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**Review Article**

# Recent research on the role of urodynamic study in the diagnosis and treatment of male lower urinary tract symptoms and urinary incontinence

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**Abstract**

Although evidence shows that urodynamic study may not improve outcomes, it can be used to evaluate men with lower urinary tract symptoms (LUTSs) which have not been adequately delineated and treated. In young men with LUTS not responding to treatment based on clinical examination, or elderly men with LUTS and incontinence, a complete urodynamic evaluation is mandatory to understand the pathophysiology underlying LUTS, such as bladder outlet obstruction (BOO), detrusor overactivity, and detrusor underactivity. Preoperative urodynamic study-proven BOO is a predictor of a successful surgical outcome. An urodynamic study should be performed when patients with LUTS are planning to undergo surgical treatment for benign prostatic obstruction.

**Keywords:** *Bladder, Lower urinary tract symptoms, Urethra, Urodynamics, Voiding dysfunction*

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## Introduction

The diagnostic rationale of urodynamic study in association with the currently changing management paradigm of lower urinary tract dysfunction (LUTD) has been debated for a long time. The International Consultation on Incontinence (ICI) Research Society has discussed the diagnostic process and suggests that patient presentations can be more precisely delineated as syndromes, such as overactive bladder (OAB) syndrome, stress urinary incontinence (UI) syndrome, and neurogenic LUTD (NLUTD) syndrome. The diagnostic process for patients with LUTD should be carefully delineated and personalized to rationally select patients for invasive urodynamic study and improve the outcome of initial management [1]. This review covers recent research on the role of urodynamic diagnosis and application in the diagnosis and treatment of male lower urinary tract symptoms (LUTSs) and UI.

## Clinical applications of urodynamic study for male lower urinary tract symptoms and urinary incontinence

Urodynamic study for men with LUTS and UI should start with symptom assessment. The Urogenital Distress Inventory (UDI-6) and Incontinence Impact Questionnaire (IIQ-7) assess symptom distress from UI and its impact on daily life. A Dutch group evaluated the UDI-6 and IIQ-7 and revealed that both questionnaires were reliable, valid, and responsive instruments in both men and women [2]. The ICI performed a cross-sectional study comparing successive urodynamic study using both the ICI questionnaire-UI short form (ICIQ-UI-SF) and 1-h pad weighing test and found that the best independent predictors of urodynamic incontinence were the patient's age and the ICIQ-UI-SF [3]. The ICI also developed and validated an ICIQ 3-day bladder diary for the assessment of LUTS and showed it to be valid, reliable, and responsive to change [4].

Urodynamic study has not been recommended in the initial evaluation of OAB syndrome. Urodynamic detrusor overactivity (DO) can be characterized as phasic DO and terminal DO according to the occurrence of uninhibited detrusor contractions during the storage and voiding phase without and with urine leakage [5]. Phasic DO occurs more in young individuals with OAB syndrome. However, there is no significant difference between genders or neurological status [6]. In patients with detrusor underactivity (DU), diminished bladder sensation to volume increase was noted in nonobstructed, nonneurogenic symptomatic patients [7]. In patients with OAB syndrome with failed empirical treatment, urodynamic study can provide definite information that can identify associated pathologies and/or alter the treatment course [8]. Clinically, video-urodynamic study and urodynamic study have also been used in the evaluation of the function of intracorporeally reconstructed orthotopic U-shaped ileal neobladders [9] and Studer orthotopic ileal neobladders [10] and investigation of pouch incontinence to assess

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the functional length, static and dynamic closure pressure, and pouch capacity [11].

A retrospective study of urodynamic studies involving men with OAB symptoms revealed that most of these men also had voiding symptoms and 43% of them had evidence of bladder outlet obstruction (BOO). However, there was a weak correlation between OAB symptoms and urodynamic findings [12]. An assessment of urodynamic patterns in poststroke UI found that urodynamic patterns vary depending on the timing of the study. Compared with findings at admission, urodynamic findings 1 month after a stroke showed normal results in 30% versus 15%, DO in 48% versus 56%, detrusor hyperactivity and inadequate contractility in 6% versus 14%, and DU in 16% versus 15% [13].

