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Review Article

Role of videourodynamic study in precision diagnosis and treatment for lower urinary tract dysfunction

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Abstract

Lower urinary tract symptoms (LUTS) are complicated and cannot be used alone to diagnose lower urinary tract dysfunctions (LUTDs) and guide treatment. Patients with bladder outlet obstruction (BOO), impaired detrusor contractility, and hypersensitive bladder might present with voiding predominant symptoms, whereas patients with detrusor overactivity (DO), dysfunctional voiding, or BOO might also present with storage symptoms. To clearly identify the pathophysiology of LUTD, a comprehensive urodynamic study (UDS) including pressure flow and image during the storage and emptying phases, naming videourodynamic study (VUDS), is necessary. This study is especially mandatory in the diagnosis of (1) male LUTS refractory to medical treatment for benign prostatic hyperplasia, (2) female voiding dysfunction and urinary retention, (3) diagnosis of overactive bladder syndrome refractory to first-line medication, (4) management of female stress urinary incontinence and postoperative LUTS, (5) diagnosis and management of neurogenic LUTD, (6) pediatric urinary incontinence and enuresis, (7) geriatric urinary incontinence, and (8) recurrent bacterial cystitis. Although VUDS should not be used as a screening test for any LUTS, it should be considered when the initial management cannot relieve LUTS, or when invasive surgical procedure is planning to undertake for patients with refractory LUTS. VUDS should be recommended as the second-line investigation when the initial diagnosis and treatment based on the symptoms alone or noninvasive tests fail to improve LUTS.

Keywords: *Diagnosis, Lower urinary tract symptoms, Treatment, Urodynamics*

Precision medicine for lower urinary tract dysfunction

Lower urinary tract dysfunctions (LUTDs) include bladder and bladder outlet disorders, and patients with LUTD may present with either storage or voiding lower urinary tract symptoms (LUTSs) or both [1]. Previous studies in men and women with LUTS have revealed that symptom alone cannot provide accurate diagnosis of LUTD [2,3]. Patients with severe bladder outlet obstruction (BOO) might have storage predominant LUTS, whereas women with hypersensitive bladder might complain of voiding predominant LUTS such as severe dysuria [3,4]. Symptom score assessment; uroflowmetry; postvoid residual (PVR) volume; cystometry; urethral pressure profilometry; and image study of the prostate volume, bladder wall thickness, and upper urinary tract, alone or in combination, have been widely used as office-based examinations to make an initial diagnosis of LUTD [5]. However, although most of the LUTDs can be categorized according to the results of these studies and initial medical treatment is given, some LUTDs with extreme diagnostic criteria can still be missed and incorrectly treated. Because LUTD involves dysfunction of the filling and voiding phases, only combined pressure flow study and voiding cystourethrography enables us to investigate the vesicourethral function and dysfunction at one test. The combination of pressure flow study and voiding cystourethrography into one investigation, i.e., videourodynamic study (VUDS), can provide accurate medical treatment and avoid incorrect or unnecessary surgical intervention.

Role of videourodynamic study in lower urinary tract symptoms

The role of urodynamic study (UDS) in broad perspective is to identify the bladder or urethral dysfunctions that contribute to the LUTS, which are symptoms of LUTDs, and to

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search for the origins of LUTS. UDS can be considered as an objective measure and documents the lower urinary tract functions and dysfunctions. The results of UDS can have therapeutic consequences and may change the management strategy of LUTD [6].

VUDS includes (1) pressure flow study to detect abnormal bladder and bladder outlet function in storage and voiding phase; (2) external sphincter electromyographic (EMG) study to detect the coordination or discoordination during storage and voiding; (3) bladder image to visualize bladder wall trabeculation, diverticulum, and detrusor contractions; (4) bladder outlet image to investigate the bladder neck (BN), prostate urethra, external sphincter, female urethra, and pelvic floor dysfunctions; and (5) upper urinary tract image for the vesicoureteral reflux (VUR) and obstructive uropathy by Whitaker test. VUDS has also been widely used in diagnosis and assessment of surgical outcome [7-9]. The clinical applications of VUDS in the diagnosis and treatment of LUTDs are shown in Table 1.

Role of videourodynamic study in the diagnosis of male lower urinary tract symptoms

LUTS is highly prevalent in men. The incidence of LUTS increases with age [10]. Previous concept of male LUTS always connects it with benign prostatic hyperplasia (BPH); however, many clinical studies have demonstrated that LUTSs have a poor diagnostic specificity for BPH with BOO [5]. In fact, only 25%–50% of men with BPH have LUTS, and only 30% of male LUTSs result from BPH and BOO [2,11]. Using VUDS in men with LUTS after medical treatment also revealed that bladder dysfunctions such as detrusor overactivity (DO, 17%), detrusor hyperactivity and inadequate contractility (DHIC, 5.3%), detrusor underactivity (DU, 5.1%), and hypersensitive bladder (3.3%) comprised one-third of male LUTSs. In the remaining two-thirds, primary BN obstruction (PBNO) and poor relaxation of the external sphincter (PRES) also contribute to LUTS, in addition to BPH and BOO [8] [Figure 1].

