



Transabdominal and Transrectal Sonographic Variation of the Prostate Volume and Dimensions: In Evaluation of Benign Prostatic Hyperplasia

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Authors' contributions

This work was carried out in collaboration between all authors. Author SKPK designed the study and wrote the protocol. Authors AA and PM assisted in conducting the ultrasound. Authors SM and TRR managed the literature searches, analyses of the study performed by authors BS and SRR coordinated and wrote the final draft of the manuscript. All authors read and approved the final manuscript and all the process.

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ABSTRACT

Benign prostatic hyperplasia (BPH) is the non-malignant enlargement of the prostate. Estimation of Prostate volume and dimensions contribute significantly to the management of BPH. Correlations between the trans-abdominal and trans-rectal ultrasound methods in estimating prostate volume

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and dimensions were studied with variable results. Ninety-one consecutive patients of 50 years or older with were scanned by Trans abdominal and transrectal sonographs (TA&TRUS) at the same session after obtaining the consent. All the scans were performed on a single ultrasound machine. The volume and dimensions of the prostate obtained by both methods were compared and correlated using Pearson correlation coefficient. The data was analysed further in groups based on volumes and ethnicity. Twenty-four patients were also scanned by other consultant radiologist and the data was analysed to compare the interobserver variations.

Results: The mean age of the patients was 66.03 ± 10.41 years. The mean prostate volume for ninety one patients by TA & TRUS was 44.4 ± 35.1 ml and 46.2 ± 34.7 ml, respectively ($r = 0.965$, $p < 0.001$). Among the total patients 42 were of East Indian (EI) origin, 45 were of Caribbean African (CA) origin and 4 were of mixed race. The mean prostate volume of EI race by TA & TRUS was 35.3 ± 23.3 and 38.9 ± 25.9 ml respectively ($r = 0.950$, $p < 0.001$). The mean prostate volume of CA race by TA & TRUS was 50.8 ± 39.4 and 51.0 ± 38.5 ml, respectively ($r = 0.967$, $p < 0.001$). The mean prostate volume of observer A and observer B by TA & TRUS was 43.5 ± 28.8 and 45.8 ± 25.9 ml ($r = 0.953$, $P < 0.001$) and 46.6 ± 39 and 46.9 ± 27.4 ml ($r = 0.877$, $p < 0.001$) respectively.

Conclusion: Strong correlation between TA & TRUS estimation of prostate volume and dimensions for volumes up to 100ml found in our study offers TAUS as a cost effective, less invasive, quick and well tolerable alternative to TRUS. TRUS however may be a reasonable choice for accurate measurements in larger (>100 millilitres) prostates, this needs to be further investigated by a larger sample size.

Keywords: Benign prostatic hyperplasia; transabdominal ultrasound; transrectal ultrasound; prostate volume and prostate dimensions; ethnicity.

1. INTRODUCTION

Benign prostatic hyperplasia (BPH) is the non-malignant enlargement of the prostate. It refers to stromal and glandular epithelial hyperplasia that occurs in the periurethral transitional zone. BPH clinically manifests as lower urinary tract symptoms (LUTS) consisting of irritative symptoms like urgency, frequency and nocturia and obstructive symptoms like hesitancy, a weak and interrupted urinary stream, straining to initiate urination and a sensation of incomplete bladder emptying [1]. Chronic obstruction may eventually lead to acute urinary retention (AUR), recurrent urinary tract infection (UTI), hematuria, bladder calculi, and renal insufficiency [2]. LUTS in old age significantly reduces the patient's quality of life. Berry et al. [3] in his histological studies proposed that hyperplasia existed almost exclusively in glands greater than 20 gm in men greater than thirty years of age. The prevalence of LUTS due to BPH increases with increasing age. Moderate to severe symptoms occur in 40% of men after the age of 60 and 80% of men by 80 years. Nearly all men develop microscopic BPH by the age of 90 years. The approach used to treat BPH depends upon a number of factors like age, quality of life, prostate size, weight, prostate-specific antigen level, and severity of the symptoms [4]. The aim of treatment of BPH is to improve symptoms, relieve obstruction, improve bladder emptying, prevent UTIs, and

avoid renal insult for this the treatment options considered as watchful waiting, pharmacological treatment and surgical treatment. The surgical treatment options include transabdominal open prostatectomy, transurethral resection of prostate and laser ablation. During the last decade laser therapy has developed significantly and is emerging as a challenging alternative to TURP. Various authors based on the volume of prostate have studied different types of lasers in treatment of BPH [5]. Dimensions and volume of the prostate hence are important preoperative criteria for deciding on the surgical method. Therefore, it is quite important to accurately assess the dimensions and volume of the prostate in patients with benign prostate hyperplasia [6].

