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Research

Evaluation of Non-invasive Parameters for the Detection of Bladder Outflow Obstruction in Patients with Symptomatic Benign Prostatic Hyperplasia

Semptomatik Benign Prostatik Hiperplazili Hastalarda Mesane Çıkış Obstruksiyonunun Tespitinde Non-invazif Parametrelerin Değerlendirilmesi

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ABSTRACT

Objective: To identify sonographic and morphological parameters of the prostate and bladder that predict bladder outlet obstruction (BOO) in benign prostate hyperplasia patients with lower urinary tract symptoms (LUTS).

Methods: The data of patients evaluated for LUTS between 2019-2023 were retrospectively screened. Following the inclusion and exclusion criteria, 320 patients were included in the study. The patient's medical history, physical examination, laboratory findings, ultrasonography findings, and urodynamic examination results were recorded. In the urodynamic examination, participants were divided into two groups: Group 1 (n=180) with a BOO index (BOOI) ≥40, and Group 2 (n=140) with a BOOI <40. These two groups were then compared.

Results: There was no statistical difference in age and international prostate symptom score results between the two groups. In univariate analysis, maximal flow rate (Qmax), post-void residual urine volume, serum Prostate specific antigen, intravesical prostate protrusion (IPP), ultrasound estimated bladder weight, and bladder wall thickness were found to be significant predictors, while in multivariate analysis Qmax and IPP were determined as significant predictive factors.

Conclusion: IPP and Qmax can be used as non-invasive tests to predict BOO in patients evaluated with LUTS.

Keywords: Benign prostatic hyperplasia, bladder outflow obstruction, non-invasive parameters, ultrasonography, urodynamic

ÖZ

Amaç: Alt üriner sistem semptomları (AÜSS) olan iyi huylu prostat büyümesi hastalarında mesane çıkış obstrüksiyonunu (MÇO) öngören prostat ve mesanenin sonografik ve morfolojik parametrelerini belirlemek.

Gereç ve Yöntem: 2019-2023 yılları arasında AÜSS açısından değerlendirilen hastaların verileri retrospektif olarak tarandı. Dahil etme ve dışlama kriterleri sonrasında 320 hasta çalışmaya dahil edildi. Hastaların medikal öyküsü, Fizik muayene, laboratuar, ultrasonografi bulguları ve ürodinamik inceleme sonuçları kaydedildi. Ürodinamik incelemede MÇO ≥40 olanlar Grup 1 (n=180), MÇO <40 olanlar Grup 2 (n=140) olarak ayrılarak bu iki grup karşılaştırıldı.

Bulgular: İki grup arasında yaş ve uluslararası prostat semptom skoru sonuçları arasında istatistiksel anlamlı fark izlenmedi. Tek değişkenli analizde maksimal akım hızı (Qmax), İşeme sonrası rezidü idrar, serum Prostat Spesifik Antijen, intravezikal prostat uzanımı (IPP), ultrasonla hesaplanmış mesane ağırlığı ve mesane duvar kalınlığı anlamlı prediktörler olarak bulunurken Çok değişkenli analizde Qmax ve IPP anlamlı olarak predikte edici faktörler olarak belirlendi.

Sonuç: AÜSS ile değerlendirilen hastalarda mesane çıkış obstruksiyonunu predikte etmek için IPP ve Qmax non-invazif testler olarak kullanılabilir.

Anahtar Kelimeler: Benign prostat hiperplazisi, mesane çıkış tıkanıklığı, non-invazif parametreler, ultrasonografi, ürodinami

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INTRODUCTION

Bladder outlet obstruction (BOO) is a complex condition influenced by various factors. The factors contributing to BOO include detrusor contractility, smooth muscle remodeling, reduced blood flow, and mechanical stress. The diagnosis of BOO benign prostatic hyperplasia (BPH) has been one of the controversial topics in urology (1). Various methods, including questionnaires evaluating symptoms, urine flow rate and post-void residual (PVR) urine volume were used for the differential diagnosis of BOO. However, these tests are not specific for BOO (2).

Pressure flow studies (PFS) are considered to be the most useful tests in the diagnosis of BOO. However, its use in daily practice is limited because it is not easy to perform, it is not available in every clinic, there is a risk of infection related to the procedure, and it is invasive (3). Many researchers have investigated the accuracy of the diagnosis of BOO/BPH with intravesical prostate protrusion (IPP), bladder wall thickness (BWT), detrusor wall thickness, ultrasound estimated bladder weight (UEBW), prostate volume (PV), and transitional zone volume (TZV) measurements of bladder and prostate sono-morphologic parameters (4-6).

