Urodynamics: What to Do and When Is It Clinically Necessary?

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The role of urodynamics in the evaluation and treatment of men with lower urinary tract symptoms is not well defined. Symptoms do not correlate very well with urodynamic findings, but patients with prostatic obstruction fare better after ablative prostatic surgery than those with impaired detrusor contractility. The only proven method for distinguishing between the two is urodynamics, ie, the detrusor pressure/uroflow study. This article reviews urodynamic techniques and the literature pertaining to urodynamics, along with their clinical utility in benign prostatic hyperplasia. The role of urodynamics in clinical practice is discussed as well.

Introduction

Benign prostatic hyperplasia (BPH) is an age-dependent process with initial histopathologic development after 40 years of age and prevalence rates of approximately 50% and 90% by 60 and 85 years of age, respectively. Cell proliferation associated with BPH comprises both epithelial and stromal elements and may result in benign prostatic enlargement (BPE), which can cause bladder outlet obstruction (BOO). Prostatic obstruction results from both static (increased prostatic growth and tissue bulk) and dynamic (prostatic tone) components. Existing medical and surgical interventions attempt to reduce one or both components of obstruction to provide symptomatic relief. The association between BPH, BPE, and BOO is complex. Although most men with lower urinary tract symptoms (LUTS) have BPH, not all do. Not all men with LUTS have BPE or BOO, and not all men with BOO have BPH or BPE. The best method to definitively diagnose BOO is the detrusor pressure (P_{det})/uroflow study, but there is much more to be learned from urodynamics than simply diagnosing obstruction.

This article describes existing urodynamic techniques used in the diagnosis of BPH, reviews current literature regarding the role of urodynamics in the evaluation of BPH, and makes recommendations for the use of urodynamics in clinical practice.

Background

LUTS are subdivided into storage and emptying symptoms. Storage symptoms include urinary frequency, urgency, urge incontinence, nocturia, and bladder/urethral pain. Emptying symptoms comprise hesitancy, straining to void, weak stream, a feeling of incomplete bladder emptying, and urinary retention. BOO resulting from BPH is only one of the many causes of LUTS. Other causes include idiopathic and neurogenic detrusor overactivity (DO), sensory urgency, impaired detrusor contractility, and polyuria. Even the most skilled and experienced urologist cannot make the diagnosis of BOO on symptom assessment alone. In patients with LUTS and suspected BOO, urodynamic evidence of BOO exists in only 50% to 66% of patients [1–4]. A number of studies have demonstrated a lack of correlation among symptoms, American Urological Association (AUA) symptom score or the Danish Prostate Symptom Score, and urodynamic data in patients with suspected BPH and BOO [5–8].

Knowing the (urodynamic) abnormalities responsible for LUTS is important so that treatment can be directed at the underlying pathophysiology. The majority of medical and surgical interventions target the reduction or elimination of prostatic obstruction, yet only about two thirds of men are actually obstructed. We believe that in the near future there will be specific therapies for DO, sensory urgency, and impaired detrusor contractility, and urodynamics are needed to make the necessary distinctions between these entities. The most definitive method of diagnosing obstruction and impaired detrusor contractility is the P_{det}/uroflow study, whereas cystometry is necessary to distinguish sensory urgency from DO. Uroflow, postvoid residual (PVR) urine volumes, symptom analysis, and questionnaires all play a role in evaluating men with suspected BOO, but only urodynamics can make the necessary distinctions that allow therapy to be tailored to the underlying condition.

Urodynamic Techniques

From a clinical standpoint, the purpose of urodynamic testing is to measure and record various physiologic variables while the patient is experiencing the symptoms that constitute his usual complaints. In this context, urodynamics may be considered to be a provocative test of vesicourethral function. Therefore, it is the responsibility of the examiner to insure that the patient's symptoms are, in fact, reproduced during the study. To this end, it is important that the examiner keeps all relevant clinical information in his or her consciousness as the urodynamic study progresses. Thus, before the study, the patient should have undergone a fairly extensive evaluation including 1) a focused history and physical examination; 2) a urinalysis ± culture; 3) a 24-hour bladder diary; 4) a 24-hour pad test (for patients with incontinence); 5) a uroflow test; and 6) an estimation of PVR urine. Further, in order to interpret urodynamic studies properly, the following information should be available to the examiner before the start of the study.

