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Doppler velocimetry of the prostate and its relationship with biochemical index in patients with benign prostate hyperplasia in Kano

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Abstract

Background: Benign Prostatic Hyperplasia (BPH) is a non-malignant prostate gland enlargement that produces lower urinary tract symptoms in older men. This study investigates the Resistive Index (RI) of blood flow in prostate patients diagnosed with Benign Prostatic Hyperplasia (BPH). It compares the RI values of patients with obstructive BPH, non-obstructive BPH, high Prostate-Specific Antigen (PSA) levels, and aberrant prostate size. **Materials and Methods:** The study studied 80 male patients aged 50-85 with benign prostate hyperplasia and lower urinary tract symptoms during 8 months. **Results:** The blockage rate was 65% out of 52 patients, with 35% not having it. An obstructive pattern was shown by the markedly elevated resistance index of the right and left capsular arteries. Prostate Specific Antigen (PSA) values were high in 74% of patients and low in 26%. Additionally, PSA levels were directly impacted by the enlargement of the right and left capsular. **Conclusion:** The RI measurement using prostate Doppler ultrasound can be added to the modalities available for diagnosis of BPH. Moreover, its value can be correlated to the prostate size, prostate-specific antigens, and degree of obstruction.

Keywords: *Doppler ultrasound, Prostate, Prostate-specific antigen, Transrectal ultrasound*

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1. Introduction

Benign Prostatic Hyperplasia (BPH) is a condition that primarily affects males in their middle-aged and older years (Park *et al.*, 2013). Benign prostatic hyperplasia is a condition characterized by the excessive and uncontrolled expansion of the prostate gland, which is not cancerous (Seyunkwon *et al.*, 2016). BPH is a prevalent urological disorder that affects a significant number of people (Mehmet *et al.*, 2015). BPH is the main cause of Lower Urinary Tract Symptoms (LUTS) in older men. Nearly 90% of men in their 70s experience Lower Urinary Tract Symptoms (LUTS) that indicate Benign Prostatic Hyperplasia (BPH), leading to a decline in their overall quality of life due to these bothersome symptoms (Mahmet, 2015). Benign prostate hyperplasia can occasionally lead to severe complications such as acute urine retention (Nelson and Pedorious, 1998), the requirement for surgical intervention, urinary incontinence, or recurrent urinary tract infections. The development of BPH and LUTS is influenced by aging and genetics (Terris and Stamey, 1991). Additionally, recent studies have identified unhealthy diets, lifestyle choices, inflammation, and certain cardiovascular system risk factors such as hypertension, noninsulin-dependent diabetes mellitus, obesity, smoking, dyslipidemia, and metabolic syndromes as novel modifiable risk factors for BPH. The management of these patients is dependent on the collection of patient history, conducting clinical examinations, doing laboratory investigations, and utilizing investigative modalities. These extra tools are crucial for achieving an accurate diagnosis and subsequent follow-up.

Trans-Rectal Ultrasonography (TRUS), introduced by Watanabe *et al.* (2010), has emerged as the most dependable method for diagnosing the majority of prostatic disorders. Ultrasound has been employed in structural analysis such as prostate volume assessment, investigation of echogenicity, tissue elasticity illustration etcetera. Over the last two decades, this method has been employed successfully in evaluating prostatic disease (Taylor *et al.*, 1998). Power Doppler Ultrasound (PDUS) is employed, later followed by Color Doppler Ultrasound (CDUS) which allowed us to analyze the vascular architecture of the prostate through a non-invasive method. Power Doppler ultrasonography has a high sensitivity for depicting blood flow; It also reveals the number, course, and continuity of prostatic vessels. The Resistance Index (RI) of prostatic vasculature are able to distinguish individuals with normal prostate and those with Benign Prostate Hyperplasia (BPH) and be beneficial as a novel hemodynamic parameter (Cho *et al.*, 1998).

