2.7)	<0.001
Bladder filling at DWT measurement (ml)	414 (301–566)	400 (310–480)	0.588
Q_{max} (ml/s)	13.1 (9.8–17.8)	8.0 (5.3–10.3)	<0.001
Q_{ave} (ml/s)	6.4 (4.6–9.0)	3.8 (2.8–5.6)	<0.001
Postvoid residual urine (ml)	70 (20–142)	145 (50–240)	0.001
Prostate volume (ml)	32.9 (22–44)	40 (29–58)	0.014

IPSS = International Prostate Symptom Score, DWT = detrusor wall thickness, Q_{max} = maximum urinary flow, Q_{ave} = average urinary flow.
Note: All parameters but bladder filling at the time of DWT measurement, age, and IPSS differed significantly between the two groups.

index tests varied between 52–69%. $Q_{max} \geq 15$ ml/s at free uroflowmetry showed the highest negative predictive value, which was 97%. Q_{max} with a cutoff value of 15 ml/s had the highest sensitivity (99%), and DWT measurements had the highest specificity (95%). The likelihood ratio of BOO was the best with DWT ≥ 2 mm, and the likelihood ratio of non-obstruction was the best with $Q_{max} \geq 15$ ml/s. There was an 89% agreement between the results of pressure–flow studies and DWT, whereas the agreement between pressure–flow studies and all other index tests was maximally 70%.

ROC analyses of all tests are shown in Fig. 3. The AUC of ROC demonstrated that the measurement of DWT was the best test to detect BOO, with an AUC of 0.93 (95% confidence interval [95%CI], 0.88–0.98). In contrast, measurements of Q_{max} (AUC: 0.84; 95%CI, 0.78–0.91), Q_{ave} (AUC: 0.82; 95%CI, 0.75–0.89), postvoid residual urine (AUC: 0.64; 95%CI, 0.55–0.74), and prostate volume (AUC: 0.62; 95%CI, 0.52–0.71) were less accurate to detect BOO.

4. Discussion

This study showed that the diagnostic accuracy of BOO assessment is better with DWT measurements than with measurements of Q_{max}, Q_{ave}, postvoid residual urine, or prostate volume. BOO can be detected with DWT measurements almost as accurately as with pressure–flow studies.

The characteristics of the patients of this study were very similar to those in previously published studies [3]. Patients of our study therefore appear to be representative of patients who visit their doctors because of BPH. In patients with BPH, no strict relationship between LUTS, BPE, and BOO has been found so far. A recently published article, which reviewed the morphologic and functional changes of the bladder wall in response to BOO, describes comprehensively how mechanical stretch induces gene expression and protein synthesis in the epithelium and smooth muscle cells, and explains how BOO could cause LUTS [20]. It is the policy of the Hannover University Hospital to investigate all men with BPH according to a workup protocol prior to therapy to clarify the relationship between LUTS, BPE, and BOO. Uroflowmetry, and measurements of postvoid residual urine and prostate volume as well pressure–flow studies are performed in all patients accordingly. For this study, only DWT measurements were added to the investigational protocol. To avoid evaluation bias, we measured DWT at the beginning of the patient evaluation and performed

Table 4 – Diagnostic parameters of noninvasive or minimally invasive tests to diagnose BOO in men with BPH