1. What symptoms need to be reproduced?
2. What is the functional bladder capacity (maximum voided volume on the voiding diary)?
3. What is the PVR urine?
4. What is the uroflow?
5. Is there a neurologic disorder that could cause neurogenic bladder?

The widespread availability of many different urodynamic techniques and parameters may confound the practicing physician, but in principle, there are only five in number: cystometry, uroflow, leak point pressure, sphincter electromyography, and radiographic visualization of the lower urinary tract. Each may be performed alone or synchronously with one another. When done synchronously, the tests are called multichannel urodynamics, and when they are performed with fluoroscopic visualization of the lower urinary tract, it is called videourodynamics. The variables chosen for a particular study depend on a number of factors, but as a general rule, uroflow and PVR are usually obtained first, and if further testing is deemed necessary, multichannel or videourodynamics is done.

Uroflowmetry

Uroflowmetry is a simple, objective, and noninvasive method to evaluate LUTS. It should be performed in a private setting while sitting or standing to reproduce normal voiding patterns. The most useful information obtained includes maximum urinary flow (Qmax), flow pattern, voided volume, and shape of curve. After voiding, PVR bladder volume is recorded with ultrasound of catheterization if invasive urodynamics follows.

The study should be performed when the patient experiences a normal desire to void. A minimum urine volume of 150 mL provides an accurate study [9]. Existing nomograms provide values with age- and volume-adjusted flow rate [5,6,10]. A Qmax greater than 15 mL/sec is considered normal, less than 10 mL/sec is abnormal, and a Qmax of 10 mL/sec to 15 mL/sec is equivocal [11].

Uroflowmetry is unable to distinguish obstructed from unobstructed patients [12]. A normal flow may be seen in patients with significant obstruction, and an abnormal flow may be seen in patients with poor detrusor function. It is obvious that BOO is associated with a low urinary flow rate, but it may also be associated with impaired contractility. In patients who are obstructed, uroflowmetry cannot differentiate types of urethral obstruction (BPH, urethral stricture). Despite these limitations, uroflowmetry remains a useful screening test in the initial evaluation of men with LUTS. The AUA guidelines (2003) recommend uroflowmetry as an optional test in men with moderate/severe symptoms. The European Association of Urology Guidelines on BPH recommends uroflowmetry in the assessment and diagnostic work-up of men with LUTS. It is considered mandatory before surgical intervention [13••].

Uroflowmetry remains an important tool in evaluating efficacy of medical and surgical treatments. It is a constant and powerful parameter utilized in reporting outcomes.

Cystometry

Filling cystometry is performed as an integral part of the urodynamic study. It is the only method that can detect sensory urgency, DO, and low bladder compliance, but it is not useful as a stand-alone procedure in men with LUTS. Rather, the AUA guidelines recommend cystometry be performed as part of the pressure-flow study (PFS). DO may be found in up to two thirds of men with LUTS. Resolution of DO can be expected in 50% to 70% of patients after outlet reduction [14,15].

Multichannel urodynamics and videourodynamics

The synchronous measurement and display of multiple urodynamic parameters is the most precise diagnostic tool for evaluating disturbances of micturition. When combined with radiographic visualization of the lower urinary tract, it is termed videourodynamics. In these studies, radiographic contrast is used as the infusant for cystometry, and other urodynamic parameters including abdominal pressure (Pabd), uroflow, and sphincter electromyography are recorded as well. By measuring multiple urodynamic variables, one gains a better insight into the underlying pathophysiology. Moreover, because all variables are visualized simultaneously one can better appreciate their interrelationships and identify artifacts. The International Continence Society has recommended standards for the performance of these studies [16,17].

