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ORIGINAL ARTICLE

Clinical and video urodynamic characteristics of adult women with dysfunctional voiding

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Background/Purpose: Dysfunctional voiding (DV) is an abnormality of bladder emptying in neurologically normal individuals where the external sphincter activity increases during voiding. This study investigated the clinical presentations and videourodynamic characteristics of adult women with DV.
Methods: A total of 1605 women with lower urinary tract symptoms (LUTS) were investigated with videourodynamic (VUD) studies from 1997 to 2010. The clinical urinary symptoms and VUD characteristics of DV were compared with a group of urodynamically normal controls. Antimuscarinic or alpha-blocker treatment according to the chief complaint of storage or voiding LUTS was respectively given.
Results: There were 168 women diagnosed with DV. Detrusor overactivity (DO) occurred in 69% of women with DV. Patients with DV had significantly lower cystometric bladder capacity, higher detrusor pressure, lower maximum flow rate, and larger post-void residual volume than the controls. A total of 114 (67.9%) patients had storage symptoms and 54 (32.1%) had voiding symptoms as their chief complaints among those with DV. Among them, urinary frequency ($n = 69$, 41.1%) was the most common chief complaint, followed by dysuria ($n = 53$, 32.1%), and urgency incontinence ($n = 26$, 15.5%). The incidence of urgency incontinence and dysuria were significantly greater than that in the control group, however, the incidence of frequency, urgency, or nocturia showed no significant difference between DV and control groups. The success rates were 41.2% ($n = 47$) for antimuscarinic therapy and 51.9% ($n = 28$) for alpha-blocker therapy in patients with storage and voiding LUTS, respectively ($p = 0.366$).
Conclusion: DO and storage LUTS commonly occurred in women with DV, suggesting DO could be one of the etiology in the pathophysiology of DV. VUD studies yielded a high diagnostic rate for DV in women with LUTS.

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

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Introduction

Dysfunctional voiding (DV) is an abnormality of bladder emptying in neurologically normal individuals where the external sphincter activity increases during voiding. In 1973, Hinman and Bauman[1] popularized the concept of incoordination between the detrusor and activity of the pelvic floor-external sphincter complex. DV was first described as the failure to coordinate the detrusor and external sphincter in children in 1978.[2] Since then, most DV studies focused on the elimination syndrome and urinary tract infection (UTI) in children. Nonetheless, this phenomenon was also noted in women presenting with lower urinary tract symptoms (LUTS)[3] and is postulated to be a learned voiding dysfunction in adults.[4] Statistically significantly more mothers of children with overactive bladder (OAB) or DV reported having had similar symptoms in their childhood. When OAB of childhood persists into adulthood, it is likely to cause DV in the adult.[5]

Although DV is common in children and can be detected early in those with characteristic clinical presentations or recurrent UTIs, the differential diagnosis between DV and detrusor overactivity (DO) in adult women is difficult and can be inaccurate when based on LUTS alone. A video-urodynamic study (VUDS) is an examination combining voiding pressure, urine flow, and imaging studies during the voiding phase and can provide great help in differentiating DV from LUTS in women.[6] An accurate diagnosis of DV is essential in order to select correct treatment. Therefore, we analyzed the clinical presentations and VUD characteristics of women diagnosed with DV.

Patients and methods

This study was a retrospective analysis among a total of 1605 consecutive women with LUTS were analyzed from 1997 to 2010. All women who received VUD study had LUTS that could not be eradicated after medical treatment or physiotherapy for more than 3 months. The medical record charts were reviewed, and the clinical LUTS, comorbidities, VUD characteristics, urodynamic parameters, and result of treatment were recorded in detail. Patients with pelvic organ prolapse, genuine stress urinary incontinence, previous genitourinary surgery, history of genitourinary tract cancer, neurogenic voiding dysfunction, established diagnosis of interstitial cystitis/painful bladder syndrome, or active UTI were excluded. These female patients with LUTS received VUD study for diagnosis. The diagnosis was made according to International Continence Society (ICS) terminology.[7] If patients suffered from LUTS but normal in VUD study, they were considered as urodynamically normal and enrolled as control group.