2. MATERIALS AND METHODS

The study was conducted at San Fernando General Hospital, Trinidad. The study was planned and conducted strictly in accordance with Helsinki principles and good clinical practice. Ethics committee approval was obtained in prior for the study. The patients were consented for the study after explaining the procedure in detail. Patients had a free will to participate in the study.

2.1 Sample Selection

Patients having lower urinary tract symptoms with proven or suspected benign prostatic

hypertrophy were included in the study. Patients with history of transurethral resection of prostate and known cases of prostate cancer were excluded from the study because the volume determination by ellipsoid method is inadequate in such patients. Patients unwilling to undergo transrectal ultrasound were also excluded from the study.

A total of 107 patients presented in three months to ultrasound department with requests for transrectal ultrasound (TRUS). Ninety one patients met the inclusion criteria for the study. Seven patients were uncomfortable with TRUS and did not consent to the procedure and nine patients had prostate cancer as the primary diagnosis and hence were excluded from the study (Table 1).

The patients were all scanned for transabdominal, and followed by transrectal ultrasound, during the same session. Twenty four patients were also scanned randomly during the same session by an independent consultant radiologist in order to exclude the bias, and to see if any significant inter observer variations were present in the study. The volumes measured by the two observers were blinded in order to avoid any possible bias.

2.2 Materials

SIEMENS ACUSON ANTARES ultrasound machine was used for scanning the patients. The patients were all scanned on the same machine in order to avoid calibration errors. Transabdominal scans were done with a low frequency of 3-5 MHz with curved transducer. Transrectal ultrasound scans were performed with a high frequency of 4-9 MHz with endocavitary transducer. Dulcolax 10 mg per oral and 5 mg suppository was given to take the night before the day of appointment for bowel preparation as a prerequisite for performing TRUS which is the standard protocol followed in most hospitals.

2.3 Procedure

The patients were asked to fill the bladder. The desirable bladder volume was a moderate amount approximately 100-200 millilitres (ml) [7]. Once the patients had the desire to micturate, the volume of bladder was calculated. Patients with larger volume were advised to partially empty the bladder until the desired volume was

achieved. The transabdominal ultrasound scans were performed in the supine position and necessary measurements obtained. The patient then was asked to empty the bladder completely for transrectal ultrasound. The patient after being prepared was scanned in a lateral decubitus position using endocavitary probe transrectally. A latex condom was used as a probe cover for performing TRUS.

2.3.1 Prostate dimensions and volume

The craniocaudal dimension is measured in the sagittal plane. The transverse and anteroposterior dimensions of the prostate were measured in the transverse plane. The craniocaudal dimension was measured from the base of the prostate to the apex. The transverse dimension was measured as the maximum distance between the right and left lateral margins where the prostate is visualized at its maximum width. The anteroposterior dimension was the maximum distance between the anterior and posterior margins of the prostate where it was perpendicular to the transverse dimension. The prostate volume was calculated by using the ellipsoid formula, which is multiplication of the three dimensions, by 0.524 ($\pi/6$).

$$\text{Volume} = \text{length} \times \text{width} \times \text{height} \times 0.524(\pi/6).$$

2.4 Statistical Analysis

Statistical analysis were done by using the paired-sample *t* test to compare the differences between prostate volumes in different groups and ethnicities. The correlations were assessed by using the Pearson correlation coefficient. IBM SPSS VER 13 software was used to calculate correlation coefficients.

