

# Transrectal Ultrasound Prostate Volume Correlation with Serum Prostate Specific Antigen Level in Patients with Prostatic Enlargement in Port Harcourt

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## Abstract

**Background:** Prostatic enlargement is common among aging men which is associated elevation of serum prostate specific antigen (PSA) level. Prostatic enlargement could be due to benign prostatic hypertrophy, prostatitis, or prostatic neoplasms. **Aim:** The aim of this study is to determine transrectal ultrasound prostate volume (TPV) correlation with serum prostate specific antigen level in patients with prostatic enlargement. **Subjects and Methods:** One hundred and forty-three (143) males referred for ultrasound prostate evaluation with clinical diagnosis of prostatic enlargement that fulfill the study criteria were studied, using LOGIQ P6 PRO GE Healthcare machine fitted with 10MHz transrectal probe while the PSA level was estimated by Enzyme Immunoassay using DIAGNOSTIC INC PSA KIT. The blood samples were collected before the ultrasonic evaluation. The antero-posterior, transverse and cranio-caudal diameters of the prostate gland were obtained and the prostate volume generated by the ultrasound machine. The data collected was analyzed using SPSS windows version 21.0 statistical software. Correlation between variables was determined using Pearson correlation coefficient and linear regression analysis. **Results:** The mean (Mean±SD) transrectal Prostate Volume (TPV) and serum PSA levels were 66.13±30.43cm<sup>3</sup> and 8.50±3.95ng/ml respectively. Pearson's Correlation between TPV and Serum PSA level gave a correlation coefficient (r) of 0.809 (pvalue of 0.01). TPV and Serum PSA concentrations did not show correlation with Body Mass Index. **Conclusion:** This study showed a significant correlation between transrectal prostate volume and serum PSA concentration in patients with prostate enlargement. Therefore, TPV can be used as alternative method of estimating serum PSA concentration where direct measurement is absent.

**Keywords:** Transrectal Prostate Volume, Serum Prostate Specific Antigen, Prostatic Enlargement, Rivers State University Teaching Hospital.

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## Introduction

In the evaluation of the morphology and function of the prostate gland, prostate volume<sup>[1,2]</sup> and prostate specific antigen concentration are very valuable diagnostic tools. The prostate gland is a fibromuscular male reproductive organ located at the base of the urinary bladder and anterior to the rectum. Embryologically it is endodermal in origin and had up of peripheral zone, central zone and transition zones in proportions of 70%, 25% and 5% glandular tissues respectively as well as an anterior non-glandular isthmus.<sup>[3]</sup> The prostate gland enlarges with ageing due to benign prostatic hyperplasia, prostatitis and prostatic cancer with benign prostatic hyperplasia (BPH) been the commonest cause<sup>4</sup>; and its surgical intervention being the second most common surgery among aged men<sup>5</sup>. Prostate volume evaluation is valuable in the treatment of BPH.<sup>[6,7]</sup> Several imaging modalities such as plain films, Intravenous Urography (IVU), Micturating Cystourethrography (MCUG), Retrograde Urethrography (RUG), Magnetic

Resonance Imaging (MRI), Computed Tomography (CT) and Sonography can be used in the assessment of the prostate gland.

Transabdominal, trans-perineal, trans-urethral, and trans-rectal ultrasonography are the common routes in the evaluation of the prostate. Trans-rectal route is the most common route of investigation of the prostate gland by urologist because it is useful in the evaluation of the size, shape, and morphology of the gland relatively accurately and non-invasive.<sup>[8]</sup> Thus it has been proven to be more accurate among others although associated with some patient discomfort.<sup>[9]</sup> It is safe noninvasive, reproducible, and cost effective as the transabdominal route.

Prostate specific antigen (PSA) is a glycoprotein enzyme found in blood and tissue of men which serves as a tumour marker in the diagnosis and management of prostatic diseases. It is also present in normal quantity in the serum of men with normal prostate but often elevated in prostatic diseases such as prostatic enlargement.

The correlation of ultrasound prostate volume and PSA has contributed immensely to the management of numerous

prostatic disorders.<sup>[10]</sup> Most data on the index study were obtained from western populations and very few studies have been done in Nigeria and African<sup>[11]</sup> The study by Gupta et al<sup>[2]</sup> revealed that Japanese men that they release more PSA per unit prostate tissue than Caucasians men. Therefore, it becomes imperative for us to evaluate the Nigerian experience in this context. In the assessment of the morphology and function of the prostate gland, prostate volume and prostate specific antigen level are very valuable and also serve to determine treatment options, lifestyle modification and monitor the therapeutic efficacy of treatment modalities. This study was necessitated by the paucity of data among Nigerian men and will also expand the scope of existing knowledge in the field of medicine.

## Subjects and Methods

A cross-sectional study was carried out from 2015 to 2017 in the ultrasound suite of the Department of Radiology in Rivers State University Teaching Hospital Port Harcourt, Nigeria.