Concerning the treatment, transurethral resection of the prostate (TURP) is the standard treatment for male LUTS due to BPH if medical treatment does not effectively relieve LUTS. However, patients suffered from LUTS not related with BPH might not benefit from this surgical procedure [12]. Total prostate volume (TPV) of >40 mL and maximum flow rate (Q_{max}) of <15 mL/s usually imply the presence of BOO. However, in men younger than 70 years and TPV <40 mL, PBNO and PRES are more common in VUDS investigation [13]. In men younger than 50 years and having voiding dysfunction, PBNO was noted in 54% and PRES in 24% [14]. Among various causes of non-BOO male LUTS, PRES is the most frequently encountered condition in young men [11]. Therefore, accurate diagnosis of male LUTS due to BPH and BOO by pressure flow study is important to avoid unnecessary surgical intervention, especially in men with preoperative UDS showing low pressure low flow tracing and with storage predominant LUTS [15].

LUTS in young men has different types of voiding dysfunction, including PBNO, dysfunctional voiding, DU, and DO [16]. Transurethral incision of the BN (TUI-BN) rather than standard TURP has the advantage of improving voiding function and preserving both antegrade ejaculation and sexual function [17]. In addition, TUI-BN may prevent the potential complication of BN contracture after TURP.

LUTS can also result either from bladder dysfunction or bladder outlet dysfunction. The treatment strategies of these two distinct dysfunctions are different [11]. In men with LUTS not due to bladder outlet dysfunction, surgery for BOO such as TURP may not alleviate LUTS. Patients usually have persistent storage or voiding LUTS after the surgery. VUDS provides a clear differential diagnosis to differentiate the etiology of male LUTS and may avoid unnecessary operation or overtreatment [6]. Although men with storage predominant LUTS are likely to have bladder dysfunction rather than BOO, a certain percentage of men might have BOO-related overactive bladder (OAB). In a recent study, among 2991 men with male LUTS refractory to medical treatment, 30.7% (n = 919) of them had bladder dysfunction and 64.9% of the 1941 men were found to have bladder outlet dysfunction [4]. Using VUDS, we can also identify male patients with OAB symptoms refractory to medical treatment for BOO.

Role of videourodynamic study in the diagnosis of female voiding dysfunction

Voiding dysfunction in women has been overlooked for a long time. In fact, about 54.8% of women with voiding dysfunction and LUTS might have bladder outlet dysfunction,

Table 1: Clinical applications of videourodynamic study in the diagnosis and treatment of lower urinary tract dysfunctions

LUTD	Possible bladder and bladder outlet disorders
Male LUTS	PBNO, poor external sphincter relaxation, prostatic obstruction, DU without BOO
Female LUTS and voiding dysfunction	PBNO, dysfunctional voiding, DU, and low bladder compliance
Urinary incontinence	DO, ISD, mixed urinary incontinence, cystocele with BOO, DU with ISD
Refractory overactive bladder	Hypersensitive bladder, BOO, PBNO, idiopathic DO
Neurogenic LUTD	Spinal cord lesion with neurogenic DO, DSD, BN dysfunction, central nervous system lesion with bladder or bladder outlet disorders
Pediatric LUTD	Neurogenic DO, DSD, dysfunctional voiding, VUR, low bladder compliance
Complicated LUTD	Elderly incontinence, postprostatectomy incontinence, recurrent urinary tract infection, chronic urinary retention, postreconstructive surgery LUTS, etc.
Upper urinary tract disorders	Hydronephrosis, ureteral obstruction

LUTD: Lower urinary tract dysfunctions, LUTS: Lower urinary tract symptoms, BOO: Bladder outlet obstruction, VUR: Vesicoureteral reflux, BN: Bladder neck, PBNO: Primary BN obstruction, DU: Detrusor underactivity, DO: Detrusor overactivity, ISD: Intrinsic sphincter deficiency, DSD: Detrusor sphincter dyssynergia

