Evaluation of a noninvasive uroflowmetry parameter (Delta Q value) in detrusor underactivity and bladder outlet obstruction

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Purpose
To determine the significance of the Delta Q value in discrimination between detrusor underactivity (DU) and bladder outlet obstruction (BOO) in adult male patients.
Methods
A total of 238 patients in this cohort study underwent pressure-flow study. Patients were divided into two groups based on UDS outcomes: DU ($n = 121$) and BOO ($n = 117$). From uroflowmetry, 5 variables including maximal flow rate (Qmax), average flow rate (Qave), voiding volume (VV), postvoid residual urine (PVR), and the difference between (Qmax) and (Qave) known as (Delta Q) were obtained. Diagnostic prediction of these variables was evaluated with DU and BOO.
Results
Delta Q was less in the DU group compared with the BOO group 2.9 ml/s and 6.2 ml/s, respectively. Delta Q showed a promising diagnostic value in the discrimination between DU and BOO. A cut-off value of 6.1 ml/s was found to be discriminatory between the two groups with a sensitivity of 96.58% and specificity of 92.79%.
Conclusion
Delta Q value has proven to be a useful noninvasive screening and diagnostic tool in differentiating between DU and BOO in men with obstructive lower urinary tract symptoms.

Keywords:
delta Q value detrusor underactivity, bladder outlet obstruction, pressure-flow study, urodynamics

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Abbreviation List: Average flow rate (Qave); bladder outlet obstruction (BOO); detrusor underactivity (DU); Lower urinary tract symptoms (LUTS); Maximal Flow rate (Qmax); postvoid residual urine (PVR); pressure-flow study (PFS); voiding volume (VV).

Introduction

Lower urinary tract symptoms (LUTS) are considered one of the most common morbidities in elderly men. These symptoms were usually attributed to enlarged prostate and outflow obstruction. With a better understanding of the pathophysiology of the lower urinary tract and voiding dysfunction, other pathology could contribute to such a pathology as Detrusor underactivity (DU) [1,2].

Both DU and BOO affect the voiding phase of micturition in elderly men with almost similar clinical symptoms perceived by the patient. Because of the clinical similarity is clinically difficult to distinguish between both conditions that could only be evaluated by a pressure-flow study. It is important to differentiate between those two entities to select the proper management and to expect the outcome following the intervention [3–5].

There are certain limitations with the Pressure-flow study (PFS) due to the invasive nature of the test with significant cost to healthcare systems and the need for special equipment and expertise. Additionally, it is usually associated with some morbidities such as urinary tract infection, and the associated pain and discomfort during the test [6,7].

Because of these limitations, the PFS is not a preferred diagnostic tool in such conditions. On the other hand, uroflowmetry is a reliable, noninvasive, and cheap substitute that could be considered a substitute for the differentiation between DU and BOO, based on the difference between maximal (Qmax) and average flow rate (Qave) which is named (Delta Q). the principle is that Delta Q would be lower in DU

because of the deteriorated detrusor function that leads to a decrease in the flow rate both average and maximum, while in BOO, detrusor function is intact giving a normal contraction with a force to overcome the outflow obstruction without the aid of an abdominal pressure giving to a slightly higher Qmax which is still weak compared with a normal person but higher than in those with DU and hence, Delta Q value is obtained and evaluated. Lee and colleagues in their study in 2016 over 240 patients suggested that delta Q could be used to differentiate between DU and BOO in patients with obstructive voiding symptoms [8].

Based on this principle we constructed our study to evaluate the significance of the delta Q value in discrimination between DU and BOO using uroflowmetry.

Methods

After obtaining written informed consent from the local ethical committee. Each patient was subjected to the following: thorough history taking, IPSS score evaluation, full clinical examination, laboratory, radiological testing, and finally the PFS that conduction at the Urodynamic Unit, Ain Shams University.

PFS was performed by a single experienced urologist. We used Laborie KT concept urodynamics system. Normal saline was used for infusion (infusion rate: 30 ml/min), and the urodynamic study was done in a sitting position using an 8 Fr double lumen urodynamic catheter. During the PFS, patients were instructed to void in a sitting position in a relaxed and silent environment.

DU was defined as bladder contractility index (BCI; detrusor pressure at maximal flow rate [Pdet Qmax]+5 Qmax) less than 100 cmH_2O with bladder outlet obstruction index (BOOI; Pdet Qmax– 2 Qmax) less than 20 cmH_2O and BOO was defined as BOOI greater than or equal to 40 cmH_2O.

