Section: Urology

Original Research Article

A COMPARATIVE STUDY ON THE USE OF DELTAQ VERSUS FLOW INDEX TO DIFFERENTIATE DETRUSOR UNDERACTIVITY FROM BLADDER OUTFLOW OBSTRUCTION

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Corresponding Author:
Dr. Senthil Kumar Kandeeban,
Email: chrome.q1@gmail.com

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Garg, Snigdh[1], Selvaraj, Sudhakaran[2], Sivalingam, Senthil K[3], Kandeeban, Senthil K[3], Ganapathi, Ramesh[3], Sangameswaran, Palanisamy[3]

[1]Post Graduate trainee, Department of Urology, Government Chengalpattu Medical College & Hospital, Chengalpattu, Tamil Nadu, India
[2]Associate Professor & Head of Department, Government Chengalpattu Medical College & Hospital, Chengalpattu, Tamil Nadu, India
[3]Assistant Professor, Government Chengalpattu Medical College & Hospital, Chengalpattu, Tamil Nadu, India

Abstract

Background: Detrusor underactivity (DUA) and bladder outflow obstruction (BOO) are prevalent causes of LUTS in aging men. Differentiating these conditions typically requires a UDE. This study investigates the use of DeltaQ (Qmax - Qavg) and Flow Index (Qavg/Qmax), two uroflowmetry-derived parameters, as alternative methods for distinguishing DUA from BOO in men with LUTS. **Materials and Methods:** A total of 80 male patients over the age of 50, presenting with LUTS were included in this prospective study. These patients underwent diagnostic assessment including the IPSS questionnaire, serum PSA testing, urine analysis, urine culture, and ultrasonography to determine prostate size and post-void residual urine. Following this, uroflowmetry was conducted, and a UDE was performed. **Result:** Of the 80 participants, 56 were classified as having BOO and 24 were diagnosed with DUA based on UDE findings. The BOO group exhibited a significantly higher DeltaQ value (9.02±3.64 mL/s) compared to the DUA group (5.63±2.76 mL/s), with statistical significance ($p < 0.001$). Although the Flow Index was greater in the DUA group (0.472±0.341) than in the BOO group (0.392±0.237), this difference did not reach statistical significance ($p > 0.05$). ROC analysis demonstrated that DeltaQ had a stronger diagnostic performance, with an Area Under the Curve of 0.82, compared to Flow Index, which had an AUC of 0.69. **Conclusion:** DeltaQ proved to be a more effective measure than Flow Index for distinguishing DUA from BOO in men experiencing LUTS. DeltaQ offers a practical, non-invasive, and cost-efficient approach for diagnosing DUA in clinical settings.

INTRODUCTION

Lower urinary tract symptoms (LUTS) are prevalent in men, affecting approximately 62% across all age groups, with the incidence rising to 80.7% in those over 60 years old[1,2]. Two of the most common causes of voiding LUTS in elderly males are detrusor underactivity (DUA) and bladder outflow obstruction (BOO)[3-6]. Due to the considerable overlap in their clinical symptoms, these conditions are primarily distinguished through the pressure-flow analysis of a urodynamic examination (UDE) [7], which is considered the diagnostic gold standard.

DUA is diagnosed when the Bladder Contractility Index (BCI = Pdet @ Qmax + 5 × Qmax) is ≤100 cm H_2O and the Bladder Outflow Obstruction Index (BOOI = Pdet @ Qmax - 2 × Qmax) is ≤20 cm H_2O, whereas BOO is defined by a BOOI of ≥40 cm H_2O. Although UDE is the most precise method for differentiating these conditions, its use of catheterization can lead to discomfort and carries a risk of complications, including urinary tract infections and haematuria, with reported morbidity rates ranging from 4% to 45% [8]. These concerns often deter both patients and healthcare providers from opting for UDE despite its diagnostic value.

Since its introduction by von Garrelts in 1957, uroflowmetry (UFM) has become a widely used non-invasive tool for assessing urinary function, measuring key parameters such as maximum flow rate (Qmax), average flow rate (Qavg), and voided volume (VV). Given the need for a simpler, less invasive alternative to UDE, this study aims to evaluate the effectiveness of DeltaQ (Qmax -

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Qavg)[9], and Flow Index (Qavg/Qmax) in distinguishing DUA from BOO in men presenting with LUTS. If proven reliable, these parameters could serve as practical, low-cost indicators to facilitate diagnosis without requiring invasive procedures.

MATERIALS AND METHODS

This study was conducted following approval from the Institutional Ethics Committee. A prospective study design was implemented, enrolling men over the age of 50 who were undergoing evaluation for LUTS between January 2024 and June 2024 on out-patient or in-patient basis. Only those who met the inclusion and exclusion criteria were selected after providing informed consent.