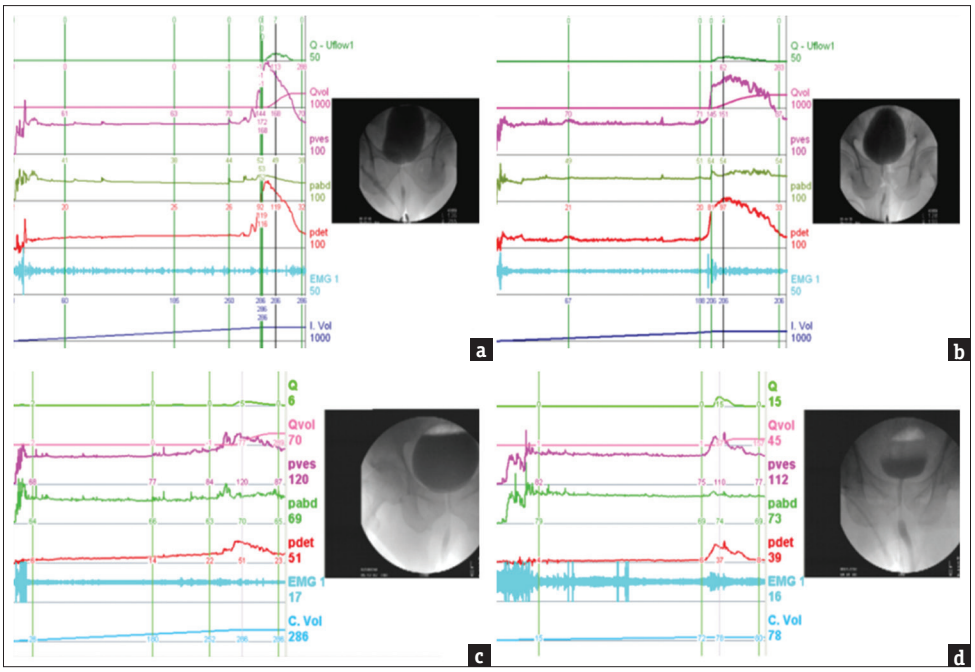

Figure 1: The videourodynamic study findings in men with lower urinary tract symptoms: (a) benign prostatic obstruction and high-pressure bladder outlet obstruction, (b) primary bladder neck obstruction and high-pressure bladder outlet obstruction, (c) bladder neck dysfunction and low-pressure bladder outlet obstruction, (d) poor relaxation of external sphincter without bladder outlet obstruction

including PBNO, dysfunctional voiding, cystocele, poor pelvic floor muscle relaxation, and urethral stricture [18]. The predominant symptoms of female voiding dysfunction could be OAB rather than voiding symptoms [3]. In addition to the bladder outlet dysfunction, bladder dysfunctions such as DU, DO, and hypersensitive bladder all contribute to the female voiding dysfunction [18].

Previous study has revealed that female LUTS alone cannot be used to differentiate bladder or bladder outlet dysfunction [3]. Using pressure flow study, we might make a differential diagnosis of bladder or bladder outlet dysfunction, but we still cannot identify the obstructive site without adding a video study during the urination. Among female bladder outlet dysfunction, the incidence of iatrogenic BOO due to inappropriate placement of suburethral sling has reduced recently. Instead, dysfunctional voiding and PBNO have been noticed to increase in incidence [19]. Women with dysfunctional voiding or BND usually present with a high voiding pressure and low flow rate tracing, but some women may present with a low voiding pressure and low flow rate, or even detrusor acontractility. An elevated bladder base during the VUDS indicates the presence of BOO in women with voiding LUTS [20]. After TUI-BN for PBNO or urethral Botox injection for DV, the detrusor contractility may appear and patients can urinate smoothly without abdominal straining [21].

DU is another frequently encountered cause of female voiding dysfunction. Among 1914 women with voiding dysfunction, DU was noted in 23.1% and DHIC in 12% of the women [22]. After VUDS proven a tight BN during attempting to voiding, TUI-BN provides around 80% of the patents to resume spontaneous voiding after the operation [23]. VUDS also provides evidence for BOO in women after anti-incontinence surgery. Once BOO has been proven, release of the sling tension after anti-incontinence surgery enables patients to urinate smoothly, without awaiting for long-term observation. Instead, if the VUDS does not show BOO, conservative management might be better to provide the surgical correction and long-term success of anti-incontinence surgery.

Role of videourodynamic study in the diagnosis of overactive bladder syndrome

Although patients with OAB usually have urodynamic DO, there have several different subtypes of urodynamic DO. Spontaneous detrusor contractions during filling phase; provoked detrusor contractions on coughing, laughing, and running water, premicturition DO; low compliance and spontaneous detrusor contractions; DHIC; and postmicturition after-contraction can be detected during the VUDS in patients with OAB. Differential diagnosis of different DO subtypes is important because the DO subtypes indicate different underlying pathophysiology of DO and might provide evidence for different pharmacological therapy and management [24]. Observation of the bladder and bladder outlet structural changes during the storage and voiding phases by VUDS can help make diagnosis of different subtypes of DO.