One hundred and forty- three males referred for ultrasound prostate evaluation with the clinical diagnosis of prostatic enlargement that fulfills the study criteria were studied. They were recruited until the sample size was achieved. Ethical approval was obtained from the Ethical Committee of the Rivers State and informed written consent from the participants.

A real time grayscale ultrasonography using LOGIQ P6 PRO GE Healthcare machine fitted with 10MHz transrectal transducer was used. On presentation, patients were booked and counselled with the need for mild bowel preparation. The procedure was explained to the patient with counselling about the technique and expectation. Thereafter, the patient was requested to undress and wear a gown. The age, height and weight of the patients and blood sample were collected prior to transrectal ultrasound prostate evaluation. The patient is positioning in a decubitus position with knees tucked up toward the chest. Visually inspection of the anus and perineal area is done to exclude hemorrhoids, anal fissure, and dermatologic conditions before transducer introducing. The transducer was covered with a plastic sheath (with gel introduced inside) and a liberal amount of lignocaine gel applied on the transducer outside of the plastic sheath to reduce pain and discomfort. Transducer is introduced slowly through the anus, using gentle pressure. On passing the anal sphincter and visualizing the prostate, no more pressure is applied and the prostate evaluated. The prostate was scanned in longitudinal and transverse planes. Then appropriate images were frozen from the freeze button on the keyboard to obtain the antero-posterior, transverse and cranio-caudal diameters of the prostate gland (figure 1 and 2). The prostate volume was generated by the ultrasound machine automatically and displayed. After obtaining and documenting the required measurements, the transducer is gently removed from the patient body.

The quantitative measurement of serum prostate-specific antigen level was assayed by ELISA – Enzyme

Immunoassay using DIAGNOSTIC INC PSA KIT was in the Chemical Pathology Department of the hospital with the supervision of a pathologist. The blood specimen was collected by venipuncture into a plain tube without anticoagulant before the patient underwent the transrectal prostate ultrasound, before also urinary catheterization, biopsy, prostatectomy or prostatic massage, since manipulation of the prostate may lead to elevated PSA levels which may persist for up to 3weeks<sup>[3]</sup>. The assayed by ELISA leads to a colour change and the PSA concentration was read out as the concentration of PSA is directly proportional to the colour intensity of the test sample. The value obtained is documented for each patient.

## Results

The mean age in the study population is  $68.72 \pm 8.50$  years with the smallest age groups being 45-54 years (6.3%) while the largest age group is 65-74 years (51.05%) as demonstrated in table 1. The transrectal Prostate Volume range from  $28.19 \text{cm}^3$  to  $185.57 \text{cm}^3$  with a mean ( $\pm$ SD) transrectal Prostate Volume (TPV) of  $66.13 \pm 30.43 \text{cm}^3$  (table 2). The highest transrectal Prostate Volume mean age group was 75-84 years with a mean age group TPV of  $87.72 \pm 33.54 \text{cm}^3$  as shown in table 2.

According also to table 2 the mean serum prostate specific antigen concentration with standard deviation in this study was  $8.50 \pm 3.95 \text{ng/m}$ . The highest serum prostate specific antigen concentration was found at age 75-84 years with a mean ( $\pm$ standard deviation) of  $10.67 \pm 4.78 \text{ng/m}$ . The smallest serum prostate specific antigen concentration is  $3.44 \text{ng/m}$  and the largest serum prostate specific antigen concentration is  $25.27 \text{ng/m}$ .

The participants BMI ranges from 13.30 to 39.17 (table 2). The mean BMI ( $\pm$ SD) was  $25.00 \pm 5.10$  this implies that most of the participants are overweight with the youngest age group having the highest BMI ( $27.36 \pm 7.30$ ) as shown also in table 2.

Scatter plots between the transrectal prostate volume with PSA, age and BMI demonstrated uniform distribution along the trend line, relatively even distribution and uneven distribution respectively (figure 3, 4 and 5). Figure 6 and 7 show a scatter plot between PSA with age and BMI. It revealed a uniform distribution between PSA and age whereas, there was a non-uniform distribution along the trendline between PSA and BMI.

Transrectal Ultrasound prostate volume correlation with PSA, age, and BMI of patients showed strong positive statistical correlation between transrectal ultrasound prostate volume and PSA with a Pearson's Correlation Coefficient (r) of 0.809 (p < 0.01). There was also positive correlation with age showing a Pearson's Correlation Coefficient (r) of 0.493 (p < 0.01) as also shown in table 3. A positive correlation was also seen between PSA and age but no correlation with BMI. A Pearson's Correlation Coefficient (r) of 0.404 and 0.032 was derived for age and BMI respectively (table 3).

