Original Article

Plateau pattern of detrusor contraction: A surrogate indicator of presence of external sphincter dysfunction during micturitional phase of urodynamic study

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ABSTRACT

Introduction: Dysfunctional voiding results from a disturbance in the coordination between sphincter relaxation and detrusor contraction. Video urodynamic studies with electromyography (EMG) are used for diagnosis but have limitations of availability and interpretation. We identified a plateau type voiding detrusor pressure tracing pattern in these patients with a potential of helping diagnosis.

Materials and Methods: Urodynamic data and tracings of adult patients having been diagnosed with external urethral sphincter dysfunction (EUSD) were retrospectively analyzed. The urodynamic studies comprised of pressure flow studies, micturitional urethral pressure profilometry, and voiding cystourethrogram (VCUG). Diagnosis of EUSD was based on the presence of intermittent or continuous narrowing in the region of EUS on VCUG along with a urethral-vesical pressure gradient of >20 cmH_2O in males and >5 cmH_2O in females.

Results: A total of 25 patients (14 men and 11 women) with a mean age 36.6 ± 16.5 years, presented with lower urinary tract symptoms (international prostate symptom score 18 ± 5) and were diagnosed with EUSD on urodynamics/cystourethrography. The cause of EUSD was neurogenic DESD in four, dysfunctional voiding in 20 and voluntary pelvic floor squeeze in one. Resting maximum urethral closure pressure at EUS was 142.2 ± 38.3 cmH_2O in both sexes. Three patients had detrusor overactivity. EMG activity during voiding was high in 10 patients, low in three, inconclusive in seven, and not performed in three. A "plateau type pattern" of detrusor contraction was observed in all the patients. This was qualitatively different from the roughly bell-shaped curve of detrusor contraction in men with prostatic obstruction ($n = 14$) and women with stress urinary incontinence ($n = 11$).

Conclusions: Patients with EUSD have a characteristic plateau pattern of detrusor contraction on urodynamics which can be used as a surrogate for urodynamic diagnosis of nonrelaxing EUSD.

Key words: Detrusor contraction, detrusor sphincter dyssynergia, external sphincter nonrelaxation, plateau pattern, urethral pressure profilometry

INTRODUCTION

Normal voiding is the result of a highly coordinated sphincter relaxation closely followed by detrusor contraction. It is controlled by several autonomic and somatic pathways organized as simple on-off switching circuits that maintain a reciprocal relationship between the urinary bladder and the urethral outlet. Any disturbance in this fine coordination would lead to a range of lower urinary tract symptoms (LUTS). The classical example of such disturbance is detrusor-external sphincter dyssynnergia

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(DSED), seen typically in patients with suprasacral spinal cord injury.[1] Neurologically intact individuals may also suffer from presumably acquired voiding dysfunction resulting from nonrelaxation of external sphincter during detrusor contraction. Voiding dysfunction secondary to nonrelaxing external urethral sphincter (EUS) due to any etiology (neurogenic/nonneurogenic), is difficult to diagnose using the standard pressure flow study (PFS) and are commonly diagnosed by video urodynamic studies (VUDS) supported by electromyographic study (EMG) of pelvic floor. Perineal surface EMG is not always conclusive particularly when the patient has to strain to void; since it represents the overall activity of pelvic floor. VUDS set-up is elaborate and expensive, and not universally available; Abrams[2] has suggested that a separately done voiding cystourethrography (VCUG) can give clinically relevant results similar to VUDS when interpreted in conjunction with UDS. Jain *et al*.[3] found a strong correlation of separately done VCUG and urodynamic diagnosis of bladder outlet obstruction.

Detrusor contraction curve is defined as a crescendo-decrescendo type bell-shaped curve, resulting in a bell-shaped voiding flow pattern. In patients with prostatic obstruction, the terminal phase of this curve tends to prolong due to slow voiding. During Urodynamic (UDS) evaluation of patients with voiding dysfunction, we identified a plateau type voiding detrusor pressure tracing pattern in patients who were diagnosed to have EUS dysfunction (EUSD).

MATERIALS AND METHODS

In an observational study conducted between 2010–2014, adult individuals with voiding dysfunction, who underwent multichannel UDS and diagnosed to have voiding symptoms secondary to EUSD were included. The UDS comprised PFS, micturitional urethral pressure profilometry (MUPP), and VCUG and was conducted using Solar Silver digital urodynamic machine with neuro module (Medical Measurement System, Enschede, the Netherlands).