Prostate-Specific Antigen (PSA) is a blood test that analyzes the level of PSA in a sample of blood. Prostate-specific antigen is a protein generated by the prostate. Prostate-specific antigen is used to screen for prostate cancer (Hayami *et al.*, 2002). Cancer screening implies looking for an indication of cancer before it develops symptoms. The prostate starts growing around the age of 40 years and never quits. It may be walnut-sized in young men, but in men over age 40 years the gland can acquire a much bigger size. As noted above, the PSA tends to grow as the prostate becomes larger. Prostate-specific antigen is an organ-specific maker that is raised in prostate lesions (Rikfin *et al.*, 1993). Because the blood level of PSA is raised in both benign and malignant illnesses of the prostate, it is therefore, non-specific although it is the most often used tumor marker for screening prostate cancer and any value greater than 4 ng/ml is suspicious of prostate lesion. The blood level concentration of PSA of malignant tissue appears to be thirty-fold bigger than the normal prostate epithelium and ten-fold that of BPH (Hayami *et al.*, 2002).

Prostate prostate-specific antigen test is a simple test that analyzes the presence of prostate-specific antigen circulating in the bloodstream (Leventis *et al.*, 2001). This test is the initial step in screening for BPH for prostate cancer detection. The resistive index is a measure of blood flow resistance that can be used to evaluate vascular injury (Miller and Ackermann, 1996). Gray scale B-mode mode ultrasonography is utilized to visualize the shape of the prostate gland while the Doppler provides information about vascularity of prostate tissue (Tsuru *et al.*, 2002). The routine (grayscale B-mode) application and reporting of Doppler parameters may assist in enhancing the specificity of BPH and contribute to monitoring of this BPH (Shih-Tsung and Ming-Li, 2008). Some research demonstrates an association between prostate arteries resistive index with some BPH indicators in developed countries. However, the Doppler resistive index can be beneficial in screening for BPH in identifying prostate cancer if there is a link between prostate-specific antigens and an increased resistive index of arteries supplying the prostate in patients with BPH. No study has been done on the evaluation of the resistive index of prostatic blood flow in BPH patients compared to obstructive BPH, non-obstructive BPH, high PSA, and non-elevated PSA, in Kano best to the researcher's knowledge. This study aims to evaluate the

resistive index of prostatic blood flow in BPH patients compared to obstructive BPH, non-obstructive BPH, high PSA, and non-elevated PSA, in Kano.

2. Materials and methods

This prospective cross-sectional study was conducted in the radiology department of Murtala Muhammad Specialist Hospital, Kano, where elderly male patients of age between 50 to 85 years with Benign Prostatic Hyperplasia (BPH) and Lower Urinary Tract Symptoms (LUTS) were recruited for the study. Elderly male patients with prostatitis, neurological bladder, and other pathological disorders (bladder stone) were excluded from the study. Ethical approval was gotten from Kano State Ministry of Health. A Sample size of 80 was used for the study. Statistical analysis was performed using SPSS, version 27. A descriptive statistic was used to get the mean ± SD, and statistical analysis was performed using a two-sample t-test. A p-value < 0.05 was regarded significant.

The prostate scan was carried out utilizing a GE Ultrasound system equipped with a 5-10MHz transrectal probe. All transrectal ultrasonography in this study were carried out only by consultant radiologists to avoid inter-observer variability. Doppler values were obtained at the right and left capsular arteries twice by the same investigator and an average is utilized for the comparison to increase the dependability of results. Digital Rectal Examination (DRE) is done before insertion of the probe to exclude contraindications to the procedure including rectal bulk, rectal stenosis, etc. the prostate was scanned through the anus in both longitudinal and transverse planes to determine the morphology. The transverse scan was done starting from above the bladder base at the level of seminal vesicles to the level of the apex of the prostate while the longitudinal scan was done from the right to left lateral aspect of the gland. The Doppler window was placed on B-mode imaging and was adjusted to cover the whole periphery and most of the central area of the gland to examine the symmetry and flow throughout the prostate. Using broadband with a 5-10 MHz dedicated endorectal probe, the Doppler spectral waveform of the capsular artery at the neurovascular bundle was measured bilaterally at a fixed angle of 56° and a sample volume (gate) of 2 mm. the pulse repetition frequency was set to 800 Hz, with a wall filter of 50 Hz. The capsular arteries at the neurovascular bundle sites were evaluated at the point right before they enter the prostate rather than the intraprostatic branches penetrating the gland. Once the pulsatile waveform of a particular Doppler spectrum becomes steady for the consecutive five repeats. The Peak-Systolic Velocity (PSV), End-Diastolic Velocity (EDV), and resistance index of each site were measured and documented in the study sheet.

