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Could Bladder Wall Elastography Be Used As An Indicator For The Diagnosys of Bladder Outlet Obstruction By Benign Prostate Hyperplasia?

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ABSTRACT

Benign prostatic hyperplasia (BPH) is one of the most common causes of bladder outlet obstruction in men. In this study we aimed to evaluate the elasticity of the bladder by Acoustic Radiation Force Impulse (ARFI) elastography in BPH patients.
Fifty benign prostate patients were included in the study. After evaluation of patients in the outpatient clinic. ARFI elastography was performed with full bladder. Elastography was performed separately on the anterior, right and left walls of the bladder. Then the patient underwent uroflowmetry. The maximum flow rate and post-mix residual values in uroflowmetry were recorded.
The mean age of the patients was 45.6 ± 3.77 The average of bladder anterior wall elasticity 3.39 ± 0.89, Bladder left wall elasticity 2,69 ± 0,82 and Bladder right wall elasticity was 3.69 ± 0.89.The mean prostate size 52.58 ± 24.16 The average of Qmax11.96 ± 4.85 The mean of PMR 77.8 ± 59.6 and mean of prostate elasticity was 2.97 ± 1.1
Urinary bladder wall elasticity with ARFI can be a diagnostic indicator for bladder outlet obstruction due to BPH.

Key Words: Bladder wall, Elastography, Indicator, Prostate hyperplasia

Introduction

Benign prostate hyperplasia (BPH) is among the most prevalent urological diseases amongst the aging men and can have a substantial effect on quality of life by contributing to bladder outlet obstruction (BOO) and lower urinary tract symptoms (1).

BPH is a major cause of voiding disorder in middle aged and elderly male population; also, the incidence increases with age (2).

The prevalence of clinical BPH is mostly identical around the world and It is mostly in correlation with age. About 20% of the men aged between 50 and 59 years, about 30% of the men aged between 60 and 69 years and about 40% of the men aged 70 years or older are affected by symptomatic BPH (3).

In BPH, blockage of bladder outlet is caused by increased detrussor pressure and decreased urine flow rate during discharge (4).

Up until now numerous indicators such as transition zone volume, intravesical prostatic protrusion, prostate urethral angulation, detrusor wall thickness, total prostate volume and resistive index of prostate capsule have been used in order to evaluate the BOO (5,6). But none of these were considered to be “the best” for the diagnosis of BOO. In order to increase the accuracy of the diagnosis BOO indicators that are non-invasive and easier to reproduce are needed (7, 8).

While promising results have been shown for ultrasound elastoghraphy for a non-invasive assessment of liver fibrosis; there is a surge of new applications for breast, prostate, lymph node, kidney, and thyroid imaging methods. In this study we review and take a through look at the principles, limitations and foundation physics behind the ultrasound elastography and summarize its current clinical use and developments currently underway in myriad of clinical applications (9).

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İn our study Acoustic Radiation Force Impulse (ARFI) elastography measurements was used in BPH patients. Whether there is a change in bladder wall elasticity in BPH patients, comparison of bladder wall elasticity with uroflowmetry and we aimed to investigate whether bladder wall elasticity is an indicator for bladder outlet obstruction by BPH.

Material and Method

Study Design: Fifty patients with primary benign prostatic hyperplasia who were admitted to our outpatient clinic with lower urinary tract symptoms (LUTS) after obtaining local ethical consent were evaluated.

Patients with primary benign prostate disease and patients who had not previously received any medical treatment for BPH were included in the study.

Patients with urethral stricture, operated from the prostate or bladder, neurogenic bladder and patients with urethritis and cystitis were excluded from study. Hemogram, urea, creatinine, full urinalysis, prostate specific antigen (PSA) and uroflowmetry were requested from the patients. Then patients were evaluated with ARFI elastography in radiology clinic. ARFI elastography was made with filled bladder. Anterior, right and left walls of the bladder and prostate elastograpy were performed. Prostate size was measured with normal transabdominal ultrasonography (US). After elastography procedure the patients were taken to uroflowmetry.

Especially, Maximum flow rate (Qmax) and post micturation residue (PMR) urine levels were determined with uroflowmetry.

