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Original Article

Monitoring bladder compliance using end filling detrusor pressure: Clinical results and related factors

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ABSTRACT

Objective: To assess the clinical significance of low compliance bladder (LCB) in women with lower urinary tract symptoms.
Materials and Methods: Medical records of 1490 women undergoing videourodynamic studies (VUSs) were reviewed. Comprehensive medical histories, physical examinations, bladder diaries, and results of multichannel VUS were analyzed. This study adopted an end filling detrusor pressure (EFP) greater than 20 cmH_2O to define LCB.
Results: Among the study patients ($n = 1490$), 9.1% were diagnosed with LCB using a cutoff value of 17.5 cmH_2O, which had a sensitivity and specificity of 89% and 92.7%, respectively. Results of multivariate analysis indicated that age ($p = 0.005$), maximum cystometric capacity (MCC; $p = 0.002$), detrusor overactivity (DO; $p = 0.001$), pelvic organ prolapse (POP; $p = 0.018$), recurrent urinary tract infection ($p = 0.001$), and radical abdominal hysterectomy (RAH; $p < 0.001$) as independent prognostic factors. Furthermore, our study results indicate that the MCC, urinary tract infection, and a history of RAH have a positive correlation with LCB, whereas, age, POP, and DO have a negative correlation with LCB.
Conclusion: Our idea using EFP ($\geq$17.5 cmH_2O) for screening women with LCB is feasible for clinical use.

Introduction

The functions of urinary bladder are not only storage of urine and emptying but at a higher level, also maintaining the relatively low intravesical pressure [1]. An increase in intravesical pressure, for whatever reason, is universally accepted to be a major factor in disorders of compliance and as clinical experience has demonstrated increased intravesical pressure plays a major role in deterioration of the upper urinary tract and the appearance of voiding disorders with severe repercussion on quality of life [2].

Bladder compliance, which describes the relationship between change in bladder volume and change in detrusor pressure ($\Delta V/\Delta P$) [3], is generally regarded as a measure of bladder dispensability and the key determinant of the upper urinary tract deterioration in clinical interpretation. Decrease of the compliance may be seen in some pathological conditions such as infection or fibrosis (e.g., radiation, Foley indwelling, obstructive uropathy, or neurogenic bladder). At present, this is no golden standard to diagnose low compliance bladder (LCB) in women and this is the primary reason for conducting this study. The normal range for bladder compliance in adults has not yet been validated and previous reports suggested it to be above 12.5–40.0 mL/cmH_2O [4,5]. Bladder compliance below this range is usually considered to indicate LCB. However, in clinical practice, physicians are unable to read the bladder compliance data from the screen while performing urodynamic studies, and thus have to wait until the end of the study to investigate the data which are printed out in sheets. Fortunately, the end filling detrusor pressure (EFP) could be a potential alternative in this regard, which is easier to measure and does appear on cystometry more readily. Therefore, this study adopted an EFP greater than 20 cmH_2O, a cutoff commonly used in clinical practice, to define LCB [6].

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A previous report [7] proposed that LCB was correlated with the presence of neurological conditions, and thus the goal of this study was to investigate the clinical significance of LCB. For this purpose, we collected and compared the correlation between patients' clinical data and the results of videourodynamic studies (VUSs).

Materials and methods

Study design

A retrospective analysis was performed in 1490 women who had received VUS to evaluate the cause of lower urinary tract symptoms (LUTSs) between January 2005 and December 2010. All the clinical data and VUS results were recorded in a prospective setting using the same protocol. The main indications for VUS included women with voiding dysfunction [8], urinary incontinence [for women who failed to respond to conservative treatment (e.g., medications, physiotherapy)], pelvic organ prolapse (POP; greater than Stage II of the POP-Q system [9]), recurrent urinary tract infection (RUTI), and neurogenic bladder. We defined RUTI as follows: either three or more symptomatic UTI episodes in the past year or two such episodes in the past 6 months [10]. Neurogenic bladder, which refers to dysfunction of the bladder due to disease of the central nervous system or peripheral nerves, in our patients most likely referred to women with diabetes mellitus (DM), a history of cerebrovascular accident, or spine surgery or radical abdominal hysterectomy (RAH).

The Institutional Review Board of Chang-Gung Memorial Hospital approved the chart evaluation of this retrospective study. In brief, the study protocol is as follows: First, all patients underwent a face-to-face structured interview that included questions related to their age, parity, medical illness, and previous surgery. Drug history was also obtained to exclude the cause that may aggravate the symptoms. Physical examination included height, weight, and pelvic examination to detect the presence of POP.

Digital examination and pinprick test were performed to assess the S2–S4 dermatome. Patients with abnormal neurological sign such as Babinski sign during pelvic examination or unsteady gait were assessed for the underlying diseases. All women in the study group had baseline assessment including urinalysis, postvoid residual (PVR) checked by an ultrasonic bladder scan (BVI 3000; Diagnostic Ultrasound Corporation, Bothell, WA, USA), and a bladder diary.

