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Urodynamic Characteristics of Female Patients with Lower Urinary Tract Symptoms and Concomitant Primary Bladder Stones

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Abstract | **Original Research Article**

Objective: To investigate the urodynamic characteristics and independent risk factors of female primary bladder stones (FPBS) in patients with lower urinary tract symptoms (LUTS). ***Methods:*** A case-control study was conducted at Shaoyang Central Hospital from June 2018 to June 2025. A total of 15 female patients diagnosed with LUTS and concomitant FPBS were enrolled as the LUTS+FPBS group, and 15 age-matched female patients with isolated LUTS during the same period were randomly selected as LUTS group. Sonography videourodynamic studies (SVUDS) parameters were compared between the two groups. Multivariate logistic regression analysis was performed to identify independent risk factors for FPBS. ***Results:*** The LUTS+FPBS group had higher maximum detrusor pressure (Pdet.max), and bladder outlet obstruction index (BOOI), as well as a lower maximum flow rate (Qmax) compared with LUTS group (all $P < 0.05$). Multivariate logistic regression analysis confirmed that lower Qmax (OR = 0.61, 95% CI: 0.41–0.91, P = 0.016) was independent risk factors for FPBS. ***Conclusion:*** Bladder outlet obstruction plays an important role in formation of FPBS and Qmax could be considered a potentially and non-invasively independent risk factor for FPBS formation. However, more sample and prospective multicenter studies will be needed in the future.

Keywords: Female Primary Bladder Stones; Lower Urinary Tract Symptoms; Sonography Videourodynamic studies; Bladder Outlet Obstruction.

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1. INTRODUCTION

Female bladder stones are a rare urological disorder, accounting for only 5% of all bladder stone cases worldwide, and the vast majority are female primary bladder stones (FPBS). The etiology of FPBS is multifactorial, involving anatomical abnormalities, endocrine disorders, pathophysiological changes, and lifestyle factors [1]. Patients with FPBS typically present with lower urinary tract symptoms (LUTS), including urinary frequency, urgency, and voiding difficulty. Notably, a significant proportion of patients experience persistent or recurrent LUTS even after complete surgical stone clearance, indicating that isolated lithotripsy fails to address the underlying bladder dysfunction [2].

Videourodynamic studies (VUDS) is the gold standard for evaluating lower urinary tract function, which allows statistically and vividly quantitative assessment of stability and contractility of detrusor [3][4]. It can accurately identify key pathological states such as impaired bladder emptying (PVR ≥ 50 mL), detrusor-sphincter dyssynergia, and functional bladder outlet obstruction, by which the etiology of FPBS could be explored [5]. Previous studies have predominantly focused on the association between metabolic syndrome and urinary calculi, while there has been little investigation of FPBS, using urodynamic studies, in the literature. Therefore, this study aimed to compare urodynamic parameters between female LUTS patients with and without FPBS to clarify to some extent the pathogenesis of FPBS using sonography videourodynamic studies (SVUDS).

2. SUBJECTS AND METHODS

2.1 Case Data

15 female patients diagnosed with LUTS and concomitant FPBS at the Department of Urology, Shaoyang Central Hospital from June 2018 to June 2025 were enrolled as the LUTS+FPBS group. During the same period, 15 age-matched female patients with LUTS alone (without FPBS) were randomly selected as the LUTS group.

2.2 Diagnostic and Exclusion Criteria

2.2.1 LUTS: Persistent storage, voiding, or post-micturition symptoms that significantly affect daily life.

2.2.2 FPBS: Bladder calculi confirmed by urinary tract ultrasound or abdominal computed tomography; exclusion of stones migrated from the upper urinary tract, organic lower urinary tract lesions (urethral stricture, bladder diverticulum, pelvic organ prolapse, etc.), and prior bladder stone surgery.

2.2.3 Inclusion and Exclusion Criteria

2.2.3.1 Inclusion criteria: ①Patients meeting the diagnostic criteria for LUTS and FPBS; ②Complete preoperative urodynamic data; ③obtained informed consent.

2.2.3.2 Exclusion criteria: History of urological surgery, long-term intravesical foreign bodies (indwelling catheters, ureteral stents), and incomplete clinical data.

2.3 Sonography videourodynamic studies Protocol

The SVUDS combined an ultrasound scan with multichannel UDS (Aquarius XT, Laborie, USA) and could synchronously integrate urodynamic measurement values with sonographic images sequences by Aquarius XT own software (UDS.V14, Laborie, USA). Prior to the examination, patients were instructed to empty bladder. In the lithotomy position, routine disinfection and draping were performed. A digital color ultrasound system was employed for transabdominal scanning to acquire measuring bladder wall thickness (BWT). A 7F dual-lumen catheter was then inserted transurethrally, and a single-lumen catheter was placed rectally to measure abdominal pressure. After calibration, all catheters were securely connected to the urodynamic equipment. Room-temperature saline was infused into the bladder at 25–50 mL/min for pressure-flow studies until the patients reached the feeling of strong voiding desire, and then patients was instructed to void into a flowmeter, in which maximal detrusor pressure (Pdet.max), maximal flow rate (Qmax), and bladder outlet obstruction index (BOOI) were obtained during pressure-flow studies and post-void residual (PVR) was measured after voiding.

2.4 female bladder outlet obstruction (BOO) diagnosis

Female BOO was diagnosed using the Blaivas-FBOO nomogram, which corrects urinary flow rate based on voided volume and reduces false-positive results caused by low-volume voiding [6].