BOO, including PBNO and BPO, comprises 62.4% (383/614) of men with persistent storage symptoms after initial medical treatment for LUTS/BPH [7]. In men who have persistent storage symptoms after medical treatment for LUTS/BPH, BOO should be carefully investigated and appropriate management being given to improve LUTS. BOO can also be found in women with OAB refractory to medical treatment. It has been estimated that BOO is present in 30% of women with refractory OAB [25].

In women with OAB, urethral incompetence is also an important etiology. Part of the urethra is involved in the activation of bladder reflexes and bladder-filling sensation from the urothelium and underlying lamina propria and underlying cellular structures of the urethra [26]. Previous animal study showed that electrical stimulation of the pudendal nerve afferents in the cat allows both inhibition and activation of the bladder [27]. It has been proposed that urethral epithelial–neural interactions could lead to a "urethral instability" that can influence storage and voiding reflexes and result in symptoms including urgency and pain in patients with OAB syndrome [28]. In patents with urethral instability-induced DO, a shorter functional urethral profile length and lower maximal urethral closure pressure were noted. A novel urethra-to-urethra reflex was also suggested in a rat model via chemical stimulation [29]. In the diagnosis of urethral-related OAB or so-called urethral instability, VUDS is the only one test that can clearly identify the changes of the urethral incompetence during bladder storage phase on abdominal straining or pressure increase [Figure 2]. These patients usually present as stress urinary incontinence (SUI) and provoked DO; the suburethral sling should be positioned at the proximal urethra to adequately obliterate the urethral incompetence and prevent the occurrence of provoked DO due to urine influx into the proximal urethra.

Role of videourodynamic study in the management of stress urinary incontinence

There has been a debate of the necessity of UDS in preoperative examination for uncomplicated SUI in women. Recent multicenter randomized trial has shown that UDS did not change the treatment strategy in women with uncomplicated SUI [30]. However, how to make a diagnosis of uncomplicated SUI is another issue. Women with SUI usually have storage symptoms, and they usually cannot clearly separate OAB incontinence and SUI by symptoms alone. Clinically uncomplicated SUI is not really simple urethral incompetence, and DU and DO might be hidden by the SUI during voiding or straining. Although history and neurological examination provide evidence for complicated SUI, a detailed UDS such as VUDS is mandatory to identify women with SUI and DU, low bladder compliance, large cystocele, provoked DO, and bladder outlet dysfunction [31]. Recent literature review also indicates that UDS provides additional information regarding lower urinary tract function that could guide the physician to make the right therapeutic choice [32,33].

There is no consensus which anti-incontinence procedure is the best for female SUI. We may choose retropubic route or transobturator route for mild-to-moderate SUI. However, for severe intrinsic sphincter deficiency (ISD) without bladder base and urethral hypermobility, a simple transobturator suburethral sling at the midurethra might not provide durable long-term therapeutic success, although the cure rats was reported to be 78.9% objectively and 62.6% subjectively at 10-year follow-up [34]. VUDS can provide clear evidence for a bladder base hypermobility, urethral incompetence during abdominal pressure increase, and the true measured leak point pressure during vigorous coughs [35]. A suburethral sling can be positioned at the proximal or midurethra, with adequate tension or nontension according to the VUDS findings. For women with DU and SUI, a loosely placed sling might cure SUI without affecting the spontaneous voiding after surgery. However, a tight transobturator suburethral sling might result in voiding dysfunction [36]. For women with urethral-related provoked DO and SUI, a suburethral sing at the proximal urethra might be better to achieve complete dryness than at the midurethra. For women with low bladder compliance and DU and ISD after radical hysterectomy, anti-incontinence surgery should not be performed unless the bladder compliance can be adequately improved.

For women with postoperative voiding dysfunction or incontinence after anti-incontinence surgery, VUDS also provides evidence for the presence of iatrogenic BOO, residual ISD, poor pelvic floor muscle relaxation during voiding, or DU. With the understanding of these vesicourethral dysfunctions, we can decide which management or operation to be done as the next step to improve patients' voiding condition and urinary incontinence. Transvaginal release of the suburethral sling tension may preserve continence in most of the patients who developed BOO after the sling operation [37]. VUDS provides an accurate diagnosis of postoperative BOO or ISD and appropriate early intervention. Without VUDS diagnosis, we might choose the wrong way and cannot treat the postoperative voiding dysfunction or incontinence appropriately [Figure 3].