The clinical symptoms of LUTS were recorded in detail. The main symptom was defined as the most bothersome symptom that drove patients to seek help. The LUTS recorded were also clustered into storage symptoms (including frequency, urgency, urgency incontinence, and nocturia), voiding symptoms (including hesitancy, difficult urination, slow stream, intermittency, terminal dribbling, and urine retention), pain symptoms (including painful sensation over bladder, urethra, or perineum), and post-micturition symptoms. Urinary retention was referred to the condition that patients could not urinate spontaneously and catheterization was necessary to evacuate the bladder.

VUD studies were performed using multichannel urodynamic equipment (Life-Tech, Houston, TX, USA) and a C-arm fluoroscope (Toshiba, Tokyo, Japan) prior to any treatment. The procedure was performed in the sitting position with a 6 Fr dual-channel urethral catheter for recording intravesical pressure and infusing warm normal saline containing 20% urograffin and an 8 Fr rectal balloon catheter to record the intra-abdominal pressure. The VUD study was performed at a filling rate of 20—30 ml/minute. The C-arm fluoroscope was positioned 45 degrees from the buttock so that the urethra could be lengthened and the bladder neck, urethral sphincter, and pelvic floor (distal) urethra could be clearly identified. Urethral sphincter electromyography (EMG) was recorded using surface patch EMG electrodes placed at the perianal area. The VUD study was repeated at least once to demonstrate reproducibility of the findings during the first examination. All descriptions and terminology of urodynamic parameters were in accordance with the recommendations of the International Continence Society.[7]

A voiding detrusor pressure (Pdet) at maximum flow rate (Qmax) of more than 35 cm H_2O was considered high Pdet,[8] 10—35 cm H_2O was considered normal Pdet, and 10 cm H_2O or less was considered low Pdet. DO was defined as evidence of spontaneous detrusor contractions occurring during bladder filling (phasic DO) or before uninhibited detrusor contraction, voiding at bladder capacity (terminal DO) during the urodynamic study. If patients had a strong desire to void at a cystometric bladder capacity (CBC) of less than 350 ml and without the occurrence of DO, they were considered to have increased bladder sensation. Bladder compliance was measured as the incrementally increased cystometric volume at full bladder sensation divided by the increased detrusor pressure.

The final diagnosis of DV was made based on the clinical symptoms and the main VUD findings. Patients with a stable bladder, normal bladder sensation, CBC $>$ 350 ml, normal detrusor Pdet, or low Pdet but a Qmax $>$ 15 ml/second, and PVR less than 10% of CBC were considered as urodynamically normal. The Qmax during VUDS was also compared to that in free uroflowmetry, the higher Qmax was adapted for final analysis. DV was diagnosed when high Pdet, intermittent or increased external sphincter EMG activity, and a "spinning top" urethral appearance on cinefluoroscopy during voiding occurred together. If patients were found to have a neurologic disease, they were classified as having external-detrusor sphincter dyssynergia but not DV.[9,10] The urodynamic parameters and clinical symptoms were compared between patients with DV and controls.

Comorbidities were recorded from the medical records, including gastrointestinal, skeletal muscular, autoimmunity, and other systemic disorders. The VUD characteristics were also compared between those with and without comorbidities.

Antimuscarinic or alpha-blocker treatment, with or without a skeletal muscle relaxant according to the chief complaint of storage or voiding symptoms, respectively, was given to patients with DV. Patients were treated for 1—3 months and the treatment results were recorded using

the validated 6-scale Patients Perception of Bladder Condition questionnaire.[11] An improvement in more than two scales on the questionnaire was considered a treatment success. The result of treatment in chart was reviewed and recorded for analysis.

The statistical analysis was performed using SPSS for Windows (Version 10.0, SPSS, Chicago, IL, USA). Student's *t*-test and chi-squared test were used to compare differences between the DV and control groups for continuous and categorical variables, respectively. A *p* value of less than 0.05 was considered statistically significant.