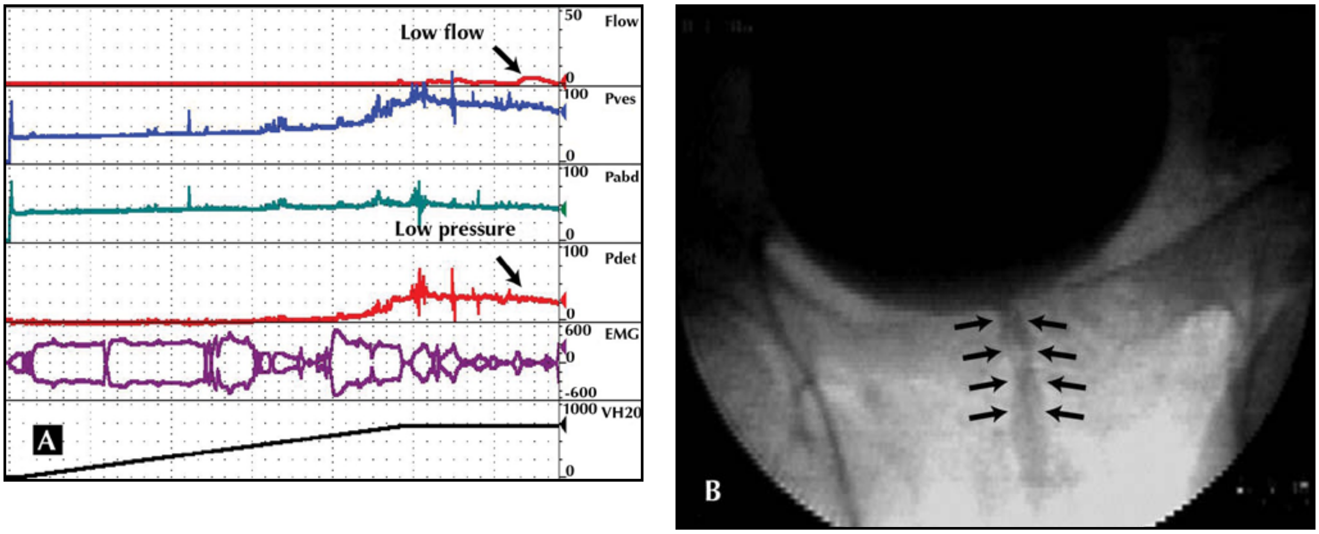

Figure 1. A, Impaired detrusor contractility in a 58-year-old man who complains of severe LUTS (urinary frequency, urgency, occasional urge incontinence, hesitancy, and weak stream). **B**, Urodynamic tracing. Despite the history of urge incontinence, there were not any involuntary detrusor contractions at cystometry. This is termed type-1 overactive bladder [18••]. Unexpectedly, the patient had a large bladder capacity (710 mL). When asked to void, he had a sustained detrusor contraction and a low flow (Qmax = 6 mL/sec, P_{det}Qmax = 28 cm H_2O). This corresponds to a very weak bladder and no obstruction on the Schaefer nomogram. Radiograph obtained at Qmax shows a narrowed prostatic urethra (*arrows*). Of note, if urodynamics were not performed, this patient would have been erroneously diagnosed as having prostatic obstruction because of his low uroflow. EMG—electromyelogram; LUTS—lower urinary tract symptoms; Pabd—abdominal pressure; P_{det}—detrusor pressure; Pves—vesical pressure; Qmax—maximum urinary flow; V_{H2O}—infused bladder volume. (*Courtesy of* Jerry G. Blaivas, MD.)

The main purpose of urodynamic evaluation is to document the underlying cause of a patient's complaints and to correlate symptoms to urodynamic findings. To this end, it is essential to understand the nature of a patient's complaints and to use the urodynamic evaluation as a provocative test to mimic those symptoms as alluded to earlier. The urodynamic study itself is an interactive process between the examiner and the patient. At the time of the study, the examiner should document whether or not the patient's symptoms are reproduced, and if they are, the underlying cause should be clearly understood before completion of the study.

Urodynamic Methodology

Before the urodynamic evaluation, a uroflow is obtained. A 7 Fr double-lumen bladder and rectal catheter are passed into the bladder and rectum to measure vesical pressure (Pves) and Pabd, respectively, and PVR is measured. The pressure transducers are zeroed to atmospheric pressure at the level of the symphysis pubis. Pves and Pabd are displayed on a computer screen and P_{det} is electronically calculated by subtracting Pabd from Pves and displayed on a third channel. Other channels display sphincter electromyelogram infused bladder volume, voided volume, and uroflow. For videourodynamics, fluoroscopic images are sampled periodically during filling and voiding.

During bladder filling, the presence or absence of DO is noted and bladder compliance is recorded. If DO is documented, the patient's awareness, concern, and ability to contract the sphincter, abort the stream, and prevent incontinence are noted. These characteristics are used to classify the type of overactive bladder (OAB) [18••].

