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Where can urodynamic testing help assess male lower urinary tract symptoms?

Abstract

Urodynamic studies assess the function of the bladder and bladder outlet and are often useful in the assessment and diagnosis of patients presenting with lower urinary tract symptoms (LUTS). The evidence regarding the value and risks of invasive urodynamics remains insufficient. However, men with LUTS who are assessed by invasive urodynamics are more likely to have their management changed and less likely to undergo surgery. This review discusses the role of urodynamic diagnosis and application in the diagnosis and treatment of male LUTS.

Keywords; Urodynamic study, Lower urinary tract symptoms, prostate, benign prostate hyperplasia

Lower urinary tract symptoms (LUTS) comprise storage symptoms, voiding symptoms and post-voiding symptoms. [1] LUTS are prevalent and bothersome in men of all ages. [2,3] Determining the underlying mechanism is important in choosing the optimal management. [4] Invasive urodynamic tests (filling cystometry and pressure flow studies) are used to investigate men with. LUTS to determine a definitive objective explanation. A Committee of the International Consultation on Incontinence (ICI) advised that the investigation should be performed before surgical intervention. [5] However, urologists have been undecided on whether urodynamic studies (UDS) bring essential information, or whether a sufficient assessment can be achieved by clinical evaluation alone.

This review covers recent research on the role of urodynamic diagnosis and application in the diagnosis and treatment of male LUTS. Several tests, including non-invasive free flow rate testing, **penile cuff test (PCT), external condom catheter and doppler ultasound and near-infrared spectroscopy** can be described as urodynamic tests. Attempts to find non invasive alternatives have not yet revealed an adequate approach. Therefore, invasive urodynamics remains the key indicative test in the care path way for male LUTS.[6]

Urodynamic testing

The term ‘’Urodynamics’’ was defined as the assessment of the function and dysfunction of the urinary tract by any appropriate method. [7,8] UDS allows direct assessment of LUT function by the measurement of relevant physiological parameters during filling cystometry and pressure-flow study (PFS). It is carried out in an assessment pathway that also can include symptom score, bladder diary assessment, uroflowmetry and post void residual urine (PVR) evaluation, as set out by the International Continence Society (ICS). [9] It is always driven by the LUTS reported by the patient, specifically whether any particular symptom remains bothersome despite conservative or medication therapy.

Invasive urodynamics (Figure 1) involves the placement of intravesical and rectal catheters. Bladder pressure (P_{ves}) is normally recorded via a fine, fluid-filled catheter passed into the bladder via the urethra with the distal end connected to an external pressure transducer. The continuous subtraction of the pressures in the rectal line (P_{abd}) from those in the vesical line gives the 'detrusor pressure' (P_{det}), and estimate of bladder contraction. The bladder is filled at a steady rate with body temperature isotonic saline (filling cystometry; CMG) (Figures 1 and 2), until the patient reports a strong desire to void or experiences severe urgency or severe incontinence. Following 'permission to void' uroflowmetry is performed while still recording pressures (pressure flow study; PFS) (Figures 1 and 3).

Rationale of testing and interpretetion of findings

The measurements are performed with the aim of answering the following two questions;

1- In the storage phase; Can the bladder be filled to normal capacity without leakage or significant pressure rise, due to either an **overactive detrusor or low compliance**?

2- In the voiding phase; Can the patient empty his bladder completely, with a normal flow rate and voiding pressure, without straining?

Filling is ideally started with an empty bladder. Normally detrusor pressure should remain near zero during the entire filling cycle until voluntary voiding is initiated. Involuntary bladder contractions can occur with filling and are seen as a rise in Pves in the absence of a rise in Pabd. This phenomenon is known as detrusor overactivity (DO) (Figure 2). DO may be accompanied by a feeling of urgency or even loss of urine (DO incontinence). Steady rise in pressure with filling indicates impaired compliance, which is quantified by the relationship between change in bladder volume and detrusor pressure (**ΔVolume/Δ p det**); a value of less than **20 mL/cm H_2O** implies a poorly accommodating bladder. [10]