2.5 Statistical Analysis

Data analysis was performed using SPSS 27.0. Normally distributed continuous variables were expressed as "mean ± standard deviation", and non-normally distributed data as "median (interquartile range)". For normally distributed data, group comparisons used ANOVA followed by independent samples t-test (if variances were homogeneous); non-normally distributed data were analyzed using the Mann-Whitney U test. All hypothesis tests were two-tailed, with $\alpha<0.05$ was regarded as statistical significance.

3. RESULTS

3.1 Comparison of Univariate Analysis of Urodynamic Parameters between LUTS and LUTS+FPBS groups

Compared with the female patients with LUTS, the patients with LUTS+FPBS showed significantly increased Pdet.max, Qmax, and BOOI, while PVR showed no significant difference (P=0.247) (Table 1).

Table 1 Comparison of Urodynamic Parameters Between the Two Groups

Item	LUTS（n=15）	LUTS+FPBS（n=15）	t/z	P
Pdet.max(cmH2O)	22.40(17.30,28.50)	36.70(28.90,54.90)	3.991	<0.001
Qmax(ml/s)	16.80(14.80,24.30)	9.60(8.00,14.70)	4.107	<0.001
BOOI	-23.50(-32.40,-13.60)	10.60(-6.00,29.80)	4.394	<0.001
PVR (ml)	115(50.00,150.00)	119.57(10.00, 130.00)	0.64	0.247

3.2 Multivariate Logistic Regression Analysis

Three variables with statistical significance, including Pdet.max, Qmax, and BOOI, in univariate analysis were included in the multivariate logistic regression model. The results showed that only reduced Qmax remained independent risk factor for FPBS. Specifically, decrease of 1 ml/s in Qmax was associated with a 0.61-fold increased risk of FPBS (Table 2).

Table 2 Multivariate Logistic Regression Analysis of Risk Factors for FPBS

Item	β	S. E	Wald	*P*	OR	95% CI
Qmax	-0.495	0.206	5.784	0.016	0.61	0.41–0.91

4. DISCUSSION

This study demonstrated that FPBS is closely associated with voiding dysfunction, characterized by increased bladder outlet obstruction (BOO) and decreased Qmax. The lower Qmax in FPBS patients (median 9.60 ml/s vs. 16.80 ml/s in LUTS+FPBS) reflects the net effect of increased urethral resistance and potentially impaired detrusor contractility. Although the detrusor attempts to compensate with high pressure (Pdet.max 36.70 vs. 22.40 cmH2O), the resulting flow rate remains a 'higher pressure-lower flow' pattern consistent with findings reported by previous studies focused on female BOO other than FPBS, by which urinary stasis (median PVR 119ml) was caused, providing a favorable environment for stone formation.

The independent predictive capacity of Qmax for formation FPBS is clinically important because Qmax is a non-invasive parameter that can be obtained during free uroflowmetry, making it an ideal screening tool for female LUTS patients at risk of female BOO and FPBS [6]. Previous studies have indicated that a thin and forced urinary stream of complains without stress urinary incontinence, associated with urodynamic findings of "sustained high detrusor pressure" and "prolonged flow curve", suggested that LUTS is caused by female BOO, supporting our finding in this study [5]. The present study found that most patients still had persistent LUTS one year after FPBS-related surgery, further confirming that removing of bladder stone alone cannot eradicate BOO of female LUTS. Therefore, targeted intervention of BOO is necessary to reduce the recurrence rate of FPBS and improvement of female LUTS.

Although increased BWT is a reliable marker of chronic bladder injury and patients in the LUTS+FPBS group had thicker BWT than LUTS (not presented in the finding), there has been a causal relationship between increased BWT and more severe of BOO and BWT was excluded from multivariate logistic regression analysis for evaluation of risks factors in formation of FPBS in this study. Given BWT thickening is a pathological compensatory response to long-term obstruction and chronic inflammation and the Blaivas-FBOO nomogram provided accurate grading of obstruction severity and confirmed its central role in FPBS pathogenesis [7] [8], BWT should be considered a potentially reliable non-invasive parameters in differentiation of female BOO.

Beside BWT, Qmax had a significant difference between LUTS and LUTS+FPBS groups and a decreased Qmax forecasts an increased incidence of FPBS formation in multivariate logistic analysis. There has been a consensus that Qmax is mutual results between BOO and detrusor contractility and it has been regarded as a non-invasive parameter for evaluation of BOO on condition of similar detrusor function. Although the comparison of detrusor contractility between two groups was not directly conducted, reduced Qmax could be considered an independent risk factor of FPBS formation given a tendency of abdominal pressure be more frequently used than detrusor in female voiding.

This study has limitations inherent to single-center retrospective designs, including limited sample size and potential selection bias. Additionally, female-specific factors such as pelvic floor function and gynecological surgical history were not analyzed [9]. In the future, prospective multicenter studies will be needed for generalization of the findings and evaluation of the efficacy of obstruction-targeted interventions in preventing stone recurrence.

5. CONCLUSION

Bladder outlet obstruction plays an important role in formation of FPBS and Qmax could be considered a potentially and non-invasively independent risk factor for FPBS formation. However, more sample and prospective multicenter studies will be needed in the future.

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Competing interests

The author reports no conflicts of interest in this work.

Data availability

The data that support the findings of this study are not openly available due to reasons of sensitivity and privacy protection and are available from the corresponding author upon reasonable request. Data is located in controlled access data storage at The Second Affiliated Hospital of Guilin Medical University and The Shaoyang Central Hospital.

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