BOO is defined by PFS parameters. The bladder outlet obstruction index (BOOI) is used to measure the degree of obstruction (BOOI = P_{det}Qmax - 2Qmax). Men are classified as obstructed (BOOI > 40), equivocally obstructed (20 < BOOI < 40), or unobstructed (BOOI is < 20). Multiple nomograms have been described to interpret PFS [11,19,20]. These plot P_{det}Qmax versus the Qmax and then divide the results into unobstructed, obstructed, and equivocal categories. We prefer the Schaefer nomogram because it provides a simple 6-point obstruction scale [16]. An example of a videourodynamic study is shown in Figure 1.

Cystoscopy

Urethrocystoscopy is appropriate in evaluating men with suspected BPH with a history of microscopic or gross hematuria, prior lower urinary tract surgery, bladder cancer, and urethral stricture. Urethrocystoscopy is not necessary in those patients opting for medical therapy. AUA guidelines recommend urethrocystoscopy as follows: the "endoscopic appearance of the prostate may guide the choice of therapy in patients who have already decided to proceed with an invasive approach" [21]. We also recommend it for those with refractory OAB.

Other Novel Methods of Assessing Obstruction

Although the PFS remains the most objective and definitive method of diagnosing BOO, it is invasive, expensive, time consuming, and subject to variability [22,23]. The lack of a simple (but definitive) noninvasive method of diagnosing BOO has paved the way for current research efforts.

The measurement of a prostatic resistant index is a method that uses transrectal color Doppler sonography to measure vascular resistance, which is increased in BPH [24]. It measures the intraprostatic pressure changes and blood flow, and this is hypothesized to reflect the severity of obstruction [25]. Although interesting, this technique is still investigational.

Several authors have described the use of an inflatable penile cuff to obstruct flow progressively during voiding. This was based on a method first developed in 1975 by Brindley and Craggs [26–28]. A recent publication describes a nomogram to classify men with LUTS using uroflowmetry and noninvasive bladder pressure measured during voiding using an inflatable penile cuff [29]. The technique measures the cuff pressure required to interrupt flow and is being studied by a prospective clinical trial. Some authors have questioned the utility of urodynamic parameters to predict transurethral resection of the prostate (TURP) outcomes and devised a formula consisting of two noninvasive variables, ie, Qmax and age, with good sensitivity and specificity in predicting outcome [30].

Indications for Urodynamic Evaluation

Current AUA guidelines on the management of BPH recommend PFS as an optional diagnostic test for patients with moderate/severe symptoms (AUA symptom score/International Prostate Symptom Score > 8) who choose invasive therapy (minimally invasive or surgery) [21], and the International Scientific Committee of the Fifth International Consultation of BPH regards PFS as an optional diagnostic test [31] but recommends it before invasive therapy or when a precise diagnosis of BOO is important.

PFS has been shown to be of predictive value for TURP [13]. van Venrooij et al. [32] compared the outcomes after TURP in obstructed versus unobstructed or equivocal men. Although their study was limited by a lack of follow-up in 39 of 132 patients, men with unequivocal BOO did better than their unobstructed and equivocal counterparts. Men in the latter group treated with TURP did have significant improvements in uroflow rate, symptom score, and quality of life. The authors concluded that after failure of conservative therapy there is still a role and significant benefit for TURP in unequivocal and unobstructed patients.

Hakenberg et al. [33] prospectively assessed the value of preoperative symptom-score assessment and pressure-flow measurement in 95 men with LUTS. They concluded that both were helpful in excluding patients who are unlikely to benefit from TURP. Knutson et al. [34] performed a prospective study to evaluate if urodynamic assessment of outflow obstruction could predict outcome from watchful waiting in 37 men with LUTS and suspected BOO who underwent PFS at baseline. They were categorized as severely, moderately, or mildly obstructed and followed for 4 years. Failure was defined as the need for treatment with medication, microwave treatment, or TURP. There was a statistically significant difference in the failure rates, 56%, 25%, and 11%, of each corresponding group.

