FEATURE

What You Wanted to Know About Urodynamics but Were Afraid to Ask

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What is so dynamic about urine? Many clinicians who see patients for pelvic muscle dysfunction may wonder just that when they receive records with diagnoses based on this functional bladder testing. This article will provide a general overview of urodynamics testing, including its principles, interpretation, and implications for the pelvic muscle dysfunction biofeedback clinician.

Introduction

Urodynamics is the study of the storage and evacuation phases of the micturition cycle. The various components of urodynamics are used to evaluate symptoms (Table 1) or to assess the impact of a disease or disorder on the urinary tract. A complete history, physical exam, and appropriate urologic evaluation should always accompany urodynamic testing. Urodynamics should be used as a piece of the patient's urologic puzzle, as voiding dysfunction is not always what it seems.

Uroflowmetry

The *uroflow* is the measurement of the rate of the flow of urine over time (measured in cubic centimeters per second [ml/second]). It is typically performed at the beginning of the urodynamic study (before urethral instrumentation) or as a stand-alone, noninvasive diagnostic tool. Clinical indications for *uroflowmetry* include screening of the lower urinary tract dysfunction, assessment of the result of treatment, and comparison with the postinstrumentation *pressure flow study*. Patients are asked to arrive with a comfortably full bladder and are instructed to urinate into a funnel-type apparatus equipped with a transducer. A normal uroflow pattern is a smooth bell-shaped curve with a moderately steep rise to the peak of the curve of the maximum flow rate (Table 2). Consistently low flow rates with small voided volumes are indicative of increased outlet resistance (or bladder outlet obstruction) and/or decreased bladder contractility (or detrusor underactivity). Intermittent flow patterns or "bursts" of flow often accompany abdominal straining to void, detrusor sphincter dyssynergia, dysfunctional voiding, or even patient anxiety in the test setting.

Filling Cystometry or the Cystometrogram (CMG)

Filling cystometry, the key component or backbone of urodynamics, assesses the bladder's response to being filled and determines the pressure/volume relationships within the bladder. The *cystometrogram* evaluates bladder capacity, competence of the outlet, compliance of the bladder (or the ability to accommodate to being filled), stability of the bladder (or control over micturition), and bladder sensation (Abrams et al., 2002).

Filling cystometry is performed via urethral catheterization with a catheter capable of bladder filling and measurement of bladder or intravesical pressure (Pves). The abdominal pressure (Pabd) is an estimation of the pressure outside the bladder and is typically measured rectally or vaginally. An important concept of urodynamics is the subtracting of abdominal pressure (or extrinsic forces) from the intravesical pressure (or bladder pressure) to obtain the detrusor pressure (Pves − Pabd = Pdet). Detrusor pressure is "that component of intravesical pressure that is created by forces in the bladder wall" (Abrams et al., 2002, p. 172) and is representative of the detrusor muscle of the bladder. Filling cystometry is performed seated, standing, or supine, and the bladder is filled at a set rate (typically 40–100 ml/minute)

Table 1. Lower urinary tract symptoms

Storage symptoms	Increased diurnal frequency, urgency, urinary incontinence, nocturia
Voiding symptoms	Urinary retention, decreased force of stream, intermittent stream, hesitancy, abdominal straining to void
Postmicturition symptoms	Feeling of incomplete emptying, postvoid dribble

Table 2. Uroflow terminology	
Bladder volume	Voided volume + postvoid residual
Voided volume	Amount of urine evacuated from the bladder
Postvoid residual	The amount of residual after voiding, obtained by catheterization or ultrasound
Flow time	Length of time urine flow actually occurred
Maximum flow rate	Maximum flow rate measured in cubic centimeters per second (ml/second) in the absence of abdominal straining or artifact
Average flow rate	Voided volume divided by flow time

Table 3. Sensations during filling cystometry		
First sensation of bladder filling	90–150 ml	When the patient first “becomes aware of bladder filling”
First desire to void	200–400 ml	When the patient would “pass urine at the next convenient moment but voiding can be delayed”
Strong desire to void	300–600 ml	”Persistent desire to void without the fear of leakage”

with sterile water, sterile saline, or a contrast medium suitable for bladder instillation.

The *sensation* to void is a subjective feeling, and during bladder filling an individual should feel certain sensations of fullness (Table 3). Sensations can be influenced by the patient’s anxiety in the test setting, but pain in response to bladder filling is abnormal. Premature (or increased) sensations could be associated with a small bladder capacity as a result of irritative voiding symptoms due to outlet obstruction (as in benign prostatic hyperplasia or pelvic organ prolapse); poor bladder compliance (due to neurologic disease, radiation cystitis, or interstitial cystitis); or overactive bladder. Absent or delayed sensations may be the result of neurologic disease, prolonged bladder outlet obstruction, or neuropathy (as in diabetes).