In conclusion, urodynamic study can be used to evaluate men with LUTS which have not been adequately delineated and treated. Evidence that urodynamics improves outcomes is limited. Nevertheless, all elderly male patients with LUTS with incontinence should receive a complete urodynamic evaluation to understand the problem.

## The role of urethral function and bladder contractility assessment in men with lower urinary tract symptoms and urinary incontinence

In urethral function assessment, a novel technique for simultaneous recording of pressures and the cross-sectional area called "urethral pressure reflectometry" (UPR) has been designed and has been shown to be more reproducible than conventional urethral pressure profilometry. UPR was demonstrated feasible in the male prostatic urethra [14]. Retrograde leak point pressure has also been used to test the tightness of the Virtue quadratic sling (Coloplast, Humlebaek, Denmark) for postprostatectomy incontinence (PPI) [15]. Retrograde leak point pressure was measured through perfusion sphincterometry at baseline, after transobturator tensioning, after prepubic tensioning, and after transobturator, and prepubic arms were secured in place [15]. However, the ICI Research Society reported that each method of assessment has limitations as to its use, and in some cases, the methods have yet to be proved reliable [16].

Ambulatory urodynamic study is complex but sensitive for the detection of DO, but it is prone to artifacts and is time-consuming. Therefore, the method is considered of best value when all other diagnostic means have failed. Ambulatory urodynamic study has been considered a valuable diagnostic tool in patients with LUTS who have already undergone conventional urodynamic study but do not have a definite diagnosis, such as patients with suspected detrusor acontractility and UI of unclear origin [17]. Ambulatory urodynamic study has been shown reliable for the reproduction of the main urodynamic parameters in patients with NLUTD syndrome, except for the end filling detrusor pressure [18].

The bladder contractility index and maximum Walt factor obtained from pressure flow analysis were tested in 786 men with varying grades of BOO. Oelke *et al*. found that both detrusor contraction power parameters continuously increased with rising BOO grade. With increasing BOO grade, the voiding efficiency significantly decreased [19]. The authors concluded that it is impossible to determine the threshold value for detrusor contraction power in determining a threshold value for the diagnosis of DU.

There is a risk that people who have invasive cystometry or urodynamic study will develop urinary tract infections. A systemic review evaluated nine randomized controlled trials and concluded that prophylactic antibiotics did reduce the risk of bacteriuria after urodynamic study, but there was no enough evidence to suggest that this effect reduced symptomatic urinary tract infection [20].

## Urodynamic evaluation of bladder outlet obstruction in male patients with lower urinary tract symptoms

LUTS can result from a complex interplay of pathophysiological features. LUTS in elderly men does not equate to BOO due to benign prostatic enlargement. Young men with LUTS have a different prevalence of underlying etiologies than older men. About one-third of men with LUTS older than 55 years had benign prostatic obstruction, but those younger than 55 years were more likely to have poor relaxation of the urethral sphincter [21].

Uroflowmetry is a commonly used diagnostic test for the assessment of male LUTS. One study tested the clinical value of a simple flowmeter to measure uroflow on an ordinal scale at home. They found that home uroflowmetry values were superior to the International Prostate Symptom Score (IPSS) in correlating with the mean maximum flow rate (Qmax) in clinical uroflowmetry. Home uroflowmetry was most sensitive in identifying a mean Qmax >19 mL/s and most specific in identifying a mean Qmax <10 mL/s [22]. In evaluation of male urethral stricture, a new visual prostate symptom score (VPSS) significantly correlated with the IPSS, Qmax, and urethral diameter. A combination of VPSS >8 and Qmax <15 mL/s had high positive and negative predictive values for the presence of urethral stricture and can be used to avoid further invasive evaluation [23]. Medical treatment for male LUTS was more likely to fail in the first 3 years in patients with low baseline Qmax and high American Urological Association (AUA) bother scores [24].