ARFI Elastography: All ultrasound (US) examinations were performed using the Acuson S2000 ultrasound system (Siemens Solutions, Mountain View, CA, USA) with convex probe (6 C1, frequency range: 1-4 MHz). Acoustic Radiation Force Impulse (ARFI) measurements (Virtual Touch Tissue Quantification package) were performed by the same radiologist who had 8 years of abdominal US and four years of elastography experience and was blinded to the clinical data of the patients. Primarily, Virtual Touch Tissue Quantification (VTTQ) was implemented with the introductory recognition of a target region of interest (ROI) (box with fixed dimension of 1×0.5 cm) on a conventional ultrasound views. Then an acoustic push pulse was transported instantly on the right side of the ROI where the Shear wave velocity (SWVs) were calculated and expressed with a quantitative value (meter/second, m/s).

SWV measurements of the right, left lateral and anterior walls of the bladder and prostate parenchymal elastos were performed. The ROI was placed in the parenchyma of the bladder wall and prostate gland.

In case of invalid measurement (in X.XX m/s), the measurement was repeated. Measurements were performed while the bladder was at optimal occupancy. Numerical measurements and quantitative data on parenchymal elastic properties were expressed in meters per second (m/s) and SWV values were expressed in mean (± SD) and range.

Statistical Analysis: In this study, bladder wall elastography was compared with prostate elastos, prostate volume and uroflowmetry. In calculating the sample width and power of test was determined by taking at least 0.80 and Type 1 Error 0.05. Shapiro-Wilk test (n<50) was used to determine whether the mean distribution was normal and nonparametric tests were applied because the variables were not normally distributed. Spearman Correlation coefficients were calculated to determine the relationship between the measurements. Statistical significance level was taken as 5% in the calculations and SPSS (IBM SPSS for Windows, ver.24) statistical package program was used for the calculations.

Results

A total of 50 BPH male patients were included in the study. The mean age of the patients was 45.6 ± 3.77 The average of bladder anterior wall elasticity 3.39 ± 0.89 , bladder left wall elasticity 2,69 ± 0,82 and bladder right wall elasticity was 3.69 ± 0.89. The measurement of bladder elastography with ARFİ elastography is shown in Figure1.

The mean prostate volume was 52.58 ± 24.16 The average of Qmax11.96 ± 4.85 , The mean of PMR 77.8 ± 59.6 and mean of prostate elasticity was 2.97 ± 1.1 There was positive correlation between bladder wall elasticity, prostate elasticity, prostate size and PMR. On the other hand there was a negative correlation between bladder wall elasticity and Qmax (P<0,05).The Correlation coefficients between measurements are shown in table 1.

Interpretation of coefficients marked with a star symbol: There is a statistically significant

Table 1. Correlation coefficients between measurements

	Bladder anterior wall elastography	Bladder right wall elastography	Bladder left wall elastography	Prostate Volume	Q Max
Bladder anterior wall elastography (m/s)	1				
Bladder right wall elastography(m/s)	0.237	1			
Bladder left wall elastography(m/s)	0.277	0151	1		
Prostat Volume(cc)	.0037*	0024*	0025*	1	
Q max	0.028*	0011*	0038*	0.066	1
PMR(cc)	0.017*	0013*	0021*	0.051	0.034*
Prostate Elastography(m/s)	0012*	0018*	0017*	0.075	0.12
Urination volume(cc)	0150	021	041	024	0.31

*p<0.05 r: Spearman's rho correlations coefficients

correlation between the measurements at the intersection of this coefficient ($p < 0.05$).

Discussion

Ultrasound elastography (USE) is an imaging technology that is sensitive to tissue stiffness. It was first introduced in 1990 (10). In recent years, this method has become advanced enough to quantitatively assess the tissue stiffness. The main advantage of the elastoghrapy methods is their capability of detecting the changes of elasticity in the soft tissue which can result from specific pathological or physiological events (11).

For example many solid tumors are structurally different from surrounding healthy tissues. Therefore this difference can be utilized by elastography methods in diagnostic approaches (12).

Advancements of the method of real time ultrasound elastography as a non-invasive method for evaluation of the tissue hardness and quantitative tissue diffusion analysis has also improved the ultrasonic qualitative diagnosis behind the scenes. It improves the clinicians ability to identify and differentiate benign and malignant prostate lesions. With its popularity and usage increasing, this method might play an important role in the coming years (13).