3. Results

In total, 80 patients were enrolled in this trial. The age range was 50 to 85 years with mean age of 64.29 ± 9.39. Four parameters were researched and the values of these parameters are given in the Table 1. According to the pelvic ultrasonography, patients were classified: as obstructive and non-obstructive. Fifty-two (65%) patients were obstructed and twenty-eight (35%) patients were non-obstructed. There is a highly significant rise in RI of the right and left capsular arteries connected to higher obstructive pattern of patients (Table 2).

According to the prostate-specific antigen test and velocimetry Doppler index, our patients were categorized into PSA elevation and non-PSA elevation. Fifty-nine (74%) patients have raised PSA and twenty-one (26%) patients had no elevated PSA. The mean RI of right and left capsular arteries was measured in each group and summarized in (Table 3). There is a highly substantial rise in right and left capsular arteries connected with higher PSA value.

The size of the prostate was assessed by TRUS and termed normal when < 25 g and enlarged if > 25 g. Four are deemed to have a normal prostate and seventy-six had an enlarged prostate. There was a significant rise in RI of right and left capsular arteries connected to an increase in the prostatic volume (Table 4).

4. Discussion

This study has compared RI values of enlarged prostate with prostate-specific antigen and bladder obstruction due to enlarged prostate utilizing prospective data from patients suspected of BPH and lower urinary tract infection.

Table 1: Mean and range distribution of participants

Parameter	Mean ± SD	Range
Age (years)	64 ± 9.4	50-85
Prostate volume (cm^3)	85 ± 28.4	46-151
RI of left capsular artery	0.69 ± 0.08	0.61-0.91
RI of right capsular artery	0.69 ± 0.09	0.60-0.90

Table 2: Comparison of RI of right and left capsular artery between obstructive and non-obstructive group of patients

	Obstructive N = 52	Non-obstructive N = 28	T	(p-value)
	Mean ± SD (Range)	Mean ± SD (Range)		
RI of right capsular artery	0.71 ± 0.90 (0.62-0.90)	0.67 ± 0.06 (0.60-0.88)	-10.6	<0.001
RI of left capsular artery	0.70 ± 0.91 (0.61-0.91)	0.67 ± 0.07 (0.60-0.89)	-10.4	<0.001

Table 3: Comparison of the RI of right and left capsular artery between patient with elevated and non-elevated prostate specific antigen

	Elevated PSA N = 21	Non-elevated PSA N = 59	T	(p-value)
	Mean ± SD (Range)	Mean ± SD (Range)		
RI of right capsular artery	0.82 ± 0.07 (0.69-0.90)	0.65 ± 0.04 (0.60-0.81)	10.3	<0.001
RI of left capsular artery	0.79 ± 0.08 (0.66-0.91)	0.66 ± 0.05 (0.64-90)	10.8	<0.001

Table 4: Comparison of parameters between patients with normal prostate size and those with enlarge prostate

	Normal size prostate N = 4	Enlarge prostate N = 76	T	(p- value)
	Mean ± SD (Range)	Mean ± SD (Range)		
RI of right capsular artery	0.64 ± 0.04 (0.62-0.72)	0.77 ± 0.06 (0.63-0.90)	-4.1	<0.001
RI of left capsular artery	0.65 ± 0.05 (0.60-0.74)	0.77 ± 0.08 (0.61-0.91)	-3.6	<0.001

In the present study, out of 80 patients, 52 (65%) were diagnosed to be obstructed and the remaining 28 (35%) were non-obstructed based on the uroflowmetric tests by pelvic ultrasonography. There was a substantial difference in RI of the right capsular artery between obstructed and non-obstructed groups ($p<0.001$). There was a significant difference in RI of the left capsular artery between obstructed and non-obstructed groups ($p<0.001$). There was a highly significant rise in RI connected to the higher obstructive pattern of flow rates of the patients. Although there was substantial statistical value between RI of the right and left capsular arteries for higher PSA value. Also, there is a substantial difference between the RI of enlarged prostate size with that of normal prostate for both the right and left capsular arteries.