One evaluation showed that 69.3% of 319 Chinese men with LUTS had moderate to severe symptoms on the IPSS. A statistically significant correlation was found between IPSS and Qmax, IPSS and quality of life index, and IPSS and postvoid residual (PVR) [25]. In young men (18–40 years old) with chronic LUTS, urodynamic study showed bladder neck dysfunction in 21%, dysfunctional voiding in 15%, DO in 13.6%, small cystometric capacity in 10.7%, and acontractile detrusor in 10.5% [26]. Another video-urodynamic study in young men with LUTS showed that the most common urodynamic abnormalities were BOO (42.5%), dysfunctional voiding (28.7%), DU (11.5%), and DO (8.1%) [27]. In 1984 men older than 45 years with LUTS suggestive of BOO, several different urodynamic patterns were noted other than BOO, including DO, sphincteric overactivity, low compliance, and DU [28].

A systemic review of the diagnostic values of office-based tests for BOO in men with LUTS revealed that individual symptoms and questionnaires for diagnosing BOO were not significantly associated with each other. An IPSS score cutoff of 20 or greater increased the likelihood of BOO [29]. Invasive urodynamic tests did change decision-making in the management of male LUTS. Men who received invasive urodynamic study were less likely to undergo surgery as a treatment for voiding LUTS [30].

For diagnosis of male LUTS, the prostatic urethral angle (PUA) was significantly different according to symptom severity, and a greater PUA was associated with a lower Qmax. The PUA should be considered in the diagnosis and treatment of male patients with LUTS [31]. Similarly, measurement of the bladder neck elevation degree (BNE-D) and bladder neck elevation angle (BNE-A) by cystourethroscopy revealed that BNE-D was strongly correlated with BNE-A. Patients with higher BNE-A (≥35°) had higher BOO index and more obstructed voiding patterns than those with lower BNE-A [32]. Urethral closure pressure had a significant positive linear correlation with the Abrams-Griffiths number and had strong agreement with BOO. Micturition urethral pressure profilometry was able to localize the site of obstruction in patients with BOO [33]. Therefore, urethrocystoscopy and urodynamic study should be considered in cases of invasive treatment, recurrent incontinence, and specific situations [34].

In conclusion, LUTS are highly prevalent in men >50 years old and storage LUTSs are frequently reported. The initial treatment for male LUTS can be based on the predominant symptoms, without urodynamic testing. When the initial management fails to resolve the LUTS, urodynamic study is recommended. In men with LUTS, urodynamic study can differentiate various bladder dysfunctions and bladder outlet dysfunction. Urodynamic study is a valuable investigation tool in the differential diagnosis of male LUTS, especially in elderly men with UI or young men with LUTS not responding to initial treatment. Invasive urodynamic study should be considered when invasive surgery is planned for male LUTS.

## Evaluation of treatment of overactive bladder syndrome by urodynamic study

Urodynamic study can be used to evaluate outcomes of medical treatment for OAB syndrome [35]. The antimuscarinic solifenacin was associated with therapeutic better efficacy in the treatment of OAB syndrome in females and patients with a high urgency severity score, high Qmax, and low PVR volume [36]. Although antimuscarinics are recommended as the first-line medical treatment for OAB syndrome, a high rate of discontinuation was observed in years 1, 2, and 3 (74.8%, 77.6%, 87%, respectively). Those using propiverine or solifenacin were less likely to discontinue treatment than those using oxybutynin [37].

A systemic review showed that percutaneous tibial nerve stimulation (PTNS) was efficacious for frequency and urgency UI in most cohort studies [38]. The long-term results of PTNS for OAB syndrome were good, and 77% of participants with an initial positive response to 12 weekly PTNS treatments safely sustained OAB symptom improvement to 3 years, with an average of 1 treatment per month [39]. Prolonged PTNS treatment also led to persistent improvement in LUTS in patients with multiple sclerosis [40].