The most important values from the PFS (Figure 3) are the maximum flow rate (Q_{max}) and the P_{det} at that moment (termed the **$P_{det}Q_{max}$**). High pressure associated with a slow flow rate implies bladder outflow obstruction (BOO); if slow flow is associated with low pressure, it signifies detrusor underactivity (DUA). The BOO index (**BOOI**) gives a quantitative assessment of BOO and is calculated using the formula **$P_{det}Q_{max}-2Q_{max}$**. If the BOOI is greater than 40, the patient has BOO; if less than 20, no obstruction exists; values between 20 and 40 are described as equivocal. [11] The bladder contractility index (BCI) is another parameter, calculated by the formula PdetQmax- 5Q. [12] A BCI of greater than 100 is normal; and less than 100 indicates DUA.

Clinical applications of UDS for male lower urinary tract symptoms

The PFS measures the relationship between detrusor pressure and flow rate during voiding. While a low flow rate alone may be more likely to be associated with BOO, it is not always the case. Hence, the principal purpose of the PFS is to differentiate BOO from DUA. Likewise, patients with relatively normal flow rate sometimes turn out to have quite elevated detrusor pressures suggestive of obstruction, a diagnosis which can only be made during pressure flow analysis. [13,14] The importance of recognising BOO and/ or DUA, is in deciding treatment. Specifically, it supports whether to recommend BOO relieving surgery, such as transurethral resection of the prostate (TURP). DUA is present in 9–48% of men undergoing urodynamic evaluation for non-neurogenic LUTS. [15] If BOO is truly present, successful surgery should improve voiding, but not if DUA is a signifcant factor. [16,17]

Lower urinary tract symptoms may reflect many potential underlying pathophysiological mechanisms. Young men with. LUTS have a different prevalence of underlying etiologies than older men. About one-third of men older than 55 years with LUTS had benign prostatic obstruction, but younger men were more likely to have poor relaxation of the urethral sphincter. [18]

The ICS defines overactive bladder (OAB) syndrome as urgency, with or without urgency incontinence (UI), usually with increased daytime frequency and nocturia. This symptom-based definition is distinct from detrusor overactivity, which is the urodynamic observation of bladder contractions during filling, which may be spontaneous or provoked. The correspondence of OAB symptoms and urodynamic DO is fairly reasonable in men- more so than in women. [19] However, the symptoms of overactive bladder can be mistakenly attributed to benign prostatic enlargement (BPE). The logic behind this is unclear, since obstruction impedes urine flow, it does not influence detrusor contraction during storage. The role of UDS in the initial evaluation of men with OAB is unclear, since it has not translated into observations relevant to therapy choice or prediction of outcome. Nonetheless, many physicians perform UDS after the failure of conservative medical management.

It is remains unknown whether preoperative DO is a significant predictor of surgical outcomes in patients with male BOO. [20] There are few available studies exploring the significance of preoperative DO in transurethral surgery, and some of them have controversial results. [21,22] Although men with urgency urinary incontinence ("OAB wet") usually have urodynamic DO incontinence, this is sometimes not the case.

Diagnostic value of urodynamic bladder outlet obstruction to select patients for surgery of the prostate

A meta-analysis done by Kim and colleagues in 2017 showed a significant association between urodynamic BOO and better improvements in all treatment outcome parameters. [23] 19 articles met the eligibility criteria, including a total of 2321 patients, but none of the studies employed a prospective design. The parameter to specify urodynamic BOO varied between studies, though generally it was defined as BOOI > 40. The review reported that BOO positive patients have better surgical outcomes in all parameters (symptom score, quality of life, Q_{max} and PVR) compared to BOO negative patients. While BOO negative patients sometimes saw symptomatic improvement after surgery, it was less than that in the BOO positive group, and adverse effects compound the complexity of reporting LUTS improvement.