Stability of the detrusor refers to the absence of involuntary detrusor contractions in response to bladder filling. The detrusor, under nervous system control, should remain stable or inhibited until the evacuation phase occurs with a voluntarily initiated detrusor contraction. Detrusor overactivity or an *unstable* detrusor may or may not involve urgency and urge urinary incontinence. Urge suppression can be an important pelvic muscle rehabilitation technique for these patients.

Bladder *compliance* is a measure of the bladder’s ability to distend with or accommodate filling and maintain a constant low pressure (Abrams et al., 2002). Normal bladder compliance is crucial for adequate storage of urine at safe bladder pressures to avoid upper tract distress or damage. Low or poor bladder compliance is characterized by a slow, steep rise in bladder pressures in response to filling that often overcomes the ureteral orifices (causing vesicoureteral reflux and/or hydronephrosis) or the urethral outlet (*detrusor leak point pressure*). Bladder compliance is especially important when evaluating patients with bladder outlet obstruction or neurogenic voiding dysfunction.

The volume or *capacity* of the bladder is also measured. Cystometric capacity is the volume in the bladder measured during filling cystometry, at the end of filling when “permission to void” is given. The normal adult bladder should hold between 300 and 600 ml. In children, bladder capacity is calculated using the formula Age in Years + 2 × 30 = the number of milliliters (Koff, 1983).

Last, the *competence* of the outlet is evaluated during filling cystometry. Normally, the tension and compression of the urethra and its subsequent watertight seal prevent leakage in the presence of increased abdominal pressure (such as with coughing, sneezing, lifting, etc.). During filling the patient is asked to perform cough and Valsalva maneuvers while the urodynamicist assesses for leakage (i.e., stress urinary incontinence). The pressure at which the leakage occurs during a Valsalva is referred to as the *Valsalva leak point pressure*. The lower the Valsalva leak point pressure, the less resistance there is at the bladder outlet and often the more urinary incontinence the patient experiences in his or her day to day life.

The Electromyogram

Often an *electromyogram* is performed in conjunction with the filling cystometry. As a recording of the electrical activity of a muscle, it is indicated in urodynamics to detect pelvic floor muscle activity and assess the integrity of relat-

Table 4. Pressure flow study interpretation guidelines	
Bladder outlet obstruction	Decreased flow rate, elevated voiding pressure
Decreased outlet resistance	High flow rate, low voiding pressure
Underactive detrusor	Decreased flow rate, low voiding pressure

ed muscles. Measured using surface or needle electrodes, it assesses for *detrusor sphincter dyssynergia* in patients with neurologic disorders and for the presence of learned dysfunctional voiding patterns in those patients neurologically intact. Normally, the striated muscles of the external urinary sphincter relax as the detrusor contracts, creating a synergic and coordinated voiding event. Detrusor sphincter dyssynergia is a common finding in spinal cord injured patients, as well as those with multiple sclerosis and Parkinson's disease. However, there is a subset of patients who have developed learned voiding dysfunctions and do not adequately relax pelvic floor muscles for elimination, creating, in essence, an outlet obstruction. Those experienced in pelvic muscle dysfunction biofeedback can work with patients to resolve this.

Pressure Flow Study

At the completion of the filling or storage phase, "permission to void" is given. The urodynamic evaluation of this evacuation phase is called a *pressure flow study.* This is defined as the "method by which the relationship between pressures in the bladder and urine flow rate is measured during bladder emptying"(Abrams et al., 2002, p. 175). This study evaluates the resistance of the outlet and the bladder's ability to empty. Resistance of the outlet may be increased (as in benign prostatic hyperplasia and pelvic organ prolapse) or decreased (as in stress urinary incontinence). Urine flow patterns are either continuous or intermittent in nature. In addition to the uroflow data (Table 2), the pressure flow study measures the opening pressure of the detrusor, the opening time, and the detrusor pressure at the maximum flow rate. The opening time is the time from an initial rise in detrusor pressure to the onset of flow (Abrams et al., 2002) and is important when evaluating how strong the detrusor force must be to initiate urine flow in bladder outlet obstruction (Table 4).

Other Urodynamic Testing

At some centers *urethral pressure profile* measurements are made after bladder filling. It is defined as a graphical representation of "the intraluminal pressure along the length of the urethra" (Abrams et al., 2002). Some centers also incorporate *fluoroscopy* (video urodynamics) for correlation of radiographic images with events during pressure measurements.

Conclusion

Although invasive, urodynamics testing is important in the objective evaluation of lower urinary tract dysfunction. The role of the urodynamicist is "reproduction and measurement of symptoms" (Albaugh, 1999) to confirm a differential diagnosis that may ultimately lead the patient to a pelvic muscle rehabilitation program.

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