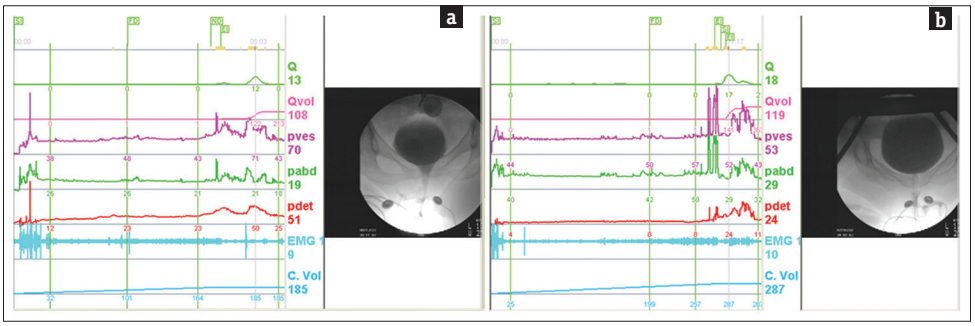

Figure 2: The detrusor overactivity occurs: (a) spontaneously during the end of bladder filling phase and spontaneous urination, and (b) provoked during coughs while urine leaks into the proximal urethra

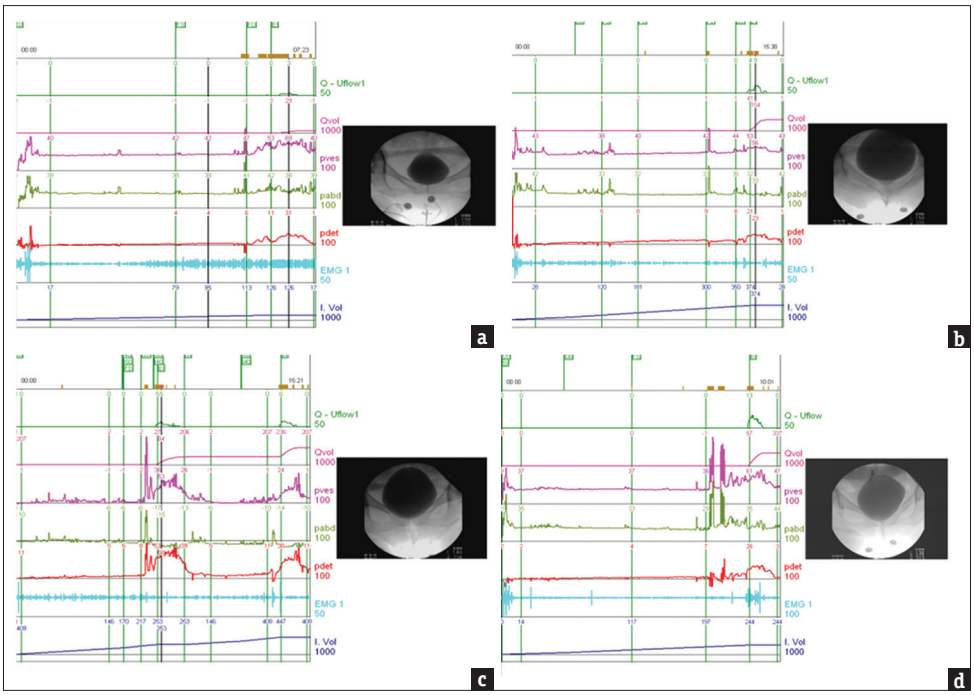

Figure 3: The patients with voiding dysfunction after suburethral sling operation might be due to (a) poor relaxation of the pelvic floor muscles, (b) after medical treatment patient regained normal voiding, or (c) bladder outlet obstruction by the suburethral sling, (d) after release of the sling tension, the patient regained spontaneous voiding without difficulty

Role of videourodynamic study in the management of neurogenic lower urinary tract dysfunction

Storage LUTS is common in patients with neurological lesions such as cerebrovascular accident (CVA), Parkinson's disease (PD), multiple sclerosis, spinal cord injury (SCI), intracranial lesion, and dementia [38]. Voiding LUTS is also common in patients with cauda equina lesion, peripheral neuropathy, or diabetic cystopathy. In aging patients with neurological lesion and LUTS, differential diagnosis of neurogenic bladder dysfunction and BOO is crucial. Incorrect diagnosis might lead to inappropriate treatment strategy and unexpected complications.

In men with chronic CVA, PD, or dementia, terminal DO and dysfunctional voiding in the initiation of urination is frequently encountered. If we do not use VUDS, we might incorrectly diagnose the voiding LUTS as BOO, especially when the prostate of patient is enlarged. TURP usually does not alleviate voiding LUTS, but might exacerbate the storage LUTS, resulting in intractable urinary incontinence which is difficult to treat.