Preparation for UDS was as per standard practice. A sterile urine culture was ensured before the study. Patients not dependent on urinary catheter were asked to report with comfortably full bladder for study.

Methodology

UDS was performed in accordance with the Good Urodynamic Practice Guidelines laid down by the International Continence Society (2002).[4] Briefly, a catheter-free uroflowmetry was performed first. Multichannel UDS was then performed using 7Fr triple lumen UPP catheter for measurement of vesical (Pves) and urethral pressures (Pura), and 5Fr balloon-rectal catheter for measuring abdominal pressure (Pabd). Pelvic floor EMG was performed using perineal surface electrode. During the filling phase, resting UPP was performed, and bladder was filled until maximum cystometric capacity was reached. At this time, the infusion was interrupted, and the patient was asked to void. Once the flow was initiated and established, the catheter was pulled using the puller and urethral pressure profile was recorded during voiding phase. The pattern of detrusor contraction during voiding in these patients was studied.

After completion of UDS, the patients were shifted to fluoroscopy suite next door for cystourethrography. The whole procedure was monitored with fluoroscopic surveillance and spot films were taken as appropriate.

Diagnosis of EUSD was based on VCUG findings showing presence of narrowing in the region of EUS during voiding, along with MUPP findings of urethral-vesical pressure gradient of >20 cmH_2O in males[3,5] and >5 cmH_2O in females[6] at EUS level. In case of a discrepancy, VCUG was considered as the gold standard. Voiding detrusor pressure tracing pattern in these patients was studied and compared with that of an equal number of patients with prostatic obstruction. The plateau pattern was described as a steep rise of Pdet and maintaining the same level for most of the micturitional phase; the plateau could be flat or irregular shaped. In any case, the pattern had to be significantly distinguishable from crescendo-decrescendo bell-shape curve defined for prostatic obstruction.

RESULTS

A total of 25 patients (14 men and 11 women) with a mean age 36.6 ± 16.5 years with LUTS (international prostate symptom score 18 ± 5) were diagnosed with EUSD on UDS/VCUG. Details of urodynamic data are depicted in Table 1. Ten patients had associated constipation. The cause of EUSD was neurogenic DESD in four, dysfunctional

Table 1: Clinical and urodynamic parameters of patients (*n*=25)

Parameters	Mean±SD	Minimum	Maximum
Age (years)	36.6±13.6	14	65
IPSS	18±5	9	25
Qmax (mL/s)	7.1±4.5	2	16
VV (mL)	192.7±151.7	31	516
DCI	87±36	55	156
Pdet at Qmax (cmH_2O)	52.8±29.0	22	121
Pdet.max (cmH_2O)	61.0±32.3	26	140
Resting MUCP (cmH_2O)	142.2±38.4	84	228
Pura-Pves (cmH_2O)	−44.5±21.6	−90	−17

IPSS=International prostate symptom score, SD=Standard deviation, Pdet.max=Maximum micturation detrusor pressure, VV=Voided volume, DCI=Detrusor contraction index, MUCP=Maximum urethral closure pressure, Pves=Vesical pressures, Pura=Urethral pressures

voiding in 20, and voluntary pelvic floor squeeze in one. The latter patient had severe left flank pain during voiding, which led him to squeeze pelvic floor in an effort to abort voiding; he was diagnosed with bladder neck obstruction with left vesicoureteral reflux [Figure 1]. He was successfully treated by bladder neck incision.

Resting maximum urethral closure pressure at EUS was 142.2 ± 38.3 cmH_2O in both sexes. Four patients had detrusor overactivity. EMG activity during voiding was high in 10 patients, low in three, inconclusive in seven, and not performed in five. All patients diagnosed to have EUSD had plateau-pattern of detrusor contraction smooth (n = 16) or irregular (n = 9) [Figure 2].

Detrusor pattern of 14 male patients with prostatic obstruction and 11 female patients with stress urinary incontinence and pelvic organ prolapse was studied as a comparator for respective groups. All the comparators had bell-shaped detrusor contraction, smooth or rough [Figure 3].