Based on the results of the PFS the patients were divided into two groups. The first group included 121 patients diagnosed as having DU and the other group of 117 patients represented patients with BOO. We reviewed these results retrospectively based on the diagnosis of DU and BOO. Patients who were diagnosed with DU or BOO were evaluated and included in our study. Patients included have previous failed medical treatment for obstructive urinary symptoms in the form of alpha blockers. They were informed to stop medications 3 days prior to the PFS. Uroflowmetric assessment and delta Q value was obtained. Patients with previous lower urinary tract surgery or those with both BOO and DU were excluded from our study.

With regards to the uroflowmetric assessment, uroflowmetric values included maximum flow rate (Qmax), average flow rate (Qave), voiding volume (VV), and postvoiding residual urine (PVR). Delta Q was then calculated by Qmax minus Qave. Then, we assessed the impact of Delta Q to differentiate between DU and BOO.

Statistical methods

Data were analyzed using IBM© SPSS© Statistics version 23 (IBM© Corp., Armonk, NY, USA) and MedCalc© version 15.8 (MedCalc© Software Bvba, Ostend, Belgium). The normality of numerical data distribution was examined using the D'Agostino-Pearson test. Normally distributed numerical data were presented as mean and standard deviation and intergroup differences were compared using the unpaired *t*-test. Nonnormally distributed numerical data were presented as median and interquartile ranges and between-group differences were compared using the Mann-Whitney test. Categorical (ordinal) data were presented as numbers and percentages and intergroup differences were compared using the χ^2 test for trend. The diagnostic value of delta Q was examined using receiver-operating characteristic (ROC) curve analysis. *P* values less than 0.05 were considered statistically significant.

Results

The parameters of our patients are summarized in Table 1. There was no statistically significant difference between the two groups regarding age, IPSS score, and PSA.

A statistically significant difference between the two groups could be obtained regarding Pdet, Qmax, BOOI, BCI, Qmax, Qave, and delta Q. In the BOO group, a higher value of Qmax, Qave, and delta Q was recorded. While PVR was lower compared with the DU group as shown in Table 1.

Table 2 shows that Delta Q has an excellent diagnostic value with an area under the ROC curve (AUC) of 0.932. A cut-off value 6.1 ml/s could discriminate between both groups with a sensitivity of 96.58% and specificity of 92.79%.

Table 1 Characteristics of patients in both study groups

Variable	DU group (*n*=121)	BOO group (*n*=117)	*P* value
Age (years)	64.19±7.3	62.7±8.12	0.138
IPSS	26.08±6.24	25.5±5.41	0.445
PSA (ng/dl)	2.73±1.45	2.67±0.82	0.696
Pdet.Qmax (cmH_2O)	11.5±3.3 (7.5–19.3)	32.9±2.2 (38.5-28.1)	<0.001
BOOI	11.3±4.1 (3.1-15.5)	44.5±10.9 (59.2–28.9)	<0.001
BCI	38.5±10.3 (29.5-63.8)	99.5±11.2 (86.1-111.3)	<0.001
Qmax (ml/s)	5.4±1.1 (2.3-6.5)	10.8±2.3 (7.3-13.5)	<0.001
Qave (ml/s)	3.5±0.9 (1.6-4.5)	4.1±1.5(3.1-7.1)	0.67
Delta Q (ml/s)	2.9±1.1 (1.2-3.3)	6.2±1.8 (4.3-7.4)	<0.001
PVR (ml)	234.5±50.9 (180-315)	138±34.4 (55-210)	<0.001

Table 2 Delta Q diagnostic value with an area under the ROC curve

	AUC	Cut-off point	Sensitivity	Specificity
Delta Q	1.000	≤6.1	96.58	92.79%
Pdet Q max	0.992	≤19.3	99.17	100.00
BOOI	0.992	≤15.5	99.17	100.00
BCI	1.000	≤86.1	100.00	100.00

Discussion

Both DU and BOO are common voiding dysfunction in elderly men. Due to the clinical similarity in the presentation of both disorders, it is difficult to discriminate between them. PFS usually the only tool for diagnosis is such conditions to differentiate between them Bachmann and colleagues, Lee and colleagues [6,8].