The aim of this study was to determine the sonographic and morphological parameters of the prostate and bladder that predict BOO in BPH patients with lower urinary tract symptoms (LUTS).

METHODS

This study was approved by approved by University of Health Sciences, Türkiye İzmir Tepecik Education and Research Hospital Non-interventional Research Ethics Committee (decision no: 2024/ 02-16, date: 04.03.2024). All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

All clinical data were collected retrospectively from patients evaluated for LUTS between 2019-2023. All 869 patients with LUTS were included in this study. The patients included in the study were those with an indication for urodynamics according to the European Association of Urology guidelines and who had completed a urodynamic study: (a) before to invasive treatment or when further evaluation of the underlying pathophysiology of LUTS is required, (b) men unable to void more than 150 mL and considering invasive treatment, (c) men considering surgery with bothersome predominantly voiding LUTS and Qmax >10 mL/s, (d) men with predominantly voiding LUTS and post-voiding residual >300 mL, and (e) men over the age of 80 years considering invasive treatment (7). Exclusion criteria included being under 50 years of age, having urethral stricture, having prostate or bladder malignancy, having a history of previous prostate surgery or pelvic radiation, having any neurological disorder that may affect bladder function, lacking urodynamic evaluation, and declining to participate in the study. After applying the exclusion criteria, the data of 320 patients were analyzed retrospectively.

A detailed medical history and a physical examination were performed on all patients with LUTS. LUTS evaluation was performed using the international prostatic symptom score (IPSS). Physical examination included digital rectal and neurological examinations. Urinalysis, creatinine, and prostate-specific antigen (PSA) were ordered as laboratory tests. A uroflowmetry test was ordered and peak urine flow rate (Qmax) and PVR were determined with this test. Pelvic ultrasonography and PFS were performed in patients who fulfilled the inclusion criteria.

Urodynamic evaluation was performed using the Solar Video Urodynamic system according to the recommendations of the International Society of Incontinence Good Urodynamic Practices protocol (8). Before urodynamic examination, the urine culture was sterile in all patients, and then the procedure was performed. BOO was determined using the BOO index with the following formula: BOOI=PdetQmax-2 Qmax from PFS (9).

All ultrasonography (USG) parameters were measured by a single operator. USG was performed when the bladder volume was between 100-200 mL. Bladder volume was assessed to calculate volume, using the prostate ellipsoid method, as the product of length, width, and height, multiplied by a correction factor (0.52).

The BWT hypoechoic layer was measured using a 7.5 MHz linear probe. The UEBW was then determined by combining the estimated BWT with the bladder volume (10). Following this, trans-rectal USG was performed simultaneously in the left lateral decubitus position. A sagittal image was obtained transrectally, and IPP was measured as protrusion from the bladder neck. IPP was divided into 3 grades according to its length: Grade 1 if 5 mm, Grade 2 if 5-10 mm, and Grade 3 if >10 mm. TZV was calculated by measuring its dimensions in both transverse and sagittal views, transrectally.

Patients were divided into two groups: those with BOO index (BOOI) ≥40 and those with BOOI <40. We compared these two groups in terms of age, Qmax, voided volume, post-micturition residual (PMR), serum PSA level, PV, IPSS, and sonographic non-invasive parameters.

Statistical Analysis

Statistical data analyses were performed using IBM SPSS Statistics for Windows version 25 (IBM Corp., Armonk, NY, USA). Data are presented as the mean ± standard deviation, the median, interquartile ranges, or frequency (%). The chi-square test (Continuity Correction, Fisher's exact test, or Pearson chi-square) was used to compare the categorical variables. Multivariable logistic regression models were constructed using the stepwise backward Wald method. A $p<0.05$ was considered significance level of statistically significant.

RESULTS

After applying the inclusion and exclusion criteria, 320 patients were included in the study. Patients with BOOI ≥40 were classified as Group 1 and patients with BOOI <40 were classified as Group 2. The mean age of patients in Group 1 and Group 2 was 70.1 and 68.1 years, respectively. Among the uroflowmetry parameters, Qmax and voiding volume were found to be statistically lower in Group 1 patients in univariate analyses. There was no difference between the groups in terms of PMR. There was no statistical difference in cystometric capacity between the two groups. Among the non-invasive USG parameters, BWT, UEBW, and IPP were statistically higher in Group 1 patients in univariate analysis. Univariate analyses of patients in Group 1 and Group 2 are shown in Table 1.

When the factors predicting BOO status were analyzed, 51.8% of the cases were detected in patients over 70 years of age. Patients with Qmax <10 constituted 47.5% of the population. IPP >10 mm was detected in 73.8% of patients. Other factors predicting BOO are shown in Table 2.

