



THE ROLE OF BLADDER TRABECULATION AS A DIAGNOSTIC INDICATOR IN THE ASSESSMENT OF BLADDER OUTLET OBSTRUCTION

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Abstract

Introduction: Bladder trabeculation is a morphological marker of detrusor hypertrophy, hypothesized to correlate with bladder outlet obstruction (BOO). This study investigates the prevalence, severity, and clinical implications of BOO in patients with and without LUTS.

Methods: A prospective observational study included 96 patients divided into Group 1 (Patient presenting for treatment of BOO symptoms) (BOO, n = 44) and Group 2 (Patient presenting for treatment of some other urological conditions) (non-BOO, n = 52). Trabeculation was graded via urethrocystoscopy (Grade 0–3). Follow-up revealed previously unreported BOO symptoms in Group 2 patients with trabeculation.

Results: Trabeculation prevalence was significantly higher in Group 1 (70.5% vs. 25.0%, $p < 0.001$). BOO patients exhibited 7.2-fold higher odds of trabeculation (95% CI: 2.98–17.32). On follow-up, all patients who were initially in Group 2 (non-BOO) with trabeculation (13/13) reported BOO/LUTS symptoms, suggesting underdiagnosis. Severe trabeculation (Grade 3) remained exclusive to Group 1.

Conclusion: By this study, we re-confirm that bladder trabeculation strongly associates with Bladder outlet obstruction. Incidental trabeculation in asymptomatic patients may indicate an undiagnosed Bladder Outlet Obstruction, warranting thorough clinical evaluation.

Keywords

[Urology](#), [Bladder outlet obstruction](#), [BOO](#), [LUTS](#)

Introduction

Bladder outlet obstruction (BOO) triggers adaptive detrusor trabeculation. Bladder Trabeculation is a terminology characterized by the presence of hypertrophied bladder detrusor muscle with irregular intraluminal contours in the Bladder.¹ The principal pathological mechanism was reported as a secondary change of detrusor smooth muscle caused by bladder outlet obstruction in the bladder to compensate for the increased outflow resistance in the urethra or lower bladder which is caused by anatomical or physiological reasons.²⁻⁴ High bladder pressure induces adaptive changes in the bladder structure, which are visible in the long term as muscle enlargement and collagen deposition.^{5,6} Besides symptoms, BOO can also lead to progressive tissue remodelling of the bladder and of the upper urinary tract with subsequent serious functional impairments.^{7,8} While trabeculation is linked to BOO and neurogenic bladder, its clinical significance remains debated. This study compares the prevalence of trabeculation and symptomatology in patients with Bladder Outlet Obstruction versus General

hypertrophy and collagen deposition, manifesting as Populatdiagnostic utility and pathophysiological implications.

Patients and Method

Study design

Prospective Observational Study

Study Population

Patients who get admitted in the Urology ward for some intervention

Inclusion criteria

Group 1: Adults presenting with symptoms of Bladder Outlet Obstruction (BOO) / Lower Urinary Tract Symptoms (LUTS) undergoing endourological procedure for its relief (e.g., BPH, Urethral Stricture)

Group 2: Adults undergoing endourological procedures for other conditions, who do not present with symptoms of BOO/ LUTS

Exclusion criteria

Patients who are known cases of Neurogenic Bladder

Prior history of surgery to relieve BOO

Refusal to Consent.

Sample size

Sample size was calculated using difference in proportions ($\alpha = 0.05$, power 80%) with required sample of 76 (38 in each Group

Table I : Grading criteria

Grade	Muscle Bundle Layer	Height to Width
0 (None)	None	N/A
1 (Mild)	One Layer	N/A
2 (Moderate)	Two Layers (<50% of bladder)	Height < Width
3 (Severe)	More than 2 Layers (>50% of bladder)	Height > Width

Grade 0 was assigned when no muscle bundle was detected. Grade 1 was assigned if a single layer of muscle bundle formation was seen. Grade 2 was assigned if muscle bundles were in 2 layers but involve <50% of bladder or height of muscle bundle was smaller than the width. Grade 3 was

assigned if >50% of bladder involved or 3 layer of muscle bundle were seen or height of muscle bundle was same or larger than the width (Image 1). The findings were noted, patients were graded accordingly and statistical analysis was done.



Image 1: Cystoscopic Image showing Various Grades of Trabeculation

Statistical Analysis

Statistical analysis was done using IBM SPSS v25.0 and Jamovi v2.4.14. Descriptive statistics were performed, categorical data were presented as percentage and frequencies. The Prevalence of Trabeculation will be expressed as percentage with 95% confidence interval.

The difference between proportions will be assessed using Chi Square test. Logistic regression (adjusted for age/gender) was done, Mann-Whitney U test was done for severity grades.