Osama *et al.* (2012) study 82 patients with lower urinary tract infections and enlarged prostate. Out of 82 patients, 62 (76%) were diagnosed to be obstructed and 20 (24%) were non-obstructed uroflow-metric tests. There was a significant difference in RI of right capsular arteries between obstructive and non-obstructive groups ($p<0.001$). There was a significant difference in RI of the left capsular artery between the obstructive and non-obstructive groups ($p<0.001$). Same as my study. Kojima *et al.* (1997 and 2000) reveal a substantial association between RI and urodynamic parameters blocked in peak flow rate (Q-max) of uroflow-metry and IPPS in their investigation. Out of 33 patients with blockage, 28 (85%) had a RI of 0.7 or greater, while 11 out of 24 patients (46%) without obstruction had a RI of less than 0.7.

Jamal and Khadir (2001) showed that RI increased significantly correlated to an increase in prostatic volume and that there was a significant difference in RI between patients with normal prostate and those with BPH (0.64 ± 0.04 vs 0.74 ± 0.06 $p< 0.001$) this result agrees with previous study and similar to our result.

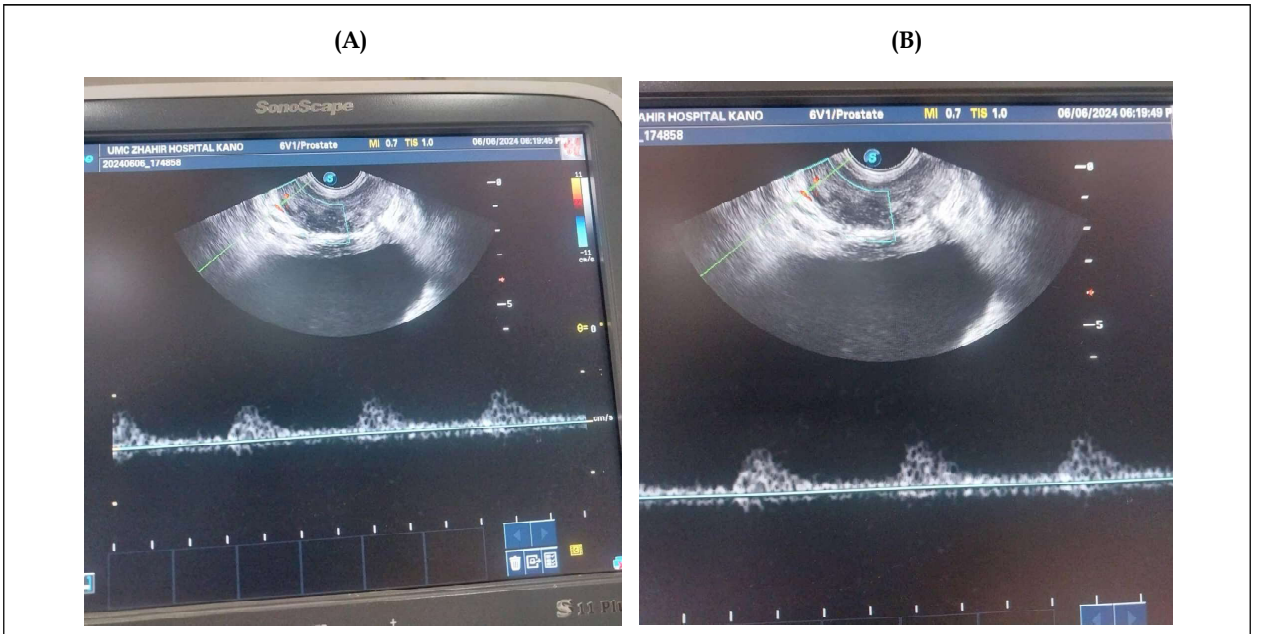

Figure 1: Doppler velocimetry of the prostate capsular arteries demonstrating low-resistive monophasic waveforms. Both A and B demonstrates unidirectional (monophasic) waveform that did not cross the zero-flow baseline throughout the cardiac cycle

5. Conclusion

This study has shown the association between RI of the right and left capsular arteries in a group of patients with prostate obstruction the bladder, enlarged prostate, and also those groups with elevated PSA value. Therefore, the RI measurement by prostate Doppler ultrasound can be added to the modalities available for diagnosis of BPH. Moreover, its value can be associated to the prostate size, prostate-specific antigens, and degree of blockage.

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