The Cochrane Database of Systematic Reviews searched for all randomised or quasi-randomised controlled trials on the management of voiding dysfunction in which men with symptoms were randomly assigned to invasive urodynamic testing in at least one arm of the study. [24] Only two trials met the inclusion criteria[25,26] and analysis was only possible for 339 men in one trial. No difference was seen in Q_{max} or IPSS before and after surgery for LUTS in the two groups who underwent UDS or did not. However, the test was influential for therapy choice.

The UPSTREAM study (Urodynamics for Prostate Surgery Trial: Randomised Evaluation of Assessment Methods) is a prospective randomised controlled trial in 820 men who have bothersome difficulty passing urine and who are considering having surgery for the symptoms. [27] Patients were randomized to two arms; the first undergoing clinical evaluation and flow-rate testing, the other additionally undergoing Urodynamic testing. The trial will determine whether urodynamics reduces surgery rates while achieving similar symptom outcome, and will report in 2019. The first qualitative results have been published, and revealed that the patients value the additional information that urodynamic testing brings. [28]

Implications of preoperative urodynamic detrusor underactivity on prostate surgery

The effect of DUA on transurethral surgery outcomes was evaluated in 10 non-randomised studies covering 1113 patients. [29] The parameter used to identify DUA was BCI < 100. DUA was significantly associated with worse outcomes for symptoms and Q_{max}. However, since some improvement was sometimes seen, DUA is not an absolute contraindication for surgery, provide the patient is fully counselled.

Implications of storage dysfunction for surgery to relieve BOO

Seki and colleagues evaluated whether urodynamic findings have any predictive value regarding the outcome after TURP. A retrospective review was done for 1,397 men. Multivariate analysis suggested that the presence of DO was an independent determinant against symptom improvement. [30] The statistical analysis revealed that patients with greater initial storage problems attained less improvement after prostatectomy.Persistent DO can be noted in about 30% and 50% of the patients after prostatectomy. [31,32] The emergence of *de novo* DO is unusual following prostatectomy, so any post-operative DO is likely to represent persistence of DO, as opposed to new onset.

Evaluation of medical treatment of LUTS by urodynamic studies

Most recommendations place UDS after conclusion of conservative therapy, but if used at an earlier stage the information does provide some insight into mechanisms by which medications might bring clinical response. A systematic review and meta-analysis of studies evaluating alpha adrenergic antagonists (alpha blockers) for urodynamic outcomes in patients with LUTS/BPE were performed by Fusco et al. [33] Alpha blockers improved BOOI mainly by reducing $P_{det}Q_{max}$, particularly where BOO was present at baseline. Meta-regression analysis demonstrated a significant positive association between the percentage of patients with obstruction at baseline and the improvement in BOOI after alpha blocker treatment. As a consequence, patients with obstruction can be regarded as the subpopulation that could benefit the most from alpha blocker therapy, as opposed to those merely with voiding LUTS. Nonetheless, PFS is not routinely performed in clinical practice to identify the subgroup of men with BOO among those presenting with voiding LUTS. This is simply because the easily-reversible nature of drug therapy, and relatively low risk of adverse effect, makes the cost and adverse effects of UDS difficult to justify. According to the EAU guidelines, free uroflowmetry may be performed in the initial assessment of male LUTS. However, a threshold free Q_{max} value of 15 ml/s has a positive predictive value of only 67% for BPO, which means that approximately one third of men treated with alpha blockers at this level do not really have obstruction. [34] Most studies evaluating alpha blocker therapy for LUTS/BPE consider free Q_{max} as the only urodynamic measure of treatment effect. However, treatment induced improvements in this parameter are generally loosely related, [35] and the actual urodynamic response may be a relevant decrease in PdetQmax. [33]

More than 50% of maleLUTS patients have complaints of storage symptoms requiring anticholinergic therapy. [36] Initial combination treatment employing both alpha blockers and anticholinergics could improve response and ameliorate adverse events in male patients with voiding and OAB symptoms. [37,38,39] Only a few studies have used urodynamic measurements to monitor clinical changes with anticholinergic treatment in men with LUTS. [40,41] $P_{det}Q_{max}$ and Q_{max} were assessed by combination of alpha blocker plus anticholinergic versus placebo, and was found to be non-inferior to placebo. Hence, the clinical value of UDS on combination therapy choice is still doubtful.