Parameter	Nonobstructive/obstructive	PPV (%)	NPV (%)	Sensitivity (%)	Specificity (%)	Accuracy (%)	LR+	LR−
DWT	<2/≥2 mm	94 (88–100)	86 (79–93)	83 (74–91)	95 (91–100)	89	17.57 (6.71–45.98)	0.18 (0.11–20.02)
Q_{max}	≥15/<15 ml/s	59 (50–67)	97 (91–103)	99 (96–101)	39 (28–49)	67	1.61 (1.36–1.91)	0.03 (0–4.42)
	≥10/<10 ml/s	69 (58–79)	72 (63–82)	68 (57–78)	73 (63–82)	70	2.5 (1.7–3.68)	0.44 (0.31–3.2)
Q_{ave}	≥7/<7 ml/s	59 (50–68)	83 (72–94)	89 (82–96)	46 (35–56)	66	1.65 (1.34–2.04)	0.23 (0.12–1.98)
Postvoid residual urine	≤50/>50 ml	52 (43–62)	63 (51–76)	72 (62–82)	42 (32–53)	56	1.25 (0.99–1.57)	0.66 (0.43–1.33)
Prostate volume	≤25/>25 ml	51 (42–60)	67 (51–83)	85 (77–93)	27 (18–36)	54	1.16 (0.99–1.37)	0.56 (0.29–0.98)

BOO = bladder outlet obstruction; BPH = benign prostatic hyperplasia; DWT = detrusor wall thickness; Q_{max} = maximum urinary flow; Q_{ave} = average urinary flow; PPV = positive predictive value; NPV = negative predictive value; LR^+ = likelihood ratio of positive test result; LR^- = likelihood ratio of negative test result.
Note: The 95% confidence interval of the result is listed in parentheses.

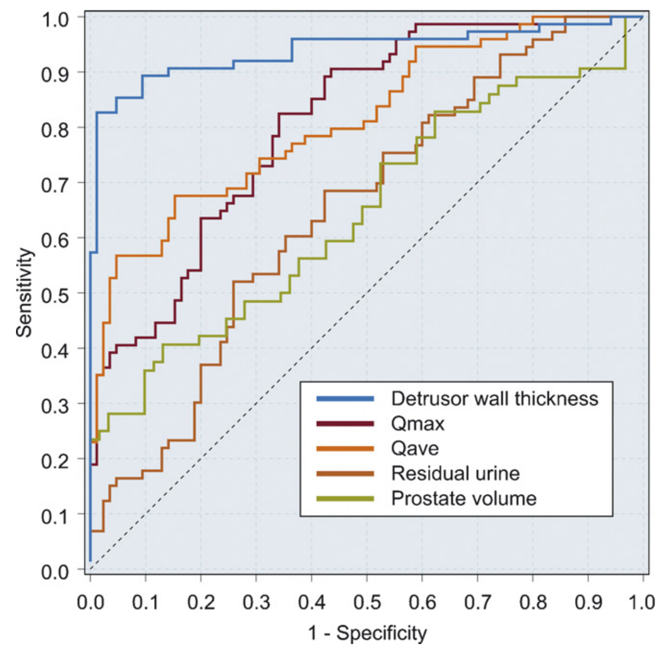

Fig. 3 – Receiver operating characteristic curves of investigated noninvasive or minimally invasive tests commonly used to predict bladder outlet obstruction.

pressure–flow studies, the reference standard of BOO evaluation, as the last test, without knowing the results of the previous tests. The time between the index tests and the pressure–flow study appeared to be too short to develop BOO in the meantime.

The reference standard (pressure–flow studies) is considered to be the best available test for the assessment of BOO [14]. Several classification systems were established with the use of varying amounts of information of the pressure–flow plot. The CHESS classification uses foot point and curvature of the passive urethral resistance relation because both parameters have been shown to be independent predictors of BOO [17,21,22]. In contrast to CHESS, the ICS classification uses only one point ($P_{detqmax}$) and the Schäfer classification only two points of the pressure–flow plot ($P_{detminvoid}$ and $P_{detqmax}$) [21]. If a classification system uses only a few classes, small changes in urethral resistance may not be detected. Therefore, CHESS appears to be the most precise method to assess BOO. CHESS is an established BOO assessment algorithm that was recommended by the ICS [22].