Ethical Consideration

The Study was started after obtaining Institutional Ethics Committee Approval

Bladder Trabeculation as a Diagnostic Indicator of Bladder Outlet Obstruction

Informed consent was obtained from participants.

Patient confidentiality and privacy were maintained throughout the study.

Results

The study included a total of 96 patients with the following demographic details as demonstrated in Table II

Group 1 (BOO): 44 patients (100% male, mean age 55.5 ± 16.3). All reported BOO/LUTS symptoms.

Group 2 (Non-BOO): 52 patients (30 males, 22 females, mean age 51.6 ± 10.8). Initially, 11/52 (21.2%) reported BOO symptoms.

Table II : Age & Gender Distribution Among both Groups

Variables	Group 1 (BOO, $n = 44$)	Group 2 (Non-BOO, $n = 52$)
Mean Age (SD)	55.5 (± 16.3)	51.6 (± 10.8)
Male:Female	44:0	30:22
BOO Symptoms	44 (100%)	11 (21.2%)

The prevalence of bladder trabeculation was 70.5% in Group 1 and 25.0% in Group 2. This wide difference indicates that trabeculation is much more common in patients with BOO, suggesting it is a potential diagnostic indicator of bladder outlet obstruction. As shown in (Table III)

Table III: Table showing prevalence of Trabeculation in each group.

Group	Trabeculation (+)	Prevalence
1	31 out of 44	70.5%
2	13 out of 52	25.0%

Based on urethro cystoscopic appearance (as graded by Jung et al)⁹ , The grading of trabeculation severity demonstrates that in the True BOO cohort ($n=57$): (Table IV)

Grade 0: 13 patients (no trabeculation)

Grade 1: 14 patients (mild trabeculation)

Grade 2: 14 patients (moderate trabeculation)

Grade 3: 4 patients (severe trabeculation)

In contrast, the Non-BOO cohort ($n=39$) had no patients with trabeculation, indicating that trabeculation severity is strongly associated with BOO.

Table IV: Table showing Grading of Severity

Grade	Group 1 (n = 44)	Group 2 (n = 52)
0	13	39
1	14	6
2	14	6
3	3	1
	44	52

On clinical follow-up, all 13 patients with positive trabeculations, initially allocated to group 2 retrospectively had symptoms of BOO, which they had initially dismissed thinking irrelevant to their disease condition suggesting underdiagnosis

Revised Prevalence Analysis

True BOO Cohort (Group 1 + Symptomatic Group 2):

Total patients: 44 (Group 1) + 13 (Group 2) = 57 (77.2%).

Trabeculation prevalence: 44/57 (77.2%).

Non-BOO Cohort (Asymptomatic Group 2):

Total patients: 52 – 13 = 39.

Trabeculation prevalence: 0/39 (0%).

The statistical analysis was then updated with the updated data and the prevalence was again determined in tables V and VI

Table V: Prevalence of Trabeculation updated

Group	Trabeculation (+)	Prevalence	p-value
True BOO (n=57)	44/57	77.2%	<0.001
Non-BOO (n=39)	0/39	0%	

Table VI updated Severity Grading

	Grade 0	Grade 1	Grade 2	Grade 3
True BOO Cohort (n=57):	13	20	20	4
Non-BOO Cohort (n=39):	39	0	0	0

Multivariate Analysis

The multivariate analysis in this study aimed to isolate the independent association between bladder outlet obstruction (BOO) and bladder trabeculation while adjusting for potential confounders (Age and Gender).

Age was not significantly associated with trabeculation after adjusting for BOO. This suggests that the observed age difference between groups (Group 1 older than Group 2) did not bias the primary association.

Adjusted Odds Ratio (aOR) for BOO was 7.20 (95% CI: 2.98–17.32, $p < 0.001$)

Table VII: Adjusted Odds Ratio

Variable	aOR	95% CI	p-value
BOO	7.20	[2.98–17.32]	<0.001
Age	1.02	[0.98–1.06]	0.32
Male Gender	1.15	[0.29–4.61]	0.84

Discussion

Bladder trabeculation represents an important morphological change within the bladder wall, primarily driven by underlying pathophysiological conditions such as bladder outlet obstruction (BOO).¹⁰ This study reinforces the connection between detrusor muscle adaptation—characterized by fibroproliferative changes, increased collagen deposition, and muscle hypertrophy and the necessity for the bladder to generate higher pressure to overcome resistance during voiding. These findings align with the established understanding of the compensatory

mechanisms that occur in response to chronic obstruction.¹¹

Caution in Asymptomatic Patients:

A particularly noteworthy incident in this study was the initial misclassification of certain patients in Group 2 (Non-BOO), who, upon follow-up, exhibited symptoms associated with BOO. This suggests that clinicians should exercise caution when evaluating asymptomatic patients with incidental trabeculation. The discovery that all patients with trabeculation in Group 2 ultimately reported symptoms of lower urinary tract symptoms (LUTS) highlights the critical need for comprehensive evaluation, as trabeculation may serve as an

early indicator of undiagnosed BOO. Such findings underline the importance of continued surveillance and the potential necessity for diagnostic testing in patients who present with bladder trabeculation, even if they do not initially exhibit classic LUTS.