Many clinicians routinely use preoperative urodynamics to predict TURP outcomes [15,7], and there is a plethora of long-term, postoperative, symptomatic, and uroflowmetry data [8,35]. Jensen et al. [8] reported higher success rates in obstructed versus unobstructed patients (93% vs 78%). Robertson et al. [36] published similar results (79% vs 55%). However, there are sparse long-term, pressure-flow data after surgical treatment of BOO. Thomas et al. [37••] recently published long-term urodynamic follow-up on patients with surgically treated BOO. BOO was defined as the obstructed zone on the International Continence Society pressure-flow nomogram [16]. They reported on 217 men who underwent TURP with a mean 13-year follow-up. There was a sustained improvement in most urodynamic parameters and a decrease in most symptoms. Importantly, they concluded that long-term symptomatic failure and decreased flow rate were associated with decreased detrusor contractility rather than obstruction. A recent study by Seki et al. [38] suggested that outcomes after TURP were less favorable in those with impaired detrusor contractility. Their study revealed significantly better treatment outcomes in patients with obstruction. Rodrigues et al. [39] demonstrated that urodynamic PFS provides great predictive value of clinical improvement in obstructed patients, as well as poor clinical results in unobstructed patients. They found that 42% of patients were not obstructed and these patients could not be distinguished from their obstructed counterparts based on urinary symptoms or quality-of-life measures. Each of the above studies stresses the importance of obtaining preoperative PFS to provide detailed and informed consent and identify those patients at risk for long-term failure.

Additionally, PFS is useful in the assessment of recurrent LUTS after TURP. Thomas et al. [37••] found that there was a 12.4% reobstruction rate in men with LUTS after TURP. Likewise, Nitti et al. [40] published a 16% obstruction rate. The majority of patients in both reports with LUTS after TURP also had DO or impaired detrusor contractility, emphasizing the necessity of urodynamic investigation before treatment.

There are some who argue against routine use of PFS due to its invasive nature and risk of morbidity [23]. McConnell [41] argued there is too large of an equivocal area in the pressure-flow relationship, making it difficult to distinguish obstruction from unobstruction. Additionally, he claimed the analysis and interpretation of the data are highly variable, even between centers of excellence. Several recent reports have evaluated the tolerability and risk of urinary tract infection. Logadottir et al. [42] reported on 118 men who were evaluated with a questionnaire 1 week after PFS. Patients reported experiencing little discomfort, and if there were distressing symptoms they were in all cases mild and transient. The risk of infection and antibiotic treatment was 4.2%. They concluded the evaluation is well-tolerated, and regular use of antibiotics is not indicated. Scarpero et al. [43•] evaluated patients to determine the degrees of anxiety, embarrassment, and discomfort perceived by patients before undergoing videourodynamics and compared the results with the actual degrees experienced by patients. All patients undergoing urodynamics were given a two-part questionnaire. Part one was given immediately before the test and included questions regarding expected anxiety, pain, embarrassment, apprehension regarding radiograph exposure, and preparedness. Part two was given immediately after testing and included questions comparing anticipated experience with actual overall experience, pain and embarrassment, preparation, and whether the patient would undergo testing again. Most patients expected no anxiety to moderate anxiety, pain, embarrassment, and apprehension. After testing, most respondents thought that the test was the same or better than expected, and it was associated with an expected or less than expected level of pain and embarrassment. Of the patients, 95% would undergo urodynamic testing again if medically indicated.

Conclusions

In our judgment, the indications for urodynamics in men with LUTS depend upon the threshold of the clinician for obtaining the most accurate diagnostic information. The underlying pathophysiology of LUTS consists of urethral obstruction, impaired detrusor contractility, DO, and sensory urgency. These diagnoses can only be made with urodynamics, and all diagnoses have important implications for treatment, particularly surgical treatment. Pressure-flow evaluation has been and remains the only "absolute way of diagnosing BOO" [44]. Although PFS has not been shown to predict responses to medical therapy, numerous studies have demonstrated that patients with proven obstruction benefit more from prostatectomy than patients who are not obstructed or have impaired detrusor contractility [8,45]. Nonetheless, from a clinical viewpoint, videourodynamics does not serve a purpose unless the clinician bases therapy on the results of the study. For the male patient with LUTS, urodynamics is only useful if DO and sensory urgency are treated differently than prostatic obstruction.

Notwithstanding these theoretic considerations, we consider PFS essential and videourodynamics preferable for men who have failed conservative and surgical therapies, particularly those considering invasive treatment. We recommend videourodynamics for men with known or suspected neurologic disease, including those with a history of spina bifida, diabetes mellitus, cerebral vascular accident, spinal cord injury, multiple sclerosis, Parkinson's disease, and multisystem atrophy. Men with a history of major pelvic surgery or prior pelvic radiation should undergo urodynamic evaluation.

Finally, one should not forget the science of medicine. Even if videourodynamics were found to not have clinical importance, this would still be the best method of defining normal and abnormal physiology. Understanding physiology is the means by which we develop hypotheses that lead to new research, new diagnostic methodologies, and ultimately, new and more effective therapies.

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