All tests that aim to measure BOO as well (index tests) have to be compared with the reference standard. The index test that has the highest amount of agreement with the reference test preferably should be used to evaluate BOO non-invasively. Of all investigated index tests of our study, ultrasound measurement of DWT showed the highest accuracy to detect BOO. The results of the current investigation are in line with those of previous studies in which DWT was investigated retrospectively and was not blinded to the results of pressure–flow studies. Our study, however, investigated the diagnostic accuracy of DWT, Q_{max}, Q_{ave}, postvoid residual urine, and prostate volume prospectively in one group of patients with clinical BPH. A previous study in which 70 men with BPH were evaluated with the same technique and cutoff values found a positive predictive value of DWT measurements of 95.5% [11]. A recently published study of 102 men with clinical BPH found a positive predictive value of DWT measurements of 89% using a cutoff value of $\geq$2.5 mm and 100% using a cutoff value of $\geq$2.9 mm [12]. Both studies demonstrated that the diagnostic accuracy of BOO detection is higher with DWT measurements than with free uroflowmetry, postvoid residual urine, or prostate volume. A third study in which bladder wall thickness (instead of DWT) at a bladder filling volume of 150 ml was measured in 174 men with LUTS found a positive predictive value of 88% [10]. Again, sonographic measurement of bladder wall thickness detected BOO more accurately than Q_{max} of free uroflowmetry. However, parameters other than bladder wall thickness and Q_{max} were not evaluated in this study. The diagnostic accuracy of DWT or bladder wall thickness measurements is remarkable in all studies. Despite differences in study design and BOO evaluation algorithms, the AUC of ROC analysis varied between 0.88 and 0.93. The results came close to the reference standard, indicating that sonographic measurements of DWT or bladder wall thickness were accurate enough to detect BOO in clinical routine.

All other tests used in clinical routine to diagnose BOO minimally invasively or noninvasively were less accurate to detect BOO. It has been repeatedly demonstrated that these tests are poor predictors of BOO [23]. The results of the current study confirm these findings. Abnormal measurements of free uroflowmetry or postvoid residual urine can detect only voiding dysfunction without indicating BOO specifically. Postvoid residual urine or reduced values of Q_{max} or Q_{ave} can be caused by BOO, detrusor underactivity, or a combination of both. Changing the cutoff value of Q_{max} from 15 to 10 ml/s helps to identify more men with BOO. However, the detection rate of BOO increased from 58% to only 69%, which is clearly lower than with DWT measurements.

Ultrasound measurement of DWT is a new method to diagnose BOO. This technique is based on the results of studies with experimental animals in which the detrusor thickened and bladder weight increased after induction of BOO [8]. Bladder wall hypertrophy can be visualized and measured with an ultrasound device in animals and humans [10,11]. For precise measurements of DWT, it is necessary to use high-frequency ultrasound arrays (7.5 MHz or higher) and ultrasound devices with an enlargement function of the ultrasound picture [15]. Even small differences of DWT can be evaluated, and patients can be classified correctly with this technical support. A study with human cadaverous bladders revealed no significant differences between the anterior, posterior, or lateral bladder walls; trigone; or bladder dome [9]. Therefore, evaluation of DWT is possible at any part of the bladder; however, resolution of the ultrasound picture with a suprapubically positioned 7.5-MHz ultrasound array is usually only sufficient at the anterior bladder wall. Increase of DWT correlates very well with BOO and the grade of BOO [9–12]. After BOO relief, bladder hypertrophy is reversible within 4–12 wk [24]. All studies indicate that bladder wall thickening is associated with BOO. Although the performance of sonographic DWT measurements is operator dependent, it has been shown that these measurements are accurate, reliable, quick, and simple. Although not investigated in our study, intraobserver variability is $\leq$5.1% and interobserver variability between 4–12.3% [10,12]. Measurements of the bladder or detrusor wall are usually done in less than 2 min and can be performed by either urologists or radiologists.