A phase 3 randomized, placebo-controlled trial showed that onabotulinumtoxinA (BoNT-A) 100 U significantly decreased the daily frequency of UI episodes versus placebo (−2.65 vs. −0.87, $P < 0.001$) and 22.9% versus 6.5% of patients became completely continent [41]. A systemic review also concluded that BoNT-A detrusor injection significantly improved all OAB symptoms, urodynamic parameters, and quality of life in patients inadequately treated with anticholinergics and was well tolerated. However, the risk of urinary tract infection and the need for intermittent self-catheterization also increased after BoNT-A treatment [42]. Although treatment with 20 injections of 100 U BoNT-A was recommended in the treatment of OAB syndrome, a recent prospective randomized comparative study revealed that 1 ml BoNT-A (10 U) at 10 sites was adequate to achieve an optimal therapeutic effect. The changes in urodynamic and voiding diary parameters were comparable between the 10 site and 20 site groups [43]. OAB patients with diabetes mellitus (DM) had a similar success rate at the 6-month follow-up, compared with non-DM patients. However, DM patients had a significantly greater incidence of a large PVR volume and general weakness [44].

The European Association of Urology advises conservative initial treatment of LUTS and OAB syndrome in their guideline, including lifestyle interventions, physiotherapy, physical therapy, pharmacotherapy, and treatment of an empirical nature [45]. The 2015 version of the AUA/Society of Urodynamics Female Pelvic Medicine and Urogenital Reconstruction Adult Urodynamics guideline for diagnosis and treatment of non-neurogenic OAB syndrome in adults provides expert opinion supplementing that from the original 2012 version [46,47]. The amendment focused on four topic areas, mirabegron, which was added as the second-line therapy, and PTNS, sacral nerve stimulation, and BoNT-A injection, which were added as third- and fourth-line therapies for refractory OAB [48].

## Urodynamic evaluation of men with prostate enlargement and lower urinary tract symptoms

An alpha-blocker has been recommended as the first-line medical treatment for benign prostatic hyperplasia (BPH) and LUTS. One study found that a first dose of tamsulosin of 0.4 mg daily for 1 month can predict improvement of LUTS at mid-term [48]. Tamsulosin treatment was effective in 68.7% of patients at 1st month and 72.9% at the 3rd month. There were a significant increase in the Qmax and average flow rate and a decrease in PVR from baseline as well as at the 1st and 3rd months of treatment. A randomized, placebo-controlled, 12-week clinical trial revealed no changes in urodynamic measures in men with LUTS taking tadalafil once daily. Nevertheless, tadalafil treatment resulted in significant improvement in the IPSS and was well tolerated with mild adverse events [49].

## Urodynamic testing of men with benign prostatic hyperplasia and bladder outlet obstruction

UI after prostatectomy is mainly caused by sphincteric weakness but may also be attributed to bladder storage dysfunction and can exist in association with BOO. Laser ablation of the prostate has been widely used in the treatment of BPH and BOO. One small cohort study found that both diode laser ablation of the prostate and palliative transurethral resection of the prostate (TURP) significantly improved the IPSS, PVR, and Qmax in patients with prostate cancer and BOO. However, no significant difference was noted between procedures [50]. Similarly, a randomized double-blind prospective study revealed that 120 W laser photovaporization of the prostate (PVP) and TURP can improve LUTS and maintain the same results over a period of 24 months. There were no significant differences between groups [51]. For the 180 W PVP, one European multicenter randomized trial showed the noninferiority of PVP to TURP in the improvement of the IPSS, Qmax, and complication-free proportion of patients. Nevertheless, PVP results in a lower rate of early reintervention at the 6-month follow-up [52].