Risks of invasive urodynamic tests

Urodynamic studies are generally well tolerated and perceived valuable by patients due to the additional insight brought into the symptoms. [42] However, men may find testing to be an uncomfortable or embarrassing experience. The main risks of urodynamic testing are those associated with the process of urethral catheterisation, such as dysuria (painful urination) and urinary tract infection (UTI). The rate of bacteriuria reported after UDS ranges from 4% to 9%.[43,44]

Practical management of male LUTS

Diagnostic pathways and thresholds of testing to evaluate male LUTS generally include evaluations to exclude a serious underlying health factor, symptom score, bladder diary, urinalysis, freeflow rate testing with PVR measurement**.** Additional tests may be undertaken individually. The flow diagram (Figure 4) illustrates an approach to the diagnostic pathway for male LUTS, and the potential contribution of UDS.

Conclusion

Urodynamic studies provide an objective evaluation of the patient's presenting LUTS, which often provide an uncertain relationship in predicting the underlying UDS findings. Distinguishing between voiding LUTS due to BOO and or DUA is important, as this issue may influence management decisions specifically related to surgery for BOO. Low-level evidence suggests that making this distinction is important, as clinical out comes may be affected.

Limited evidence suggests that UDS helps to predict which men with bothersome LUTS will benefit from surgery and medical treatments. Invasive urodynamics is generally well tolerated and leads to far fewer complications than avoidable surgery, and very few serious long-lasting issues. Publication of the UPSTREAM trial data will help identify the best approach to the diagnostic pathway. Until that is clear, we recommend an inclusive approach to using invasive urodynamics to complete the full assessment of those men who have failed conservative management of bothersome LUTS.

Abbreviations:

BOO (bladder outlet obstruction), BOOI (Bladder Outlet Obstruction Index), BPO (benign prostatic obstruction), BPE (Bening Prostate enlargement), .LUTS (lower urinary tract symptoms),), PVR (postvoid residual), Qmax (maximum flow rate), Urodynamic studies (UDS), Detrusor Overactivity (DO), Pressure flow studies(PFSs), Committee of the International Consultation on Incontinence (ICI), detrusor underactivity (DUA)

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Figure 1; An example of a full urodynamic trace, plotting volume instilled (orange), Pabd (red), Pves (blue), Pdet (green) and flow (black). The filling cytometry is before permission to void (PTV), the pressure flow study is after. Coughs are denoted by the letter c, and first desire to void (FDV) is also annotated. The detrusor is stable (no change in Pdet during filling), and the bladder shows a clear contraction for voiding (rise in Pdet for voiding), though flow is rather slow (8 ml/s) and prolonged (more than a minute). PdetQmax was 51, so the bladder outlet obstruction index was 35 (i.e. equivocal) and the bladder contractity index was 91 (underactive)

Figure 2; Detrusor overactivity (DO) during filling cystometry. On the left, a bladder contraction (rise in pressure in Pdet, caused by rise in Pves) is seen. On the right, a high amplitude DO contraction is seen, initially without leakage. At this point, the patient is preventing leakage by contracting his pelvic floor (which can be seen because the rectal catheter crosses the pelvic floor, and so there is a rise in the pressure plotted in the red line). After a while, the pelvic floor gets tired, so incontinence happens- this is not voiding, as permission to void has not been given.

Figure 3; Pressure flow studies for two different men. On the left, the flow rate is slow, with a Qmax of only 5 ml/s. Detrusor pressure at the time of Qmax was 102 cmH2O, so the BOOI was 92 (obstructed) and the BCI was 127 (normal contractility). On the right, the Qmax is also only 5, but the synchronous detrusor pressure was 24, so BOOI was 14 (not obstructed) and the BCI was 49 (substantially underactive)

Figure 4- Assessment of male LUTs flow diagram. PE: physical examination; ABs: alpha blockers; UDS: Urodynamic study; Q: Questionaires; LUTS: Lower urinary tract symptoms.