A standardized technique of DWT measurement is essential to judge BOO. The technique used in our study is noninvasive and, therefore, without morbidity. It was demonstrated earlier that DWT depends only on gender, bladder filling, and BOO grade [11,15]. DWT decreases continuously with increasing bladder filling up to only 250 ml, but thereafter remains stable until maximum bladder capacity. DWT was measured in our study when the participant reported having a full bladder. Determination of bladder volume showed that all men had a bladder filling of $\geq$250 ml at the time of DWT measurement. A bladder filling less than the required volume could appear in patients with detrusor overactivity. In these patients, a DWT cutoff value of $\geq$2 mm cannot be used to diagnose BOO. Therefore, bladder volume should be determined before DWT measurement. Furthermore, DWT measurements can only diagnose BOO, but are not able to detect other abnormalities during bladder filling or voiding. It remains unknown in men with BPH if DWT is also influenced by detrusor overactivity, incontinence, low-compliance, dysfunctional voiding, or detrusor underactivity. Urodynamic studies are therefore still indicated to clarify

LUTS in BPH patients without increased DWT or those in whom bladder filling of ≥250 ml cannot be achieved.

5. Conclusions

This study showed that sonographic measurements of DWT are an accurate alternative for pressure–flow measurements to assess the presence of BOO. DWT measurements show a higher diagnostic power than measurements of Q_{max}, Q_{ave}, postvoid residual urine, or prostate volume. DWT measurements appear to be suitable for routine use in patients with clinical BPH and suspicion of BOO. The results of this study could help to assess BOO noninvasively in all men and could be useful to evaluate the value of BOO at assessment and during treatment of BPH patients in the future.

Conflicts of interest

The authors have no conflicts of interest to disclose.

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Editorial Comment on: Diagnostic Accuracy of Noninvasive Tests to Evaluate Bladder Outlet Obstruction in Men: Detrusor Wall Thickness, Uroflowmetry, Postvoid Residual Urine, and Prostate Volume

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It is well known that benign prostatic hyperplasia (BPH) can lead to benign prostatic enlargement (BPE), bladder outlet obstruction (BOO), or lower urinary tract symptoms (LUTS). Because there is no clear association among BPE, BOO, and LUTS [1], it is obligatory to assess each parameter individually for the following reasons.

If we direct indications for treatment solely on symptoms and the subjective decline of quality of life without assessing BOO, we will treat patients symptomatically (α-blockers) and after treatment failure invasively (transurethral resection of the prostate). In that case, treatment of a symptomatic patient with BOO with α-blockers would make him asymptomatic but leave him obstructed with the consequence of "silent obstruction." BOO, then, might lead to a damage of the lower and upper urinary tract. Patients with (unrecognised) BOO in the absence of LUTS who should also get treatment because damage of the upper urinary tract is caused by BOO and not by LUTS would be neglected. Finally, patients with LUTS but without BOO should not receive invasive (operative) treatment to cure symptoms but conservative treatment such as lifestyle modification, α-blockers, etc.

For these reasons, assessment of BOO and LUTS must be an essential part in the diagnosis of patients with BPH. Precise evaluation of BOO is only possible with pressure–flow studies; in the clinical routine, free uroflowmetry, postvoid residual urine, and prostate volume are used to estimate BOO in men with BPH. Determination of detrusor wall thickness (DWT) as a result of the increased infravesical resistance with ultrasound has been shown to be a valuable tool to accurately detect BOO [3]. Oelke et al provide for the first time prospective data on the diagnostic accuracy of DWT measurements [2]. By demonstrating that DWT measurements have a higher accuracy than free uroflowmetry, postvoid residual volume, and prostate volume in diagnosing BOO, they make a very valuable contribution to the diagnostic armamentarium of the practising urologist. It might be controversial whether DWT measurements are "quick and simple" because only minimal changes in detrusor wall measurement determine the presence or absence of BOO. Also, technical aspects seem to play a major role because the enlargement of the ultrasound image is one of the prerequisites but is not possible with many ultrasound instruments. Future studies will show whether DWT measurements will be realised in everyday practice; Oelke and coworkers have provided the basis to do so.

References

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