For patients with lower motor unit neurogenic lower urinary tract dysfunction (NLUTD), DU and voiding LUTS is common [38]. If patients have large PVR urine or chronic urinary retention, surgery or not surgery is a debatable issue. Recent clinical studies reported that TURP by classical procedure or laser evaporation could facilitate spontaneous voiding by abdominal straining or resuming spontaneous voiding [39,40]. VUDS provides evidence of a tight bladder outlet during voiding attempts in patients with DU and voiding dysfunction [4]. TURP can reduce the urethral resistance and facilitate spontaneous voiding by abdominal straining. If patients cannot urinate smoothly, a wide open BN can usually predict a successful therapeutic outcome of urethral sphincter botulinum toxin A injection [41]. Without the VUDS investigation, these patients might not restore self-voiding.

Suprasacral SCI results in NDO with or without detrusor sphincter dyssynergia (DSD), while lower motor neuron NLUTD results in DU with or without ISD [42]. The vesicourethral dysfunction changes with time; therefore, patients with spinal cord lesions need regular follow-up during their life span [42,43]. Because the renal function exacerbation is the mainstay issue of spinal cord lesion, the bladder condition, with or without VUR, and the urethral sphincter condition, tight or insufficient urethral sphincter, govern the renal function as well as the quality of life of urination in the chronic spinal cord patients. VUDS provides the best anatomical and functional studies in one set of investigation. VUDS is the gold standard for invasive urodynamics in patients with NLUTD. VUDS can detect bladder and urethral dysfunction as well as morphological pathology in lower and upper urinary tract [44,45]. Patients with contracted bladder and high-grade VUR may need bladder augmentation with ureteral reimplantation. Patients with a normal compliant bladder and ISD may require anti-incontinence surgery to restore urinary continence followed by clean intermittent catheterization (CIC) [Figure 4].

VUDS evaluation has been recommended as the first priority at the time of first evaluation of patients with signs and symptoms or with suspicion of NLUTD. The frequency of testing and the techniques applied in the follow-up of patients

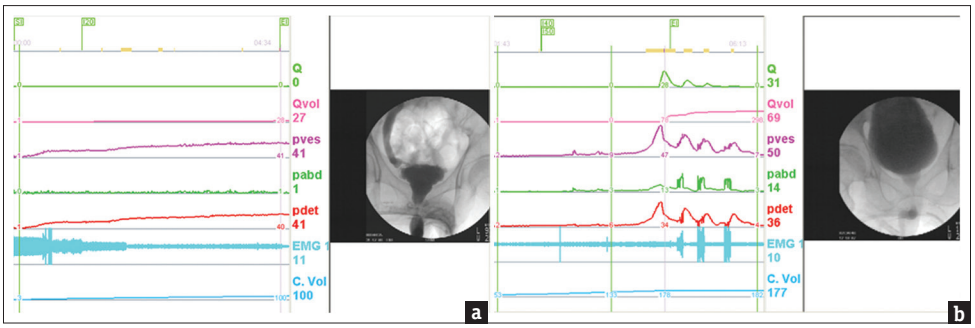

Figure 4: Videourodynamic study for spinal cord injured patients. (a) Contracted bladder with high-grade left vesicoureteral reflux and intrinsic sphincter deficiency in a patient with cervical spinal cord injury, (b) detrusor overactivity with external sphincter dyssynergia and open bladder neck. The vesicoureteral dysfunction found in videourodynamic study can guide correct treatment

with NLUTD is critical [46]. VUDS in patients with NLUTD can be performed with special attention to the specific needs of the patients. It is highly preferable that all professionals involved are specifically trained for that purpose.

Role of videourodynamic study in pediatric urinary incontinence and enuresis

Urinary incontinence may be neurogenic or nonneurogenic in etiology. Daytime urinary incontinence in children is complicated and involves genetic, demographic, environmental, behavioral, or physical factors [47]. NLUTDs such as SCI, spinal dysraphism, and myelomeningocele in children are easy to diagnose based on the history, physical examination, and UDS. However, urinary incontinence in pediatric patients is difficult to handle because the children might not cooperate during the UDS. Pediatric patients might present with both storage and voiding LUTS, and we can make the initial diagnosis by several noninvasive tests such as noninvasive uroflowmetry and PVR, pelvic floor muscle EMG, bladder wall thickness, and abdominal MRI to detect the possible nonneurogenic BOO or dysfunctional voiding [48-51]. Although some patients might be treated based on the tentative diagnosis, the definite and accurate diagnosis of pediatric urinary incontinence still has to be done by the results of VUDS, especially for the children with complicated LUTS, frequent urinary tract infection (UTI), and upper urinary tract deterioration [52,53].