In a study by Alan et al. a comparison of shear wave velocity (SWV) prostate values between BPH patients and healthy volunteers was carried out. As a result, the SWV of the central area was reported to be significantly higher in the BPH patients (14).

In this study, we performed bladder and prostate elastography by ARFI elastography method to determine whether bladder wall elastosis is an indicator for bladder outlet obstruction in BPH patients. Then bladder elastography compared prostate elastos, prostate volume and uroflowmetry. In this comparison we found a significant relationship between these measurements. ($P<0.05$)

Previous studies in the literature suggest the usage of prostatic urethra angle, prostatic protrusion and prostatic circle area ratio for evaluation of BOO (15, 16, 17). However none of these values are well recognized and widely used indicators for determining BOO. Resistive index of prostate capsular arteries was also used to evaluate the BOO on the basis that inner prostatic pressure is increased in BOO (7).

Prostate zone elasticity has shown promise in assessing the severity of BOO. However the most accurate non-invasive diagnosis of BOO in patients with BPH was the combination of total prostate volume and elastic modulus (18).

As seen in the above studies, many invasive methods have been used to evaluate bladder outlet obstruction. In this study, we compared the bladder wall elasticity with the prostate volume and prostate elastosis by measuring the bladder wall elasticity with a more noninvasive method, ARFI elastography. Bladder has determined that wall elastos is associated with both prostate elastos and prostate volume statistically significant. ($P<0,05$) Therefore we thought that bladder elastography may be a noninvasive and usable method for bladder outlet obstruction caused by benign prostatic hyperplasia.