Each participant completed the International Prostate Symptom Score (IPSS) questionnaire, either independently or with assistance. Additionally, they underwent serum prostate-specific antigen (PSA) testing, urine routine analysis, and urine culture and sensitivity tests. Ultrasonography (USG) was performed to assess prostate size and post-void residual urine (PVR). Following these assessments, uroflowmetry (UFM) was conducted to measure urinary flow parameters. Finally, a urodynamic examination (UDE) was carried out in accordance with the standards set by the International Continence Society (ICS). The study algorithm is illustrated in Figure 1.

Inclusion Criteria

Patients were eligible for inclusion if they met the following criteria:

- Males over the age of 50 experiencing LUTS.
- IPSS score of ≥8.
- Serum PSA levels ≤4 ng/dL.
- Absence of haematuria or pyuria.
- No prior use of alpha-blockers, anticholinergics, or beta-agonists that could affect detrusor function for at least eight weeks before evaluation.

Exclusion Criteria

Patients were excluded from the study if they had any of the following:

- A history of central or peripheral neurogenic disorders, including cerebrovascular accidents or spinal cord diseases, as well as severe cardiovascular conditions.
- Any pre-existing urinary tract abnormalities, including strictures, stones, or congenital anomalies.
- Prior pelvic floor or bladder surgeries, or a history of chronic pelvic pain.
- Inability to complete uroflowmetry or voiding assessments.
- A final diagnosis on UDE that indicated a condition other than DUA or BOO.

RESULTS

Initially, 124 patients were considered for the study. However, after applying the inclusion and exclusion criteria, a total of 80 patients were enrolled. Based on urodynamic examination (UDE) findings, 56 participants were diagnosed with bladder outflow obstruction (BOO), while 24 were identified as having detrusor underactivity (DUA). The comparative analysis of various clinical parameters between these groups is presented in [Table 1].

The average age of participants was 64.18 ± 8.24 years, with no statistically significant difference between the BOO and DUA groups (p = 0.8865). Similarly, no significant variations were observed between the two groups in terms of IPSS scores, serum PSA levels, prostate size, or Qavg. While the Flow Index appeared higher in the DUA group (0.472 ± 0.341) compared to the BOO group (0.392 ± 0.237), this difference was not statistically significant (p = 0.2314).

However, certain parameters showed significant differences between the groups. The BOO group exhibited a lower post-void residual urine (PVRU) compared to the DUA group (p = 0.0194), whereas Qmax values were notably higher in BOO patients (p = 0.0001). DeltaQ was also significantly higher in the BOO group (9.02 ± 3.64 mL/s) compared to the DUA group (5.63 ± 2.76 mL/s), with a strong statistical significance (p = 0.0001). Additionally, BOOI values were significantly elevated in BOO patients (p = 0.0001), while BCI was markedly lower in those with DUA (p = 0.0001).

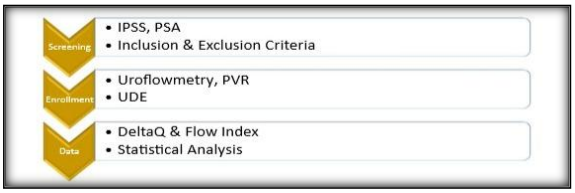

Figure 1: Algorithm of study

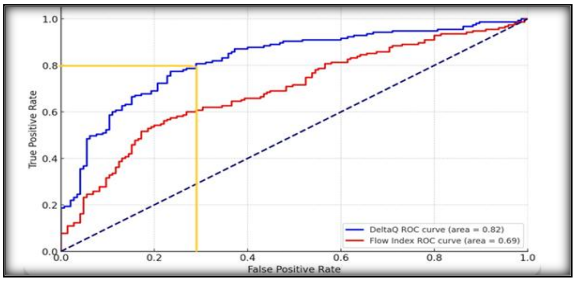

Figure 2: ROC for DeltaQ & Flow Index

Multivariate Analysis: A multivariate logistic regression analysis was conducted to determine independent predictors for distinguishing BOO from DUA [Table 2]. DeltaQ emerged as the strongest predictive factor, with a coefficient B of 1.426 (95% CI: 1.204–1.648, p = 0.0001). PVRU was also identified as a significant predictor (p = 0.026, coefficient B = 0.876, 95% CI: 0.869–0.883).

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However, other parameters, such as Flow Index and Qmax, did not demonstrate significant predictive value ($p > 0.05$).