3. RESULTS

Data was represented as means \pm 0.05 standard deviation. In all tests, *p* values of ≤ 0.05 were considered significant and *P* values > 0.05 were considered as a trend. The mean age of the patients presented for the study was 66.03 ± 10.41 years. The mean prostate volume for total patients calculated transabdominally was 44.4 ± 35.1 ml. The mean volume of prostate by transrectal ultrasound method was 46.2 ± 34.7 ml. Among ninety one patients scanned, forty two patients were East Indian origin, forty six were Caribbean African origin and three of the patients were of mixed race.

The mean prostate volume of East Indians by TAUS and TRUS was 35.3±23.3 and 38.9±25.9 ml respectively. The mean prostate volume of Caribbean Africans by TAUS and TRUS methods was 50.8±39.4 and 51.0±38.5 ml respectively. The patients were further classified into three groups based on the volume, Group A- patients with volume <50, Group B- those with volume 50 ml to 100 ml and Group C- with volume > 100 ml. The mean volume of prostate by TAUS and TRUS for the different groups was: Group A- 26.4±9 and 27.9±8.6 ml. Group B- 61.6±18.1 and 62.7±12.5 ml and Group C- 46.3±42.5 and 154.1±26.6 ml.

Among 91 patients, two observers scanned 24 patients at the same session. The mean volume of the Prostate scanned by observer A by TAUS and TRUS was 43.5±28.8 and 45.8±25.9 ml respectively. The mean volume of the prostate scanned by observer B by TAUS and TRUS was 46.6±39 and 46.9±27.4 ml respectively. The mean volumes for all the patients, different

groups, races and different observers are shown in the Table 1.

The mean and standard deviations of the prostate dimensions, craniocaudal (length), transverse (width) and anteroposterior (height), measured by both TAUS and TRUS for the total patients, groups, races and observers are given in the Table 2.

The three dimensions and volume of prostate obtained by the two methods were correlated using Pearson correlation coefficient. The correlation coefficients between the dimensions and volume of prostate for all patients, different groups, races and observers are given in the tables.

We found significant positive correlation between volumes and dimensions between the two methods involved for the total patients in this study. In all patients the strong correlation among dimensions was observed in craniocaudal dimension 0.892 and p<0.001.

Table 1. The mean volumes of prostate for all patients, groups, races and different observers. TAUS- transabdominal ultrasound. TRUS- transrectal ultrasound. N- number of patients

	Mean and standard deviation of prostate volume by TAUS	Mean and standard deviation of prostate volume by TRUS	No. of patients
Total patients	44.4±35.1	46.2±34.7	91
Group A	26.4±9.0	27.9±8.6.	59
Group B	61.6±18.1	62.7±12.5	26
Group C	146.3±42.5	154.1±26.6	6
East Indians	35.3±23.3	38.9±25.9	42
Caribbean Africans	50.8±39.4	51.0±38.5	45
Observer A	43.5±28.8	45.8±25.9	24
Observer B	46.6±39	46.9±27.4	24

Table 2. The mean dimensions of prostate by two methods. All values are in mm. SD standard deviation, TACC-transabdominal craniocaudal TATR-transabdominal transverse, TAAP-transabdominal anteroposterior, TRCC-transrectal craniocaudal, TRTR-transrectal transverse, and TRAP- transrectal anteroposterior. N- number of patients

Groups	TACC	TATR	TAAP	TRCC	TRTR	TRAP	No. of patients
Group A	33.5±4.8	46.1±6.2	31.8±4.8	40.7±4.5	45.3±4.7	29.2±6.2	59
Group B	45.9±5.8	55.5±8.9	45.3±5.2	52.9±4.6	54.0±4.6	41.9±4.7	26
Group C	63.0±9.4	70.6±7.8	61.9±6.3	69.3±4.3	64.6±5.4	65.2±6.2	6
East Indians	36.1±6.9	48.3±9.2	35.3±8.4	43.7±8.0	48.2±6.8	32.5±9.5	42
Caribbean Africans	41.0±11.1	52.2±10.1	39.3±10.8	47.7±10.3	49.6±7.8	36.9±11.8	45
Observer A	39.8±7.5	50.9±10.2	37.4±9.1	47.8±8.8	49.5±5.9	36.0±9.2	24
Observer B	45.1±11.3	45.2±8.9	37.7±8.0	47.9±9.3	49.7±5.8	35.5±9.5	24

Between the two different races also there was significant correlation for volumes and dimensions between the both methods as shown in Tables 1 and 2. The craniocaudal dimension had a Statistically significant correlation for the Ethnic population as the study group (East Indians- r 0.861 $p < 0.001$ and Caribbean Africans- r 0.916 and $p < 0.001$). The scatter plots for correlations between the volumes for all patients, races and observers are mentioned in.