Results

Among the 1605 women with LUTS, 168 were diagnosed to have DV (10.5%) and 272 were classified as urodynamically normal and served as controls (16.9%). The mean age was 67.8 ± 18.1 years in the DV group and 58.9 ± 18.4 years in the control group ($p > 0.05$). Table 1 lists the urodynamic parameters of the DV and control groups. A significantly smaller CBC, higher Pdet, lower Qmax, larger postvoid residual volume, and lower bladder compliance occurred in the DV group compared to the control group ($p = 0.000$). Of the 168 patients with DV, 116 (69%) had DO and 22 (13.1%) had increased bladder sensation. All control patients had stable bladders.

Among patients with DV, urinary frequency ($n = 69$, 41.1%) was the most common chief complaint, followed by difficult urination ($n = 53$, 32.1%), and urgency incontinence ($n = 26$, 15.5%). A total of 114 (67.9%) patients had storage symptoms and 54 (32.1%) had voiding symptoms as their chief complaints among those with DV. The incidence of urgency incontinence and difficult urination were significantly greater than that in the control group, however, the incidence of frequency, urgency, or nocturia showed no significant difference between DV and control groups (Table 2).

When we compared the different types of LUTS between the DV and control groups, storage LUTS was present in 167 (99.4%) patients with DV and in the 270 (99.3%) control group. Voiding LUTS was present in 88 (52.4%) of patients in the DV group and 100 (36.8%) in the control group. Painful LUTS was present in 27 (16.1%) of DV patients and 72 (26.5%) of controls while postmicturition LUTS occurred in two (0.74%) of the control patients, but in no patient with DV. A significantly higher incidence of urgency, urgency incontinence, difficult urination, and bladder pain occurred in the DV group compared with the control group (Table 3).

Recurrent UTI was noted in 20 (12%) patients with DV. The most common co-morbidities were chronic constipation (27, 16.1%), lower back pain (13, 7.7%), and chronic obstructive pulmonary disease (COPD; 12, 7.1%). All patients with symptoms of storage LUTS as the chief complaint received antimuscarinic therapy and all patients with symptoms of voiding LUTS as the main complaint received alpha-blocker treatment with or without a skeletal muscle relaxant. The success rates were 41.2% ($n = 47$) for antimuscarinic therapy and 51.9% ($n = 28$) for alpha-blocker therapy in patients with storage and voiding LUTS, respectively ($p = 0.366$).

Table 1 Urodynamic parameters of DV and control patients.

	DV ($n = 168$)	Control ($n = 272$)	*p* value
CBC (ml)	286 ± 160	482 ± 100	<0.001
Pdet (cm H_2O)	49.1 ± 17.4	18.8 ± 8.98	<0.001
Qmax (ml/s)	11.3 ± 7.56	20.5 ± 7.95	<0.001
PVR (ml)	77.4 ± 113	25.7 ± 44.0	<0.001
Compliance (ml/cm H_2O)	63.0 ± 82.1	120 ± 121	<0.001
DO	116 (69%)	0	<0.001
IBS	22 (13.1%)	0	<0.001

CBC = cystometric bladder capacity; DO = detrusor overactivity; DV = dysfunctional voiding; IBS = increased bladder sensation; Pdet = detrusor pressure; Qmax = maximum flow rate; PVR = postvoid residual.

Table 2 Chief complaints of the DV and control patients.

	DV ($n = 168$)	Control ($n = 272$)	*p* value
Frequency	69 (41.1%)	100 (36.8%)	0.42
Nocturia	3 (1.8%)	5 (1.8%)	0.16
Urgency	16 (9.5%)	15 (5.5%)	0.13
Urgency incontinence	26 (15.5%)	13 (4.8%)	<0.001
Difficult urination	53 (32.1%)	54 (19.9%)	0.004
Urine retention	1 (0.6%)	3 (1.1%)	1.00
Residual sensation	0	3 (1.1%)	0.29
Terminal dribbling	0	1 (0.4%)	<0.001
Bladder pain	0	49 (18.0%)	<0.001
Micturition pain	0	4 (1.5%)	0.30

DV = dysfunctional voiding.