In multivariate analyses, Qmax and IPP were found to be statistically significant. It was determined that voiding volume, PSA level, PV, UEBW, and BWT values did not predict BOO status. Multivariate analysis results are shown in Table 3.

DISCUSSION

In patients presenting with LUTS, differentiating diseases presenting with symptoms similar to BPH and determining the severity of symptoms is an important step. Uroflowmetry and PVR are non-invasive tests for BPH and can provide insight into voiding dysfunction. However, non-invasive tests are not always sufficient to decide the most appropriate treatment option. Invasive tests have been used to determine the severity of BPH in individual patients. (11,12).

A comprehensive assessment of LUTS necessitates the evaluation of voiding pressure and Qmax through the employment of PFS. Despite the proven reliability of PFS in detecting BOO, this diagnostic method is characterized by invasiveness and high expenses. Additionally, its complexity has made it difficult to use routinely in clinical practice. Therefore, patients with a presumed diagnosis of LUTS/BPH are given an empiric first-line treatment protocol and PFS is only performed when initial medical therapy fails, or surgery is indicated. The utilization of a standardized treatment plan based on clinical experience is prone to overtreating individuals with mild BOO and those experiencing LUTS due to causes other than BOO. Moreover, in cases where BOO is the primary factor contributing to LUTS, administering empirical treatment could mask symptoms, leading to silent obstruction. These factors have expedited the progress in creating straightforward and non-invasive diagnostic tests as substitutes for PFS (13-15).

BPH is recognized as linked to structural alterations in both the prostate gland and the urinary bladder. These structural modifications can be conveniently assessed using pelvic USG (16). In this study, transrectal USG was used to better evaluate PV and TZ. We did not find any correlation between PV and BOO in our study.

Table 1. Comparison of demographic data, laboratory and ultrasonographic findings between groups

Parameters (mean±SD)	Group 1 (n=180)	Group 2 (n=140)	p-value
Age (year)	70.1±8.6	68.1±9.2	0.212
Qmax (mL/sec)	9.3±3.1	12.6±5.2	**0.001**
Voided volume (mL)	220.5±114.3	302.2±127.7	**0.001**
Postvoid residual volume (mL)	92.4±56.9	80.6±50.3	0.312
Maximal cystometric capacity (mL)	346.5±110.5	386.2±106.1	0.256
BOOI	64.8±23.1	16.8±11.6	**0.001**
PSA (ng/dL)	4.4±3.1	2.1±1.8	**0.001**
Prostate volume (mL)	55.9±32.1	39.6 ± 8.5	**0.001**
IPSS (sum)	19.3±8.8	19.8±8.0	0.089
Voiding symptom	10.9±5.8	11.7±5.5	0.516
Storage symptom	8.3±3.9	8±3.7	0.225
Quality of life	4±1.3	4.2±1.4	0.678
TZI	0.6±0.3	0.6±0.4	0.829
BWT (mm)	6.1±3.1	3.4±2.8	**<0.001**
UEBW (g)	34±13	24±12	**<0.001**
IPP (mm)	10.8±7.2	7.2±5.8	**<0.001**

Qmax: Maximal flow rate, BOOI: Badder outlet obstruction index, IPSS: International Prostatic Symptom Score, TZI: Transitional zone index, BWT: Bladder wall thickness, UEBW: Ultrasound estimated bladder weight, IPP: Intravesical prostate protrusion

A PSA level blood test is required for patients with BPH, and it should be further investigated if values exceed certain thresholds (16). In our study, the possibility of BOO in patients with PSA >4 was found to be statistically significant in univariate analyses, but no association was detected in multivariate analyses.

Uroflowmetry and PMR tests are among the tests ordered in the basic evaluation of patients presenting with LUTS. These tests guide the clinician in terms of obstruction (17). Considering the relationship between BOO and Qmax, low Qmax values were found to be significant for indicating urinary obstruction in a prospective study by Affusim et al. (18). In our study, a relationship was found between Qmax and BOO in multivariate analyses. No correlation was observed between voiding volume and PMR (which are uroflowmetry parameters) and BOO. We think that the Qmax value is one of the guiding parameters for assessing obstruction.

The accuracy of BWT measured by ultrasound in diagnosing BOO is noteworthy in this study and is consistent with findings from prior studies. However, no specific cut-off value for BWT is available. For the diagnosis of BOO, the cut-off point for BWT was 3.25 mm in Güzel et al. (19), 5 mm in Manieri et al. (20), 2 mm in Oelke et al. (21), and 2.9 mm in Kessler et al. (22). While BWT can be readily assessed using USG, its practical use as a diagnostic indicator for BOO is complex. BWT tends to be thin and is significantly impacted by the extent of bladder filling (21). In this study, USG was conducted at the point when patients reported feeling, their bladder was full. In our study, BOO was found to be 68.2% in patients with BWT >4 mm when the cut-off point was taken as 4 mm. In multivariate analyses, no correlation was found between BWT and BOO.