In the treatment results of TURP, patients with a preoperative BOO index >40 (definite BOO) or between 20 and 40 (equivocal BOO) had significant improvement in the IPSS, but greater improvement in the Qmax was noted in the definite BOO group [53]. Using a noninvasive urodynamic test, a successful surgical result was achieved in 94% of men with predicted BOO, while 70% predicted as not obstructed did not have a successful outcome [54]. Most patients with BPH and BOO have OAB symptoms which can be relieved after TURP; however, one study found that preoperative terminal DO was negatively associated with improvement in OAB symptoms. The severity of OAB symptoms, detrusor contractility, and degree of BOO do not have an effect [55]. One study found moderate to severe storage LUTS decreased from 60.5% to 48.7% at week 6 and 11.8% at month 6 in patients who received PVP for BPH. DO was not a predictor of persistent storage LUTS after PVP [56].

## Urodynamic evaluation of men with lower urinary tract symptoms after radical prostatectomy

UI after retropubic radical prostatectomy (RRP) or robotic-assisted RP (RARP) is an important issue. Changes in detrusor and urethral function after radical prostatectomy deserve attention to improve continence. In one study, the Qmax increased, and detrusor pressure and urethral resistance factor decreased significantly after RRP. In univariate analysis, DO was found in 34% of patients who were still incontinent 6 months postoperatively, but in only 5.3% of patients who were not [57]. After RRP, the functional profile length (FPL) and maximum urethral closure pressure (MUCP) decreased of 64% and 41%, respectively. A nonnerve sparing technique was a prognostic factor for a higher relative decrease in the MUCP after RRP. Urethral pressure profilometry parameters did not differ in patients with different pelvic floor muscle exercise programs [58]. The reduced FPL was significantly lower and the time to continence recovery was significantly longer in the patients with orgasm-associated incontinence (climacturia) after bladder neck sparing RRP [59].

Investigation before and after RARP revealed that 25% of patients had DO associated with decreased bladder compliance, diminished FPL, and decreased MUCP after the operation, and 21.8% of patients had detrusor hypoactivity [60]. Nerve-sparing RARP significantly affected urine loss immediately after RARP compared with nonnerve-sparing surgery. Increased urine loss immediately after RARP was noted in 86% of patients, which could be attributable to decreases in the MUCP and abdominal leak point pressure [61]. In addition to a lower MUCP, reduced bladder compliance was shown in 27.2% and idiopathic DO in 31.3% of patients with PPI after RRP [62].

Chronological urodynamic evaluation of patients with PPI after RARP revealed that urethral sphincter and bladder function worsen immediately after RARP and recover over time [63]. In one small cohort study, 20.6% of patients had UI 1 year after RARP. Bladder compliance <27.8 mL/cm$H_2O$, MUCP <50.3 cm$H_2O$, and BOO were independent urodynamic factors correlating with UI after RARP [64]. The etiology of UI following radical prostatectomy, either stress or urgency UI, also cannot be predicted by the ICIQ-UI-SF survey [65]. Urodynamic study parameters changed after radical prostatectomy by releasing BOO without affecting overall detrusor contractility. Urinary continence rates gradually improved to a satisfactory level in more than 80% of patients by 12 months after radical prostatectomy [66].

DU is relatively common in patients with PPI, with 40% of patients demonstrating an isovolumetric detrusor pressure of <50 cm$H_2O$ [67]. Although DU was found in 49% of patients preoperatively, it did not affect urodynamic parameters and LUTS improvement after radical prostatectomy [66]. Another large cohort study also demonstrated DU in 41% of patients after radical prostatectomy, of whom 48% demonstrated abdominal voiding, which might affect the success of male incontinence treatment [68]. In a longitudinal observational cohort study, patients with bladder neck contracture after RRP presented with preoperative DU [69].