Discussion

The results of this study revealed that DV is highly prevalent in women with LUTS. The incidence of DO (69%) and

Table 3 Types of LUTS in DV and control patients.

	DV ($n = 168$)	Control ($n = 272$)	*p* value
Storage LUTS	167 (99.4%)	270 (99.3%)	0.16
Frequency	158 (94.0%)	260 (95.6%)	0.50
Urgency	147 (87.5%)	163 (60.0%)	<0.001
Urgency incontinence	58 (34.5%)	34 (12.5%)	<0.001
Nocturia	11 (6.5%)	116 (42.6%)	<0.001
Voiding LUTS	88 (52.4%)	100 (36.8%)	0.002
Difficult urination	85 (50.6%)	83 (30.5%)	<0.001
Urine retention	7 (0.42%)	8 (2.9%)	0.59
Residual sensation	4 (0.24%)	16 (5.9%)	0.24
Postmicturition LUTS			
Terminal dribbling	0	2 (0.74%)	0.53
Pain LUTS	27 (16.1%)	72 (26.5%)	0.013
Bladder pain	23 (13.7%)	64 (24.6%)	0.02
Micturition pain	3 (0.18%)	8 (2.9%)	0.54

DV = dysfunctional voiding; LUTS = lower urinary tract symptoms.

increased bladder sensation (13.1%) was also higher in DV group compared with the control group. In conjunction with smaller CBC and the presentation of storage symptoms in all women, we postulated that part of patients with DV might be a voiding dysfunction originating from sensory urgency or DO.

DV was previously considered as a voiding dysfunction due to abnormal coordination of the urethral sphincter during micturition. A high incidence of urodynamic DO is reported in patients with DV[9] and in this study. DO could occur primarily or secondarily to bladder outlet obstruction (BOO). Previous studies reported that 48%–53% of men with LUTS had urodynamically proven BOO, and among them, DO was noted in 55%.[9,12,13] Bael *et al*[14] suggested that BOO in women and children was not common but the prevalence of DO in these two patient groups was high. Treatment of OAB symptoms or DO by an antimuscarinic agent alone or in combination with behavior modification have been reported successful.[15,16]

Our study showed a significantly higher incidence of DO, smaller CBC, lower Qmax, larger postvoid residual volume, and higher Pdet in patients with DV compared to those of the control group. These urodynamic parameters indicate that the vesicourethral abnormalities of DV are not only due to BOO, but also exhibit sensory disorders. In patients with DV, urinary frequency was the most bothersome symptom and nearly all patients had storage symptoms (urgency, nocturia, urgency incontinence). Although difficult urination was also a chief complaint in 32.1% of patients with DV, all these patients had storage LUTS as their associated symptoms. These findings suggest that sensory dysfunction, either primary or secondary to urethral sphincter dysfunction, plays an important role in the pathophysiology of LUTS and the development of DV.

The relationship of bladder overactivity and DV are not clearly elucidated. Investigations based on male adults with benign prostatic obstruction revealed that DO was induced after BOO via multiple different pathways.[17–19] We found that urodynamic DO was present in 69% of patients with DV. High Pdet and narrow urethral sphincter appearance during VUD are not sufficient to suggest that DO is secondary to BOO in women with DV. Interestingly, all DV patients had storage symptoms and about half of the patients with primary storage symptoms were successfully treated with antimuscarinics. These results suggest that DO could be a one of etiology of DV in adult women. A longer treatment course might improve the success rate.

Normal voiding in neurologically intact humans is a complex process. Micturition is triggered by the release of tonic inhibition from the suprapontine centers and release of the trigger signal from the pontine micturition center. Relaxation of the urethral sphincter and pelvic floor muscle via the pudendal and hypogastric nerve innervations are important in the micturition cycle. Adequate relaxation of these muscles results in sustained bladder detrusor muscle contraction. If the coordination between the pelvic floor-external sphincter complex and the detrusor muscle is disturbed, DV may ensue.