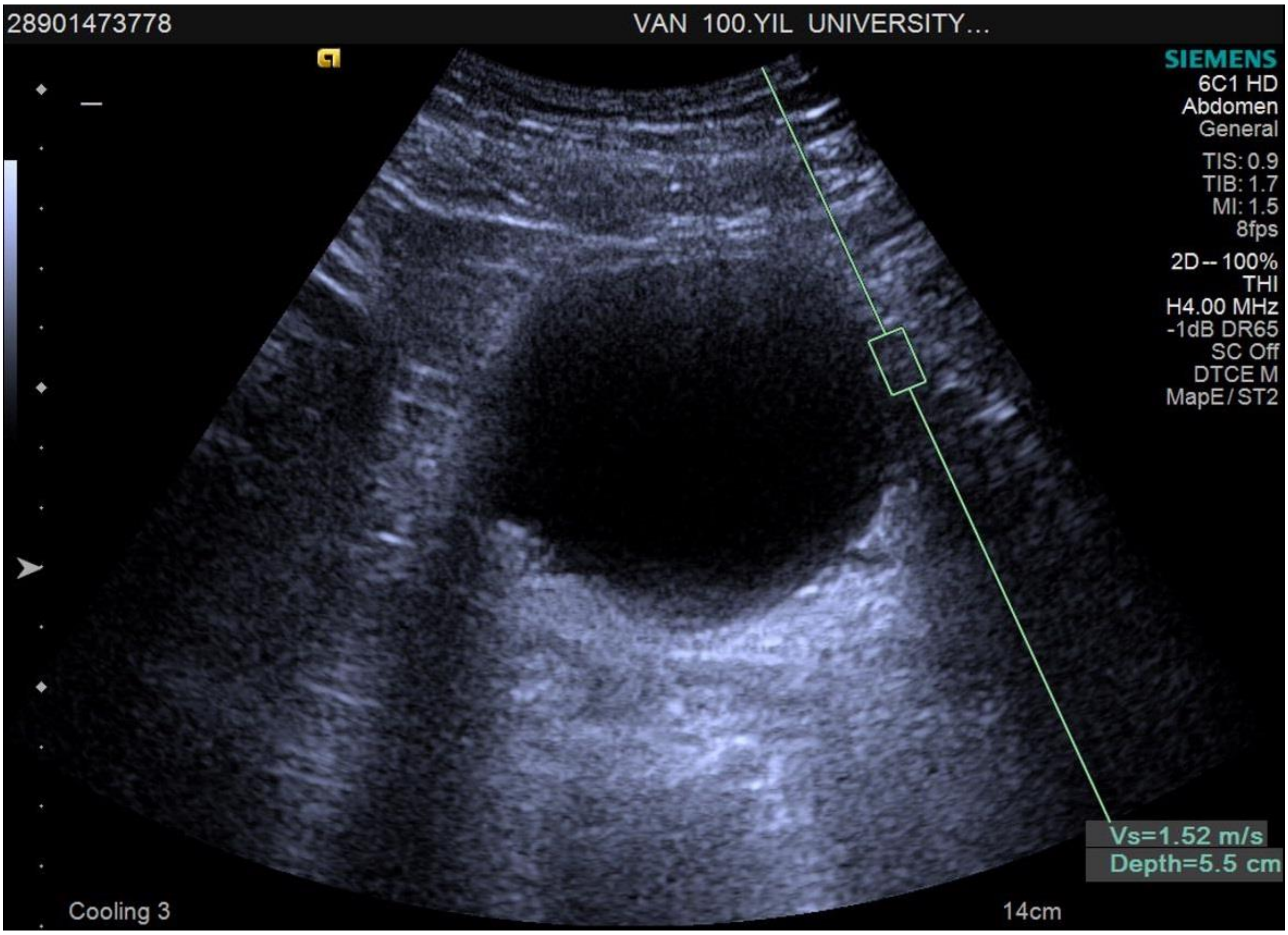

Fig.1. Measurement of bladder elastography by ARFI method

The higher elasticity of urinary bladder is due to its high rate of connective tissue relative to smooth muscle in the urinary bladder wall (19, 20). As the connective tissue to smooth muscle ratio increases the rigidity of the bladder increases and capability to expand during filling decreases which in turn reduces the bladder capacity (21).

Bladder measurements by ultrasound shear wave elastography are in correlation with bladder storage pressure and measurements of shear wave speed differentiate between compliant and non-compliant bladders (22).

Urodynamic pressure-flow study, which can differentiate BOO from detrusor underactivity is the most dependable diagnostic standard for BOO. However it is highly invasive, expensive, and because it is a painful procedure with a caveat of risks for dysuria, macroscopic hematuria, urinary tract infections, and urinary retention, it is poorly tolerated by patients (1).

Previous studies have compared bladder wall elasticity with urodynamic studies for the diagnosis of bladder outlet obstruction and found significant results. In our study, we compared bladder wall elasticity with uroflowmetry in patients with benign prostatic hyperplasia and we observed that Qmax decreases as bladder wall elasticity increases. ($P<0,05$) We found that this inverse relationship between bladder wall elasticity and uroflowmetry was statistically significant. This means, bladder outlet obstruction occurs as prostate volume increases in patients with BPH and this leads to changes in the bladder elastos.

Most of the conditions affecting the bladder are due to changes in structure and therefore shear wave elastography (SWE) might be able to determine such alterations. However the fact that physiological processes such as aging have been shown to affect tissue composition still stands. Trans-abdominal shear wave elsastography can be used in quantitative assessment of bladder neck stiffness. This method has potential to be useful in evaluation of chronic urinary retention (23).

Bladder elasticity is critical for voiding functions such as storage of the voiding cycle and stages of micturition. Bladder stiffness can show differentiation with a plethora of pathophysiological processes. The quantitative measurement of bladder elasticity is an important factor in improving our understanding of various urinary bladder disease processes and therefore improve our ability to provide better patient care. (24)

In addition, when we compared bladder wall elastography with PMR in our study we found that the bladder wall elastography increased as pmr increased and statistically significant P<0,05. Bladder elastography is to increase as the bladder function deteriorates. Therefore measurement of bladder wall elasticity in patients with benign prostatic hyperplasia by ARFI elastography is an important and non-invasive method for early diagnosis of bladder dysfunction secondary to benign prostatic hyperplasia.

The limitations of our study were the lack of urodynamic evaluation of the patients included in the study and the lack of cut-off value for bladder wall elastography is the shortcomings of the study.

Bladder wall elasticity measured by ARFI elastography in men with benign prostatic hyperplasia is easier and an inexpensive method and it can be used as an indicator of bladder outlet obstruction which caused by BPH. Comparative and larger series studies are needed in this subject.

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