4. DISCUSSION

Benign prostatic hyperplasia (BPH) is the non-malignant enlargement of the prostate gland. BPH is a disease of elderly causing LUTS and leading to decreased quality of life. The symptoms and method of management of BPH are directly proportional to the volume of the gland enlarged. The medical or surgical management of BPH, TURP, open prostatectomy or laser ablation depends on prostate size. Hence measurement of prostate volume is important in managing BPH [2-5].

In the past many methods of estimating prostate volume were described such as retrograde urethrography, cystourethrography and urethral pressure profile, etc. These methods are however inaccurate, historical and have been replaced by ultrasonography in estimating accurate prostate volume. Digital rectal examination is also used for estimation of prostate volume and is still the initial way of clinically assessing the prostate size approximately [8,9].

Ultrasound forms an integral part of evaluating the prostate in patients with BPH [6]. The prostate size using ultrasound can be estimated in many ways, transabdominally, transperineally and transrectally. Among these, the two most commonly employed methods in clinical practice for assessment are TAUS and TRUS.

TRUS is considered currently as the most accurate and reliable in measuring the volume. A strong correlation has been reported between prostate weights measured by TRUS and the real prostate weight in specimens excised operatively or in cadavers [10]. The prostate zonal anatomy is better assessed by TRUS. Determination of focal nodules and parenchymal structure of prostate is better visualized by TRUS [11-13]. It is for this reason that TRUS is used as guidance to biopsy the prostate in suspected cases of prostate cancer. Our study

also showed that in all cases the prostate was better visualized by TRUS with good anatomical and zonal distinction.

The disadvantages of TRUS have however been described. P. Prassopoulos [14] and colleagues in their study described TRUS to be discomforting in patients with anal fissures, hemorrhoids, anal fistula and low pain threshold. TRUS will also be precluded in patients with history of abdominoperineal resection. In these situations one has to rely on TAUS for measuring prostate volume in evaluation of BPH. In our study we also observed that 7 patients did not consent to the TRUS secondary to either one of the above-mentioned factors. TAUS on the other hand are non-invasive, readily available, less expensive and better tolerated by the patient. TAUS have the added advantage of evaluating the morphology of the bladder better than by TRUS in patients with BPH.

Authors from previous articles described significant correlations between prostate volume measured by TAUS and TRUS. Strong correlation between TAUS measurements of prostate dimensions and volume and the real prostate weight in excised specimens has been reported [15,16]. Yuen and colleagues also found that strong correlation existed between the TAUS and TRUS and stated that TRUS can be replaced by TAUS in evaluating prostate volume in BPH [17]. Prassopoulos and colleagues found strong correlation between the TAUS and TRUS with $r = 0.948$ and $p < 0.001$ [14].

Huang Foen and colleagues showed that there is significant correlation between the volumes measured by TAUS and TRUS with Pearson correlation coefficient(r) 0.84 and < 0.001 [18]. Ozden et al. [19] showed significant correlation between TAUS and TRUS with r -value of 0.94 and $p < 0.001$. In our study we found a similar strong correlation between TAUS and TRUS with r -value of 0.96 and $p < 0.001$.

The studies done previously also stressed the importance of not only the volume but also the dimensions of prostate in evaluating BPH. Watanabe and Miyagawa [20] concluded in their study that in addition to the prostate size, horizontal shape of the prostate (height: width ratio) is important in assessing the degree of urinary tract obstruction secondary to BPH. Chia et al. [21] suggested that the degree of bladder outlet obstruction secondary to BPH is better assessed by TAUS measurement of intravesical

prostatic protrusion (part of craniocaudal dimension) as it correlated significantly with pressure flow studies. Doebler et al. [22] from his study concluded that mathematically strong correlation was found between the maximal transverse prostate dimension determined using TAUS method and that obtained using TRUS method and described its clinical value in performing transurethral needle ablation of the prostate. Ozden et al. [19] in his study found strong correlation between the three dimensions measured by TAUS and TRUS methods. In our study we correlated the three dimensions measured by both methods for all patients and found that significant correlations existed between the two methods. The best correlation was seen for craniocaudal dimension measured by both methods. This was in agreement with the study of Ozden et al. [19].