Although the urodynamic studies may represent the only diagnostic tool, it is not an ideal option for patients, especially with diseases with high prevalence. This may be due to the technical difficulties, financial burden, and urinary tract infections, in addition to the pain and the psychological impact of the study on elderly patients Farrelly and colleagues [9].

Owing to these drawbacks of the PFS, some tried to search for other noninvasive diagnostic tools like IPSS score, postvoiding residual urine, and uroflowmetry parameters like (Qmax) and (Qave).

Delta Q is a uroflowmetry parameter which is the difference between maximal (Qmax) and average flow rate (Qave) and considered a noninvasive test more tolerable than a complete PFS was proposed by Lee and colleagues for differentiation between DU and BOO [8].

Both DU and BOO are associated with a decreased urinary flow, but DU is associated with a decreased detrusor pressure, unlike BOO where detrusor pressure is almost normal. In DU the diminished detrusor function would result in decreasing both the average and maximum flow rate and consequently, the Delta Q value will be low. On the other hand, in BOO with an intact detrusor function that tries to overcome the outflow obstruction, there will be a relatively discrepancy between (Qmax) and (Qave) and eventually, Delta Q will be higher compared with that is of DU Lee and colleagues [8].

Our study revealed that Delta Q has a good diagnostic value in discriminating between DU and BOO with a cut-off value 6.1 ml/s that could discriminate between both groups with a sensitivity of 96.58% and specificity of 92.79%. These results from a noninvasive test may be used as an alternative to the PFS in differentiation between DU and BOO in some circumstances when PFS could not be performed. Lee and colleagues reported a cut-off value of 6.65 ml/ s, the sensitivity and specificity for Delta Q were 71.3% and 70.3%, respectively [8].

Wen and colleagues [10] reported that in patients with BPH over time, detrusor muscle structural changes started to occur with denervation instability and myogenic failure started to occur resulting in an undermined contraction for urine flow suggesting the affection of both (Qmax) and (Qave) and this support the hypothesis of Delta Q value in such condition.

Tam and colleagues [11] evaluated patients with urethral strictures using uroflowmetry before and after urethroplasty. They evaluated the Delta Q value to evaluate recurrence and concluded that it represents more sensitive results than Qmax in assessing the patency and voiding function.

The accurate diagnosis of DU is challenging to say due to the clinical similarity to BOO. This was discussed by

Ahmed and colleagues in a review article that mentions that a PFS is essential in the diagnosis of DU. Delta Q which has been evaluated in our study and Lee and colleagues may represent an alternative to PFS in the diagnostic process Ahmed and colleagues [12].

Our study showed that there is no statistically significant difference between DU and BOO regarding IPSS scores and Qave. On the other hand, 2 major differences were observed between the two groups. The first is that Qmax was higher in the BOO group than in the DU group with mean values of 10.8 and 5.4, respectively (P value < 0.001). Secondly, the PVR values were significantly higher in the DU group than in the BOO group with mean values of 234.5 and 138, respectively (P value-< 0.001).

Lee and colleagues [8] mentioned that IPSS could not aid in the differentiation between DU and BOO where IPSS is more affected in the DU patients. Khalil *et al.*, proposed that IPSS and PVR only could not differentiate DU from BOO Kalil and colleagues [13].

Additionally, mounting evidence suggests that prostate volume, intravesical prostate protrusion, bladder voiding efficiency, and uroflow curves are significantly different between DU and BOO patients. Namely, an interrupted uroflow waveform is more predominant in DU compared with BOO (80% vs. 13%) and can be used to differentiate the 2 conditions with high sensitivity (80%) and specificity (87%). These strong associations culminated in new diagnostic criteria for UAB without the use of invasive UDS Yoshida and colleagues [14].

Although may find one or more parameters with a statistically significant difference. It is better to rely on a combined reliable parameter rather than a sole indicator to differentiate between two different pathologies to guide the physician in decision making in cases where PFS could not be performed.

Although we demonstrated a clinical and statistical significance for Delta Q as a noninvasive diagnostic tool for differentiation between DU and BOO. It is still considered under investigation, and it is too early to consider it before enough studies on a larger scale of patients. Also, various subtypes of bladder dysfunction should be evaluated in different age groups.

Conclusion

Delta Q value is a useful diagnostic tool in differentiating between DU and BOO that may be used as a noninvasive utility compared with PFS.

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The study was registered at clinicaltrial.gov with trial registration number: NCT05359484.

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Conflicts of interest

No competing interests to declare.

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