VUR in children may be a secondary phenomenon resulting from LUTD and not only a primary anatomic abnormality at the ureterovesical junction [54]. VUR is highly associated with recurrent UTI and renal damage in pediatric patients with nonneurogenic LUTD [55]. Children with urodynamic DO and dysfunctional voiding may lead to VUR in a marginally competent ureterovesical junction mechanism. In children with nonneurogenic urinary incontinence, UDS is necessary, especially for those patients that still have urinary incontinence, renal damage, or who are about to undergo surgical correction [56]. VUDS can provide fruitful information about the bladder condition, bladder outlet condition, as well as upper urinary tract condition in a comprehensive test [57]. Although the precise UDS (pressure flow study) criteria for bladder outlet conditions in children with urinary incontinence or VUR have not been well defined, VUDS provides useful information in the management of VUR by identifying bladder or bladder outlet dysfunctions [58].

When assessing functional disorders involving the LUT in children, one must take into account the dynamics of the maturation of the nervous and lower urinary tract system. VUDS can assess the true functional bladder capacity in children with high-grade VUR, and the safety bladder volume for CIC should be assessed during the test [58] [Figure 5]. UDS may provide guidance in children with monosymptomatic nocturnal enuresis resistant to pharmacotherapy; however, UDS is not recommended to perform as a routine procedure before first-line medical treatment in these children [59]. For children without upper urinary tract change, UDS or VUDS has a limited place in diurnal urinary incontinence. In the patients with primary nocturnal enuresis, an uroflowmetry with PVR volume determination can predict the treatment response [60]. Bladder wall thickness is also useful to detect bladder outlet dysfunction in children with monosymptomatic nocturnal enuresis and assess the treatment response [61]. However, when patients have persistent daytime and nighttime urinary incontinence and resistance to conventional behavioral and medical therapies, VUDS may be required to detect the presence of dysfunctional voiding.

Role of videourodynamic study in urinary incontinence of frail elderly

Urinary incontinence in the frail elderly commonly has diverse and multiple coexisting factors, general health, mobility neurologic diseases, medications and 'direct' effect of aging on the lower urinary tract all have effect on lower urinary tract function [62,63]. In the frail elderly, symptoms and signs are unreliable, and UDS might be used as a confirmatory test for the diagnosis of the type and grade of LUTD [64]. Voiding difficulty may coexist with urinary incontinence in the elderly, which makes medical treatment difficult to achieve a satisfactory outcome. VUDS should be offered to all elderly with signs and symptoms of LUTD that is considered not related with BPH and not responding to relevant initial management, especially when the invasive treatment procedure is planned [7,11,65].

Central nervous system (CNS) disease is a frequently occurring comorbidity in the elderly, and the clinical signs

and symptoms of LUTD are similar to OAB syndrome or DHIC [66]. Brain disorders such as stroke, PD, and white matter disease may decrease the tolerance of bladder filling and also increase the prevalence of OAB syndrome in the elderly population [67,68]. Acute urinary retention and/or voiding difficulty are frequently encountered signs of LUTD in stroke patients. Although the majority of stroke patients had remained able to void spontaneously, part of them might be bothered by voiding dysfunction and large PVR volume [69]. Surgical intervention should not be undertaken in patients with CNS lesion and voiding difficulty, unless the true BOO has been verified by VUDS [Figure 6]. If patients with LUTD due to DHIC, PRES, or dysfunctional voiding were misdiagnosed as BPO and undergo TURP, the urinary incontinence will be exacerbated after operation [70].

Role of videourodynamic study in recurrent bacterial cystitis

Treatment of women with recurrent bacterial cystitis is a challenge of urologists. Anatomical and functional LUTD should be investigated to effectively eradicate the infection [71]. VUDS discovered a high incidence of LUTD among women with recurrent bacterial cystitis [72]. The LUTDs include DO, DU, dysfunctional voiding, PBNO, poor pelvic floor relaxation, and urethral stricture [73-75]. Significantly lower cystometric bladder capacity, Q_{max}, corrected Q_{max}, and voided volume, higher detrusor pressure, and large PVR volume were noted in VUDS among women with recurrent bacterial cystitis, indicating that the women with recurrent bacterial cystitis have chronic bladder inflammation, and many of them have BOO [72,76]. However, the higher incidence of UTI is not correlated to more complex urodynamic disorders. A lack of normal regenerative ability of the bladder urothelium may lead to recurrent UTIs in patients with systemic diseases such as diabetes mellitus, chronic kidney disease, or local bladder conditions such as BOO or prior pelvic irradiation [77]. Although these VUDS disorders can be found and individualized management is given based on the vesicourethral dysfunction, only few patients could be free from UTI after treatment, suggesting that the LUTDs have not been adequately corrected, or the innate immunity of these patients does not improve after antibiotic treatment.