According to American Urological Association (AUA) guidelines the management of BPH depends on the severity of LUTS and Quality of life. One of the important factors in determining the method of management is prostate volume. Surgical options in management of BPH are open prostatectomy, TURP and laser therapies. Open prostatectomy has been recommended for large prostates with volume >80-100 ml. Open prostatectomy is however associated with greater morbidity and mortality. Kumar SM [23] studied the usefulness of laser therapy than open prostatectomy in patients with volume > 60 ml. Gurdal et al. [24] showed that YaG laser ablation of prostate combined with TURP had resulted in good homeostasis and better improvement of the LUTS in patients with larger prostates when compared to open prostatectomy. For the study they selected the patients with prostate volume of 50 ml or higher. Also in medical management of BPH the large meta-analysis done by Boyle and colleagues concluded that treatment with 5 α -reductase inhibitors is more effective in larger prostates than in smaller prostates and they took 50 ml as cut off volume [25].

Taking these management options into consideration, we studied the correlations between the TAUS and TRUS at different prostate volumes. The study group was categorized into three groups. This is the first study per our knowledge to include a group with patients having a prostate volume>100 ml. The correlations between the three groups are found as shown in the Tables 1 and 2 in the results. Compared to the previous studies, we

found that the volumes measured by the two methods had a similar significant correlation with a $p<0.001$ for group A and group B. However in group C with volumes>100 ml, weaker correlation was observed.

In the study group B with volumes 50-100 ml, the craniocaudal dimension weakly correlated compared to the other dimensions, $p<0.05$. Group C on the contrary showed only trend but no correlations among all the dimensions. This may be attributed to the small sample size of this group. In our study we found significant correlation between the TAUS and TRUS volume estimation with good agreement between the two observers. Inter-observer variability in estimating the volume of prostate according to Huang Foen JW and colleagues had no significant difference in TAUS and TRUS measurements of prostate [18]. Choi et al. [26] and Kim et al. [27] in their studies suggested that interobserver variability when performing TRUS is influenced by experience of the observer and more so in larger prostates. The explanation was that when prostate becomes enlarged the apex of prostate becomes continuous with the urethra making anatomical distinction difficult. This causes some variation in length dimension, which in turn will affect the volume. In our study we found that the correlation between the anteroposterior dimensions was higher (r 0.724, $p<0.001$) when performed by the consultant radiologist than by the investigator (r 0.502 and $p<0.05$). This could possibly be accounted for by the small sample size used for interobserver correlation. The rest of the findings were well correlated with good interobserver agreement.

Racial variations in prostate size have been described by Kristal et al. [28] who stated that black race and Hispanic ethnicity have an increased risk for BPH. Nixon RG and colleagues found that variation in prostate sizes are seen among patient populations. They stated that whites and Africans have larger prostates than Asians [29]. The variations in prostate sizes are not studied in East Indians and Caribbean Africans to our knowledge. Also the correlations between the TAUS and TRUS studied previously were done only in one individual group. We have the advantage of studying the correlations between TAUS and TRUS prostate volumes and dimensions for these races. We found that the average size of prostate was higher in CA than in EI. The average size of the prostate in CA and EI by TAUS method was 50.8 ± 39.4 and 35.3 ± 23.3

respectively. The average size of prostate in CA and EI measured by TRUS was 51.0 ± 38.5 and 38.9 ± 25.9 respectively. The TAUS and TRUS measurement of prostate dimensions and volumes in both races was also statistically well correlated.

5. CONCLUSIONS

The significant correlation between the TAUS and TRUS volume and dimensions of prostate up to 100 ml, of different ethnic groups makes TAUS more cost effective, less invasive, and quick and well tolerable alternative to TRUS. For patients with larger gland volumes TRUS may be a reasonable choice for accurate measurements. This needs to be further investigated with a larger sample size.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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