Prevalence and Diagnostic Markers:

The significant prevalence of trabeculation (77.2% in the true BOO cohort compared to 0% in the non-BOO cohort) is indicative of how these structural changes can serve as potential diagnostic markers for BOO. Moreover, the severity of trabeculation observed in this study, with Grade 3 trabeculation being exclusive to the BOO cohort, adds weight to the notion that trabeculation grading could be a useful tool in assessing the severity of obstruction. This calls for healthcare providers to integrate grading systems more systematically into clinical evaluations. For instance, fibroproliferative remodeling and collagen accumulation in the bladder wall have been directly linked to BOO-induced mechanical stress, as demonstrated in animal models of partial urethral obstruction.¹² Such structural adaptations correlate with urodynamic studies showing elevated detrusor pressure during voiding, a hallmark of obstructive pathophysiology.¹³ The hypertrophic response of smooth muscle cells, driven by increased

expression of growth factors like TGF- β 1, further underscores the molecular pathways mediating these changes.¹⁴ Chronic obstruction also activates inflammatory cascades, perpetuating extracellular matrix remodeling and reducing bladder compliance over time.¹⁵ While these adaptations initially serve to maintain urinary flow, prolonged obstruction often leads to decompensation, resulting in detrusor underactivity or irreversible bladder dysfunction.¹⁶

Demographics and Generalizability:

The demographics of the study population also warrant discussion. The predominance of males in Group 1 reflects the established epidemiological trends of BOO, primarily related to age and prostate-related pathologies such as benign prostatic hyperplasia (BPH). While this enhances the internal validity of findings concerning male patients, it also limits the generalizability of the results to more diverse populations, including women. Future studies should strive to include balanced gender representation to better understand trabeculation's role across varying demographics.

Additionally, the multivariate analysis results, indicating a strong adjusted odds ratio (aOR = 7.20 for BOO) and a lack of significant association between age and trabeculation, suggest that the relationship between trabeculation and BOO is robust

and independent of demographic confounders. These findings strengthen the call for clinicians to recognize bladder trabeculation not merely as a radiological or cystoscopic curiosity, but as a clinically relevant marker warranting further investigation and management.

In summary, this study elucidates a clear connection between bladder trabeculation and BOO, advocating for its consideration in clinical assessments. The findings articulate a pressing need for enhanced awareness and immediate action regarding incidental trabeculation, facilitating timely and accurate diagnosis of BOO, regardless of initial symptomatic presentation. As we continue to advance our understanding of bladder pathophysiology, such studies will contribute valuable insights that refine our diagnostic and therapeutic strategies in urology.

Conclusion

Key Message

1. **Trabeculation = BOO Red Flag:** Bladder trabeculation is strongly associated with BOO. Its presence, even incidentally detected, should prompt immediate evaluation for obstruction.
2. **Symptom Under reporting:** Patients may dismiss or underreport BOO/LUTS symptoms. Clinicians must proactively screen for subtle signs

This research establishes a robust association between bladder trabeculation and BOO ($p < 0.001$), supporting mid-term recommendations for its role as a marker of obstruction during urethrocystoscopy procedures. The stark contrast in trabeculation prevalence (77.2% in the true BOO cohort versus 0% in non-BOO patients) underscores the relevance of these findings in clinical practice. Moreover, the incorporation of grading systems for trabeculation severity may enhance clinicians' ability to assess and address complications associated with BOO, thereby improving patient outcomes. As such, the use of bladder trabeculation as an indicator of BOO merits serious attention during clinical evaluations, prompting further investigations and interventions, particularly in asymptomatic individuals to prevent end-stage damage eventually leading to damage to Kidneys.

(e.g., weak stream, straining) in trabeculation-positive cases.

3. **Severity Matters:** Grade 3 (Severe) trabeculation is exclusive to BOO and may indicate advanced disease, warranting urgent intervention.

Further Scope of Study

Patients with Trabeculations to be suggested for Urodynamic studies for further evaluation of bladder metrics

Develop protocols for trabeculation-positive

"asymptomatic" patients for further management.

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1.Chengalvarayan G., 2.Thanveer Ahamed Z., 3. Sivasankar G.

Work concept and design 1,2,3

Data collection and analysis 2,

Responsibility for statistical analysis 2

Writing the article 1,2,3

Critical review, 1, 2,3

Final approval of the article 1,2,3

Each author believes that the manuscript represents honest work and certifies that the article is original, is not under consideration by any other journal, and has not been previously published.

Availability of Data and Material: The corresponding author is prompt to supply datasets generated during and/or analyzed during the current study on wise request.

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