Without VUDS investigation, we can only treat patients according to their LUTS and give antibiotics according to the results of urine culture. In women with voiding dysfunction symptoms, the incidence of BOO is 54.8%. In women with OAB symptoms, the incidence of DU or BOO is around 10% and 7%, respectively [72]. In women with recurrent bacterial cystitis, a comprehensive VUDS will provide evidence of the actual LUTD behind the bacterial infection. Although the study is invasive, the advantages of VUDS in this specific cohort will outweigh its disadvantages.

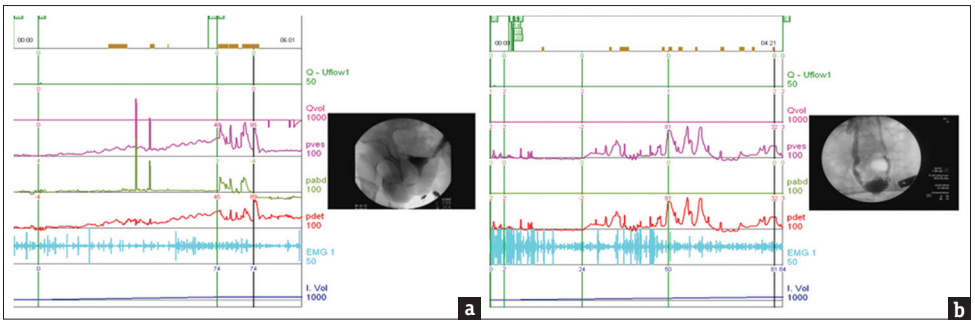

Figure 5: Videourodynamic study for pediatric urinary incontinence in (a) a child with myelomeningocele and recurrent acute pyelonephrosis, the study demonstrated contracted bladder with detrusor sphincter dyssynergia and high-grade right vesicoureteral reflux, and (b) a child with cerebral palsy with recurrent urinary tract infection, the study showed bilateral high-grade reflux, which caused incorrect measurement of the safe functional bladder capacity for clean intermittent catheterization

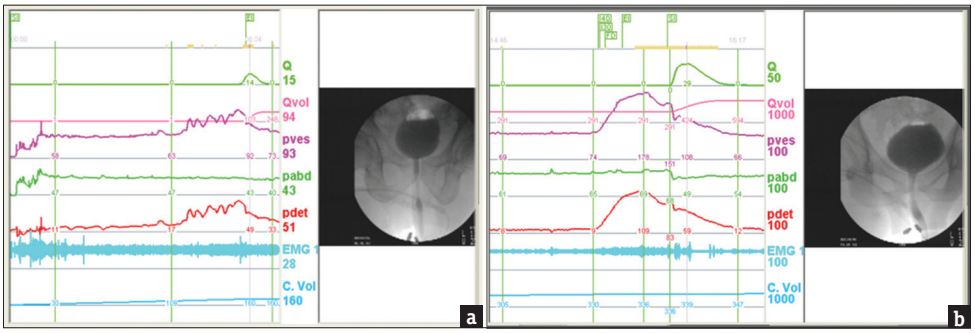

Figure 6: Videourodynamic study of geriatric urinary incontinence in: (a) a patient with Parkinson's disease and lower urinary tract symptoms refractory to alpha-blocker therapy, videourodynamic study revealed narrow bladder neck and poor relaxation of the external sphincter during voiding; (b) a patient with chronic stroke and urgency urinary incontinence, videourodynamic study revealed dysfunctional voiding at the spontaneous detrusor overactivity, normal detrusor pressure, and high maximum flow rate are noted at voiding. The voiding symptoms in these two patients are not related with prostatic hyperplasia and surgery is not necessary

Conclusion: Practical indication of videourodynamic study in lower urinary tract symptoms

VUDS provides a deep insight for the LUTS in one comprehensive test for complicated LUTDs. Through pressure flow study and concomitant voiding cystourethrography, the bladder, bladder outlet, and upper urinary tract conditions in storage and voiding phases can be visualized clearly. Precise diagnosis of LUTD can be obtained and accurate treatment strategy can be done after the study. VUDS should be the second-line investigation when the initial diagnosis and treatment based on the symptoms alone or noninvasive tests fail to improve LUTS. VUDS is especially indicated when invasive treatment such as TURP or reconstructive surgery is planned to relieve LUTS.

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Conflicts of interest

There are no conflicts of interest.

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