Receiver Operating Characteristic (ROC) Analysis

The diagnostic performance of DeltaQ, Flow Index, PVRU, and Qmax was further assessed using ROC curve analysis [Table 3, Figure 2]. Among the studied variables, DeltaQ exhibited the highest Area Under the Curve (AUC) value of 0.82, indicating strong diagnostic reliability in differentiating DUA from BOO. The AUC for PVRU and Qmax were 0.73 and 0.714, respectively, while the Flow Index demonstrated the lowest discriminative power, with an AUC of 0.69. Based on the ROC curve, a DeltaQ threshold of 7.08 mL/s was identified as an optimal cutoff, yielding a sensitivity of 80% and a specificity of 72%.

Table 1: Comparison of variables between BOO & DUA patients.

Variables	Total (n=80)	BOO (n=56)	DUA (n=24)	p value
Age (years)	64.18±8.24	64.32±8.78	64.02±8.11	0.8865
IPSS	16.22±6.80	16.47±6.35	15.89±6.88	0.7160
Serum PSA (ng/mL)	2.02±1.08	1.98±1.02	2.25±0.98	0.2758
Prostate Size (g)	26.78±14.45	27.65±13.98	25.32±15.02	0.5060
PVRU (mL)	98.74±64.21	73.93±60.46	114.02±85.55	0.0194
Qmax (mL/s)	12.22±4.24	14.85±4.19	10.67±3.27	0.0001
Qavg (mL/s)	5.37±1.83	5.83±1.75	5.04±2.02	0.0813
DeltaQ (mL/s)	6.85±3.17	9.02±3.64	5.63±2.76	0.0001
Flow Index	0.439±0.225	0.392±0.237	0.472±0.341	0.2314
BOOI (cm H2O)	35.42±12.45	57.43±15.89	14.76±5.01	0.0001
BCI (cm H2O)	102.42±14.68	126.05±13.92	78.79±15.43	0.0001

Table 2: Multivariate logistic regression analysis of variables

Variable	Coefficient B	p value	95% Confidence Interval
DeltaQ (mL/s)	1.426	0.0001	1.204-1.648
Flow Index	0.487	0.407	0.398- 0.416
PVRU (mL)	0.876	0.026	0.869- 0.883
Qmax (mL/s)	0.651	0.238	0.631-0.671

Table 3: Receiver operating curve characteristics for variables

Variable	Area under curve (AUC)
DeltaQ (mL/s)	0.82
Flow Index	0.69
PVRU (mL)	0.73
Qmax (mL/s)	0.714

DISCUSSION

This study aimed to identify non-invasive parameters capable of differentiating bladder outflow obstruction (BOO) from detrusor underactivity (DUA) in men presenting with lower urinary tract symptoms (LUTS). Traditionally, pressure-flow studies in urodynamic examinations (UDE) have served as the gold standard for distinguishing these conditions, as reflected in this study where BOOI and BCI demonstrated a highly significant distinction ($p = 0.0001$) [10,11]. However, the discomfort, invasiveness, and risk of complications associated with UDE highlight the need for alternative diagnostic approaches.

Understanding the Role of DeltaQ

The primary hypothesis of this study was that DeltaQ would be significantly different in BOO and DUA patients due to their distinct underlying pathophysiological mechanisms. In cases of BOO, resistance at the bladder outlet forces the detrusor muscle to generate increased pressure during voiding, leading to a higher Qmax compared to Qavg, which in turn results in a greater DeltaQ. Conversely, in patients with DUA, detrusor contraction is weakened, leading to both a lower Qmax and Qavg, and thus a smaller DeltaQ.

The findings in this study strongly support this hypothesis. DeltaQ was significantly higher in BOO patients (9.02 ± 3.64 mL/s) compared to those with DUA (5.63 ± 2.76 mL/s), with a p-value of 0.0001, underscoring its potential as a reliable differentiating parameter. Moreover, the Receiver Operating Characteristic (ROC) analysis revealed an Area Under the Curve (AUC) of 0.82, indicating strong diagnostic accuracy. These results align closely with prior research conducted by Lee et al., who analyzed 517 men with LUTS and concluded that DeltaQ is a valuable tool for distinguishing DUA from BOO. Their study reported an AUC of 0.806 and proposed a DeltaQ cutoff of 6.65 mL/s, achieving a sensitivity of 71.3% and a specificity of 70.3% [9]. The similarity in findings between both studies reinforces the robustness of DeltaQ as a practical diagnostic parameter.