DISCUSSION

During the study period of 4 years, 25 patients were diagnosed as having EUSD, neurogenic (4) or nonneurogenic (21). All of these had a plateau detrusor pattern, regular or irregular, significantly distinguishable from the bell-shaped pattern seen in patients with prostatic obstruction or stress urinary incontinence. This plateau detrusor pattern can be objectively understood as a voiding detrusor pressure pattern wherein the maximum micturation detrusor pressure (Pdet.max.) is almost equal to opening micturation detrusor pressure (Open.Pdet.). In accordance with our extensive search of English literature, both standard text books, as well as peer-reviewed journals, we could not find any description of detrusor pattern.

Voluntarily initiated micturition includes inhibition of the somatic neural efferent activity to the striated sphincter closely followed by stimulation of efferent parasympathetic pelvic nerve responsible for a highly coordinated contraction of bladder smooth musculature. Central pathways controlling lower urinary tract function are organized into a simple on-off switching circuits that maintain a reciprocal relationship between the urinary bladder and the urethral outlet. Micturition is facilitated to completion by a urethra-to-bladder reflex; wherein distension of membranous urethra by urine is considered to stimulate the bladder contraction.[1] Conversely, contraction of the sphincter would tend to inhibit detrusor contraction through activation of the central inhibitory pathways. We hypothesize, that in patients with nonneurogenic pelvic floor dysfunction, incomplete relaxation of EUS is likely to interfere with this facilitatory urethra-to-bladder reflex. This sum of opposing influences between the facilitatory and

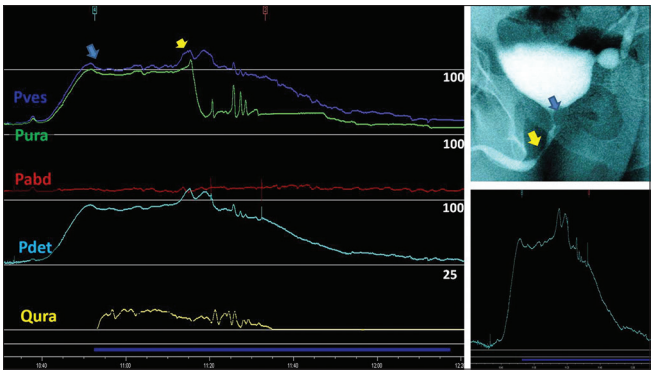

Figure 1: Micturitional urethral pressure profilometry of a 34 years man with difficulty in urination with pain left flank during micturition. It shows double obstruction, both at bladder neck as well as external urethral sphincter corroborating with cystourethrography. A close look at detrusor contraction suggests a plateau type pattern at the peak of contraction; during urethral pressure profilometry, he developed severe pain making him squeeze the external urethral sphincter voluntarily trying to abort the micturition

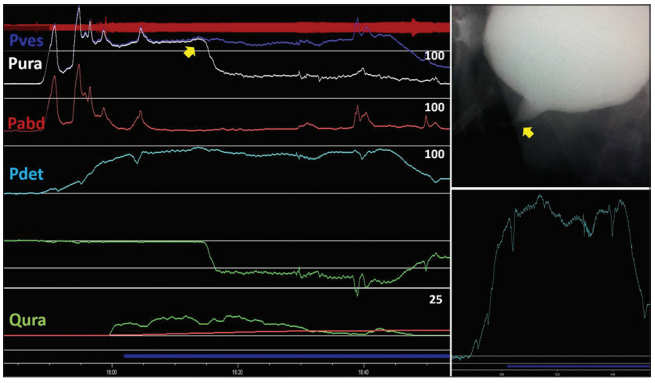

Figure 2: Micturitional urethral pressure profilometry of a 39 years woman with difficulty in urination with frequency showing the presence of obstruction at external sphincter zone corroborating with micturatingcystourethrography (solid yellow arrow). A close look at detrusor contraction suggests a plateau type pattern (irregularly flat)