Unlike BWT, UEBW is not affected by bladder filling level (23). UEWB represents hypertrophy of the bladder wall and is thought to reflect BOO (24). Miyashita et al. (10), and Kojima et al. (24), reported the cut-off limit for UEBW as 35. Kojima et al. (24) reported that a higher UEBW significantly increased the risk of acute urinary retention. In our study, we evaluated the UEBW value as <35 and >35 in patients with BOO. The rate of BOO detection in patients with UEBW>35 was found to be 54.1%. In multivariate analyses, no correlation was found between UEBW and BOO.

IPP is a parameter measured by pelvic ultrasound that shows how much the prostate protrudes into the bladder. Enlargement of the prostate lobes causes BOO by narrowing the width of the bladder neck (25). IPP ≥10 mm for BOO increases the risk of acute urinary retention and decreases the response to medical treatment (26,27). Kuo et al. (28), reported that IPP had a positive predictive value of 72% for BOO. Chia et al. (29) associated the degree of IPP with BOO in their study. They graded the patients as IPP <5 mm, 5-10 mm, and >10 mm and investigated the severity of BOO according to their grades. While 94% of IPP Grade III patients had BOO, 79% of IPP Grade I patients had BOO on PFS. In our study, we divided our patients into three groups according to the degree of IPP. In patients with IPP >10 mm, the rate of BOO was 73.8%. In addition, in multivariate analyses, there was a statistically significant correlation between IPP and BOO. Our study showed that

Table 2. Univariate analysis of predicting factors for BOO

Parameters	BOO rate (%)	p-value
Age (year)		
50-59	22.6	
60-69	26.3	**0.003**
>70	51.8	
Maximal flow rate (mL/sec)		
<10	47.5	
10-15	23.1	**0.001**
>15	1.4	
Postvoid residual volume (mL)		
≥100	40.2	**0.006**
<100	27.3	
PSA (ng/dL)		
≥4	47.5	**0.001**
<4	28.4	
IPP (mm)		
<5	10.2	
5-10	29.4	**0.001**
>10	73.8	
UEBW (g)		
<35	20.1	**0.001**
≥35	54.8	
BWT (mm)		
<4	19.4	**0.001**
≥4	68.2	

BOO: Bladder outlet obstruction, BWT: Bladder wall thickness, UEBW: Ultrasound estimated bladder weight, IPP: Intravesical prostate protrusion

Table 3. Multivariate analysis of predictive factors for BOO

Variables	value	Adjusted odds ratio	95% CI	
			Lower	Upper
Maximal flow rate (mL/sec)	**0.001**	0.78	0.711	0.857
IPP (mm)	**0.001**	0.91	0.82	0.96

BOO: Bladder outlet obstruction, CI: Confidence Interval, IPP: Intravesical prostate protrusion

IPP can be used as a non-invasive parameter in patients with BOO.

Study Limitations

A noteworthy observation from the study findings is that all ultrasound-based morphological parameters, which exhibit high diagnostic precision in identifying BOO, can be conveniently assessed using suprapubic pelvic USG. The accessibility and non-invasive characteristics of this imaging modality render the evaluation of these anatomical factors suitable for regular clinical use. However, the current study is subject to certain limitations. Firstly, it did not investigate the impact of symptom duration and the severity of BOO. Secondly, only symptomatic patients were enrolled in the research. Consequently, the outcomes of the study may not be broadly applicable to individuals with asymptomatic BOO stemming from BPH.

CONCLUSION

The values of IPP and Qmax serve as significant non-invasive indicators for identifying BOO in individuals experiencing symptoms related to BPH. Clinicians can utilize these parameters in their clinical practice to aid in the diagnosis of BOO.

ETHICS

Ethics Committee Approval: This study was approved by University of Health Sciences Türkiye, İzmir Tepecik Education and Research Hospital Non-interventional Research Ethics Committee (decision no: 2024/ 02-16, date: 04.03.2024).

Informed Consent: All clinical data were collected retrospectively from patients evaluated for LUTS between 2019-2023.

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: Y.A., M.Z.K., Consept: Y.A., Design: Y.A., U.S., H.P., M.Z.K., Data Collection or Processing: Y.A., Analysis or Interpretation: Y.A., H.P., Literature Search: Y.A., M.Z.K., Writing: Y.A., U.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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