Significance of Post-Void Residual Urine (PVRU) as a Predictor

Another key observation in this study was the role of PVRU in differentiating BOO from DUA. Patients with DUA exhibited markedly higher PVRU values, likely due to impaired bladder emptying resulting from reduced detrusor contractility. In the multivariate logistic regression analysis, PVRU was identified as a significant predictor ($p = 0.026$),

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further confirming its clinical relevance. However, its AUC of 0.73 suggests that while it holds diagnostic value, it is less reliable than DeltaQ as a standalone parameter.

Interestingly, Yono et al. investigated the variability of PVRU measurements and found significant fluctuations in repeated assessments within the same individual. They concluded that bladder voiding efficiency (BVE) was a more stable and reliable measure than PVRU in patients with underactive bladder [12]. Similarly, a retrospective study by Oelke et al., which included 822 male patients, established a nomogram incorporating bladder outlet resistance, detrusor contractility, and voiding efficiency to distinguish BOO from DU [13]. These studies suggest that while PVRU can aid diagnosis, it should be interpreted alongside other key variables.

Why Flow Index Fails as a Reliable Parameter

Although Flow Index (Qavg/Qmax) was evaluated in this study, it did not emerge as a strong predictor. Flow Index was slightly higher in the DUA group (0.472 ± 0.341) compared to the BOO group (0.392 ± 0.237), but the difference was not statistically significant (p = 0.2314). Additionally, its AUC was the lowest (0.69), indicating poor discriminative ability.

This finding aligns with prior research demonstrating that while uroflowmetry-based metrics can assist in diagnosis, not all flow-derived indices carry the same diagnostic weight. A study by Ghirca et al., which retrospectively analysed 91 patients, concluded that a combination of uroflowmetry parameters, post-void residual volume, and bladder contractility index was more effective than isolated flow indices in evaluating underactive bladder [14]. Kalil et al. further supported this notion in their research, emphasizing that symptom scores (IPSS) and PVR alone were not sufficient to differentiate BOO from DUA, but urodynamic studies were necessary for an accurate diagnosis [15].

Clinical Implications and Future Directions

The findings from this study offer important clinical implications. DeltaQ, being a non-invasive and easily obtainable parameter from uroflowmetry, could serve as a practical tool for initial screening of LUTS patients. Given its high diagnostic accuracy (AUC = 0.82), it could reduce the reliance on invasive urodynamic testing and serve as an adjunct in decision-making.

Future studies should aim to validate these findings across larger, multi-centre cohorts to strengthen the generalizability of DeltaQ as a diagnostic tool. Additionally, research integrating DeltaQ with imaging modalities or advanced urodynamic models may further refine its clinical utility. Takahashi et al., for instance, analysed 909 men undergoing pressure-flow studies and identified older age, smaller prostate volume, and fewer urgency symptoms as independent predictors of DUA [16]. Combining DeltaQ with these factors could improve diagnostic precision and assist in risk stratification for patients with LUTS.

Despite its strengths, this study is not without limitations. The sample size was relatively small, and the study was conducted at a single center, which may limit generalizability. Additionally, external factors such as patient compliance, voiding habits, and intra-individual variations in uroflowmetry parameters could influence the results. Future research should focus on multi-centre validation studies, larger cohorts, and integration of non-invasive predictive models.

CONCLUSION

This study reinforces the potential of DeltaQ as a practical, non-invasive diagnostic tool for differentiating detrusor underactivity (DUA) from bladder outflow obstruction (BOO) in men presenting with lower urinary tract symptoms (LUTS). Given its ease of derivation from uroflowmetry and its strong diagnostic performance (AUC = 0.82), DeltaQ emerges as a reliable tool to screen cases of DUA and BOO with high accuracy. In contrast, Flow Index demonstrated limited diagnostic utility, highlighting that not all uroflowmetry-derived parameters carry equal weight in clinical decision-making.

The findings further emphasize that higher post-void residual urine (PVRU) levels are associated with DUA, reinforcing its role as a supplementary diagnostic marker. However, given the variability of PVRU and its lower predictive power compared to DeltaQ, it may be more useful when interpreted in conjunction with other clinical parameters.

From a clinical perspective, incorporating DeltaQ into routine uroflowmetry assessments could significantly reduce the need for invasive UDE, improving patient comfort and facilitating early identification of DUA and BOO. However, further research involving larger, multi-centre cohorts is necessary to validate these findings and enhance the accuracy of non-invasive diagnostic models for LUTS evaluation.

In conclusion, DeltaQ stands out as a simple, cost-effective, and efficacious tool for differentiating BOO from DUA. Its integration into routine practice could streamline diagnostic pathways, minimize patient discomfort, and optimize treatment strategies, ultimately improving outcomes for individuals affected by LUTS.

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