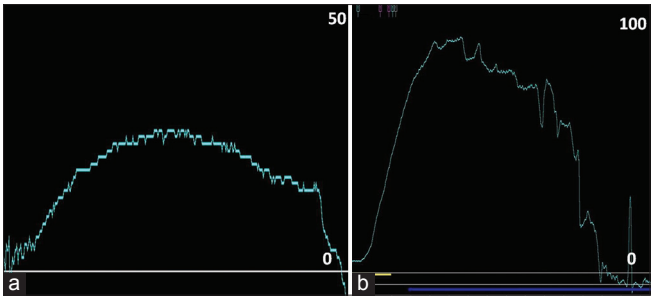

Figure 3: Detrusor pressure tracings of (a) 35-year-old lady with mixed urinary incontinence, (b) 69-year-old man with prostatic obstruction. Bell-shaped curves can be noted

inhibitory reflexes may be a plausible cause leading to sudden flattening of the detrusor pressure as soon as mictiration starts, leading to this peculiar plateau pattern [Figure 4].

Inhibitory urethra-to-bladder reflex has been used to inhibit detrusor overactivity in patients presenting with overactive bladder.[7] Conversely, inhibition of pelvic floor activity by injecting botulinum toxin A into the external sphincter

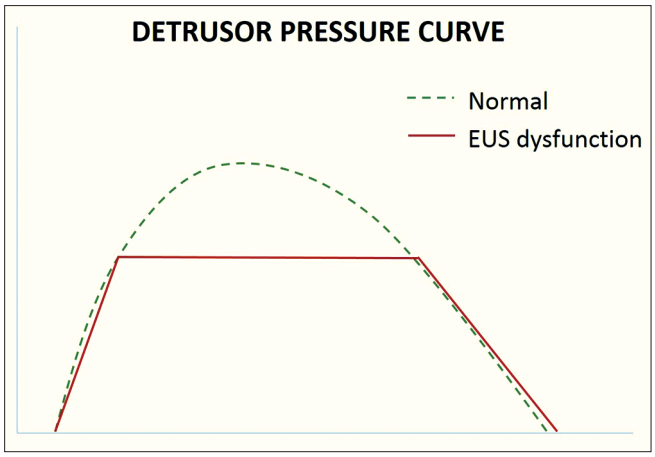

Figure 4: Line diagram showing difference between bell-shaped and plateau curve of detrusor contraction

has been employed to improve voiding characteristics in patients with pelvic floor dysfunction with detrusor underactivity.[8] In fact, Kuo observed the return of detrusor activity in one of 20 patients after the injection supporting the hypothesis of inhibition of inhibitory urethra-to-bladder reflex. Neuromodulation also has been used successfully in patients with pelvic floor dysfunction and modulation of this reflex rather than the direct stimulatory effect on detrusor has been postulated.[9]

As depicted in Figure 2, one of our patients squeezed pelvic floor due to pain during voiding. He had high-pressure low-flow voiding pattern with irregular plateau pattern. It is plausible that due to voluntary contraction of the pelvic floor, an inhibitory urethra-to-bladder reflex was initiated which conflicted with detrusor contraction. Kuo noticed that poor relaxation of the urethral sphincter could inhibit normal detrusor contractility and result in low pressure and low-flow voiding dysfunction.[8] The author and others later found that Botox injection into EUS leads to reversal of this inhibition with the recovery of detrusor function in a large proportion of patients.[8,10,11]

VUDS and EMG of the pelvic floor are the established methods for the diagnosis of EUSD. Interpretation of EMG is mainly restricted to recording of progressively increasing activity during bladder filling and relaxation of the pelvic floor during voiding. However, surface EMG is not always conclusive and subjected to artifacts especially in patients who strain to void but relax the urethral sphincter simultaneously.[12,13] VUDS is currently the most accurate investigation to diagnose EUSD, and it is used to confirm sphincteric dysfunction diagnosed by EMG.[14] However, VUDS is not widely available at all centers, like ours. Therefore, we perform dynamic VCUG and correlate findings with those of UDS. Plateau detrusor pattern can serve as a surrogate finding to suspect and diagnose EUSD.

As the incidence of EUSD is not very common, our study is limited by its retrospective nature and small data. But these results have encouraged us to perform a further large prospective study to validate our results and to develop an objective criteria to diagnose this condition.

CONCLUSION

Patients with EUSD have a characteristic plateau pattern of detrusor contraction on urodynamics that can be used as a surrogate for urodynamic diagnosis of nonrelaxing EUSD.

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Conflicts of interest
There are no conflicts of interest.

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