## Surgical intervention for and prevention of postprostatectomy incontinence and failure or revision of surgical intervention for male urinary incontinence

Surgery for severe PPI might not be successful. Preoperative use of few pads, less severe PPI, and a longer interval between radical prostatectomy and PPI surgery were associated with a successful outcome. The presence of preoperative bladder dysfunction was not predictive of surgical outcome [70]. Surgical treatment for PPI after radical prostatectomy includes a male retroluminal or quadratic sling, artificial sphincter, or bulbourethral composite suspension depending on a variety of patient-related factors [71].

A bladder neck sling suspension technique was performed to prevent PPI in a group of patients during RARP. Both patient perception and objective data of UI 4 weeks after RARP were better in the sling group than in the nonsling group. Bladder neck sling suspension seems to improve the early return of continence after RARP [72]. A randomized controlled trial compared patients receiving pelvic floor muscle training (PFMT) exercise 3 weeks before RARP and continued after surgery and those with PFMT after catheter removal. The results demonstrated that three preoperative sessions of PFMT did not improve the postoperative duration of incontinence [73].

Urodynamic study after a bulbourethral composite suspension revealed a significant increase in the MUCP (40 vs. 58 $cmH_2O$) and FPL (31 vs. 40 mm), and the Qmax was slightly reduced (16 vs. 12 mL/s). Pressure flow study revealed unobstructed voiding in all patients [74]. Functional pelvic cine-magnetic resonance image study in patients with revealed that bulbourethral composite suspension was associated with an increase in urethral length, urethral coaptation zone, and BNE, implying a noncompressive mode of action. However, no significant difference was noted between patients showing clinical success and failure [75,76].

At 30-month follow-up, 77% of patients were dry and 11% improved with use of the Argus T adjustable system for the treatment of PPI. The retrograde leak point pressure increased from 18 to 35 $cmH_2O$ after intraoperative adjustment. Transient inguinal or perineal pain was noted in 61% of patients and postoperative infection in 6% [77]. The overall cure rate for the AdVance and AdVanceXP transobturator male slings was reported to be 80%. This procedure was safe and efficient in patients with mild PPI [78]. The overall success rate of an Advance transobturator male sling for PPI was 74% (28 of 38 patients) 3 months after the operation. A small bladder capacity might impact the success of the procedure [79]. A preoperative Valsalva leak point pressure of >100 $cmH_2O$ had a high degree of predictability for success of the AdVance sling procedure [80].

Sixteen of 35 patients (46%) who underwent American medical system (AMS) artificial sphincter implantation for PPI had postoperative urinary retention requiring clean intermittent catheterization (CIC). All patients who required CIC were able to void within 7 days. Patients who experienced postoperative urinary retention had good continence outcomes [77]. In investigation of failed artificial sphincter implantation, a cadaver model demonstrated that a tandem cuff did not improve retrograde leak point pressure. The proximal bulbar urethral circumference was greater than the distal circumference and increasing urethral circumference correlated with increasing retrograde leak point pressure. This technique may be adapted for revision of a failed initial artificial sphincter [81]. Interestingly, excellent anti-incontinence outcomes were noted in men who failed to demonstrate incontinence during intubated urodynamic study before artificial urinary sphincter placement for PPI, even though they had a high rate of anastomosis stricture and a history of radiotherapy treatment [82]. However, another study showed that although the AdVance transobturator male sling provided excellent continence outcomes for PPI, previous pelvic irradiation seemed to severely compromise the effectiveness of the procedure [83]. Volume adjustable balloon implantation has also been tried to treat PPI, with a success rate of 37/49 (75.5%). A longer duration of incontinence, the use of >5 pads daily, and a small bladder capacity predicted an unsuccessful clinical outcome [84].

## Conclusion

Leak point pressures and urethral pressures are consistently reported to be improved after anti-incontinence treatment using different surgical techniques, in association with reduction in the incontinence grade. The predictive factor for anti-incontinence surgery for PPI is the grade of incontinence. Retrograde leak point pressure may be a good tool for the adjustment of male sling tension to achieve greater urethral resistance during anti-incontinence surgery for PPI.

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### Conflicts of interest

There are no conflicts of interest.

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