Second, in all cases only one physician (LHT) performed the VUS throughout the study period using the same protocol (UD-2000; Medical Measurement System, Enschede, The Netherlands), which complied with the guidelines of the International Continence Society (ICS) [1], and all the terms used in this study followed the ICS guidelines. A 4-Fr double lumen catheter (Medical Measurement Systems) was inserted into the bladder and a 10-Fr rectal catheter (Medtronic, Skovlunde, Denmark) was inserted into the rectum. VUS was performed according to the standard protocol. Data on VUS included uroflowmetry [maximum free flow rate, voided volume (VV1), and PVR], filling cystometry [first desire, maximum cystometric capacity (MCC), and EFP], and voiding cystometry [maximum flow rate (Q_{max}), detrusor pressure at maximum flow (VP), and voided volume (VV2)].

Uroflowmetry, filling, and voiding cystometry were performed using a Dantec Menuet (Dantec Medical A/S, Skovlunde, Denmark) multichannel urodynamic machine in combination with a C-arm imaging system (GE OEC 9800). All data were recorded and analyzed using the Dantec Menuet (Dantec Medical A/S) multichannel urodynamic machine.

Statistical analysis

Values were presented as mean ± standard deviation. All variables were tested for normal distribution using the Kolmogorov–Smirnov test. The Student *t* test was used to compare the means of continuous variables and normally distributed data; otherwise, the Mann–Whitney *U* test was used. Categorical data were tested using the Chi-square test on the variables that evaluated differences between groups as appropriate. The risk factors for LCB were assessed by univariate analysis initially. The statistically significant ($p < 0.05$) variables obtained by the univariate analysis were used for multivariate analysis. Multivariate analysis was performed by multiple logistic regression applied based on forward data elimination. Calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test (C statistic). Discrimination was assessed using the area under a receiver operating characteristic curve (AUROC). Areas under two AUROC curves were compared by a nonparametric approach. Finally, the cutoff point was calculated by acquiring the best Youden index (sensitivity + specificity − 1) [11], which is a global measure of a test performance used for the evaluation of overall discriminative power of a diagnostic procedure and for comparison of this test with other tests. All statistical tests were two-tailed and data were analyzed using SPSS 19.0 for Windows software (SPSS, Inc., Chicago, IL, USA). A value of $p < 0.05$ was considered significant.

Results

Patient characteristics

Of the 1490 VUS performed consecutively, 136 women [9.1% (mean age 56; mean parity 3)] diagnosed as a case of LCB based on our definition (i.e., EFP > 20 cmH_2O) were chosen for further analysis. Among the study patients ($n = 1490$), 939 (63%) were postmenopausal women. The main indications for VUS included women with voiding dysfunctions (385, 25.8%), urinary incontinence (374, 25.1%), POP (275, 18.5%), RUTI (171, 11.5%), and neurogenic bladder (285, 19.1%). Table 1 presents patients' demographic data and the clinical characteristics of LCB. Women in the LCB group seemed to have higher residual urine (168 mL vs. 104 mL, $p < 0.001$) and higher prevalence of RUTI (22.3% vs. 11.5%, $p < 0.001$). They were also more likely to have received the intermittent catheterization program (ICP) (12.5% vs. 10.4%, $p < 0.001$); besides, the incidence of vesicoureteral reflux (VUR) was also higher in this group (12.2% vs. 9.7%, $p < 0.001$).

The risk factors for LCB were assessed by univariate analysis initially. Using multivariate analysis, the following were identified as prognostic factors with a statistical significance (Table 2): age ($p = 0.005$), MCC ($p = 0.002$), EFP ($p = 0.028$), detrusor overactivity (DO; $p = 0.001$), POP ($p = 0.018$), RUTI ($p = 0.001$), and RAH ($p < 0.001$). Furthermore, we found that MCC, EFP, RUTI, and RAH have a positive correlation with the LCB, whereas age, POP, and DO have a negative correlation with the LCB.

The logarithm of odds of LCB is as follows: $1.094 - 0.018 \times \text{age} + 0.001 \times \text{MCC} + 0.003 \times \text{EFP} + 0.471 \times \text{RUTI} - 0.475 \times \text{DO} + 1.144 \times \text{RAH} + 0.599 \times \text{POP}$

Calibration and discrimination for illness scoring systems

The illness scoring systems (ISSs) can be used to compare groups of patients in research trials or predict mortality and prognosis for individuals and groups. The ISS can also measure physiological variables derived from logistic regression from large demographic data sets as in our study. The ISSs provide calibrated and validated data, high level of discrimination, and can also indicate prognosis