DV is suggested to result from a learned behavioral disturbance in early childhood and may be treated by re-educational therapy.[20] Under this consideration, DO might also be a trigger factor for DV if patients used to hold back urine at each urgency episode. Long-term increase of the urethral sphincter activity caused by a reflex inhibitory response to the occurrence of DO could result in spasticity of the urethral sphincter and finally, functional BOO appearance during voiding. One previous study showed that both the pubococcygeal muscle and external urethral sphincter contributed to DV.[21]

Diagnosis of DV should take the following clinical characteristics into consideration: (a) clinical history and difficulty in voiding; (b) intermittent free urine flow pattern; and (c) the exclusion of neurologic disorders or anatomical abnormality of the bladder outlet.[4] Although cystoscopy, bladder wall thickness, and pressure flow studies could help with the diagnosis of DV, the definitive diagnose should only be made by the demonstration of typical external sphincter contraction during micturition during a sphincter EMG study[22,23] or fluoroscopic visualization of the "spinning top" urethra sign during voiding.[24]

VUD study provides advantages for visualization of bladder outlet narrowing during voiding with high Pdet. During voiding cystourethrography, the VUD characteristics of DV are a wide open bladder neck and a dilated proximal urethra to the level of the external sphincter, which can be clearly differentiated from the primary bladder neck dysfunction or urethral stricture in female BOO.[24,25] Although VUD studies are effective tools for evaluations of patients with LUTS, Soygur[26] suggested that a detailed voiding history and physical examination were sufficient for a correct diagnosis of DV in children.

Previous studies reported 2%–25.5% prevalence of DV in women with LUTS.[27,28] The prevalence of DV (10.5%) in this study was similar to those in previous reports. Interestingly, we also found several comorbidities in patients with DV, including chronic constipation, lower back pain, and COPD. Chronic constipation occurs frequently in children with voiding dysfunction.[29] Chronic spasticity of pelvic floor muscles may result in DV and constipation in adult women as well. UTI could also be a complication if DV is left untreated.

In our analysis, more patients with DV presented with difficult urination (32.1%, $p < 0.05$) and urgency incontinence (15.5%, $p < 0.05$) as their main symptoms than the control group (19.9% and 4.8%, respectively). If we compared all clusters of symptom types, significantly increased incidence of urgency (87.5%), urgency incontinence (34.5%), and difficult urination (50.6%) occurred in patients with DV than controls. Interestingly, patients with DV were less likely to have nocturia than controls. Additionally, when patients presented with difficult urination as the chief complaint, the incidence that urgency was also an associated symptom was significantly higher in DV than control (77.8% vs. 37.0%, $p < 0.05$). Difficult urination combined with urgency seemed to be predictive symptoms of DV before any urodynamic survey was performed. This result needs further investigation to clarify the pathophysiologic link between difficult urination and urgency in patients with DV.

The first-line treatment of DV based on patients' main presenting symptoms was attempted in this study. Although 41.2% of patients were satisfied to antimuscarinic therapy, 51.9% of the patients were satisfied with alpha-blocker therapy in patients with storage and voiding LUTS, respectively. Because most of the patients with DV had

both storage and voiding symptoms and the UDS showed high voiding pressure in these patients, combined alpha-blocker and antimuscarinics might provide a better result in treatment of LUTS in DV. In patients who failed medical treatment, urethral sphincter botulinum toxin A injection provides an alternative treatment option. Patients with voiding dysfunction due to pseudodyssynergia or non-relaxing urethral sphincter can be treated with 50—100 U urethral onabotulinumtoxinA (BoNT-A) injection.[30] Urethral BoNT-A injections can be performed in the operation room under light intravenous general anesthesia (in men) or at out-patient clinic without anesthesia (in women). A dose of 100 U BoNT-A is adequate for patients with dysfunctional voiding or poor relaxation of the urethral sphincter.[30]

Limitation of this study is lack of associated questionnaire used for grading the severity of LUTS in this retrospective study.

Conclusion

LUTS storage symptoms, urodynamic DO, and VUD study features of BOO were present in most women with DV. Treatment with antimuscarinics or alpha-blockers resulted in symptomatic relief. A definitive diagnosis of DV could not be made based on LUTS alone; VUD studies are better diagnostic tools for accurate diagnosis of DV in women.

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