Linear Regression Analysis yielded the following equation

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where y is transrectal ultrasound prostate volume in centimetre cube and x is PSA in nanogrammes per millilitre and age, in equations 1 and 2 for PSA and BMI respectively (figures 3, 4 and 5).

$$y = 6.6667x \quad (r=0.809; \quad r^2=0.655 \quad p = 0.01)$$

equation 1

$$y = 4x - 160 \quad (r=0.493; \quad r^2=0.244 \quad p = 0.01)$$

equation 2

Serum PSA Concentration correlation with age and BMI yielded the following equation where y is Serum PSA Concentration in nanogrammes per millilitre and x is Age (in years) and BMI in equations 3 and 4 respectively (figures 6 and 7).

$$y = 0.6x - 24 \quad (r=0.404; \quad r^2=0.163 \quad p = 0.01)$$

equation 3

$$y = x - 10 \quad (r=0.034; \quad r^2=0.001 \quad p = 0.01)$$

equation 4

**Table 1: Age distribution of participants (n=143)**

Age (Years)	Frequency	Percentage
45-54	9	6.30%
55-64	21	14.68%
65-74	73	51.05%
75-84	40	27.97%
Total	143	100%
Mean Age = 68.72±8.50years		

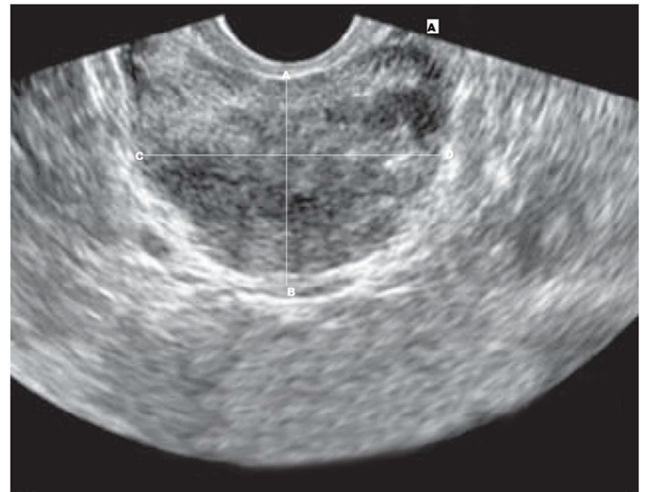
**Table 2: Ultrasound Prostate Volume, Serum PSA Concentration and BMI of Patients**

Variables Age Group (Years)	Number Of Respondents	Prostate Volume (Cm <sup>3</sup> ) Mean ± SD	Prostate Specific Antigen Level (Ng/MI) Mean ± Sd	BMI Mean ± SD
45-54	9	47.66± 29.20	5.46±3.02	27.36±7.30
55-64	21	44.93± 16.55	5.98±1.38	23.05±5.08
65-74	73	62.87±26.20	8.54±3.54	24.38±4.69
75-84	40	87.72±33.54	10.67±4.78	26.15±5.12
68.72± 8.50	143	66.13±30.43	8.50±3.95	25.00±5.10
Minimum		28.19	3.44	
Maximum		185.57	25.27	

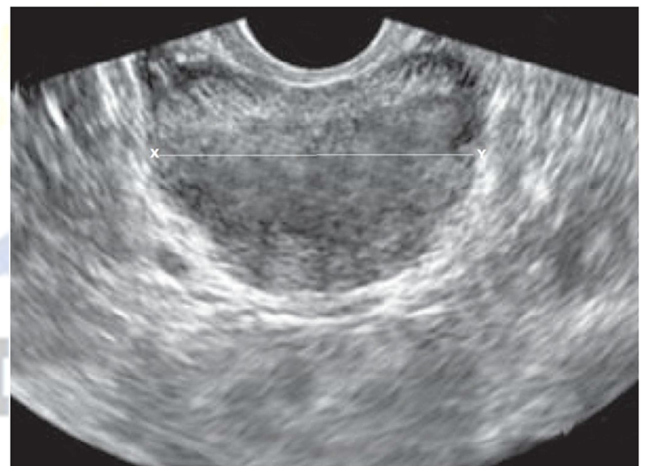
**Table 3: Pearson Correlation between transrectal prostate volume, PSA BMI and Age**

Variables		Prostate Volume	PSA	BMI	AGE
Prostate Volume	Pearson Correlation	1	.809**	.124	.493**
	Sig. (2-tailed)		.000	.140	.000
	N	143	143	143	143
PSA	Pearson Correlation	.809**	1	.032	.404**
	Sig. (2-tailed)	.000		.706	.000
	N	143	143	143	143
BMI	Pearson Correlation	.124	.032	1	.106
	Sig. (2-tailed)	.140	.706		.209
	N	143	143	143	143
AGE	Pearson Correlation	.493**	.404**	.106	1
	Sig. (2-tailed)	.000	.000	.209	
	N	143	143	143	143

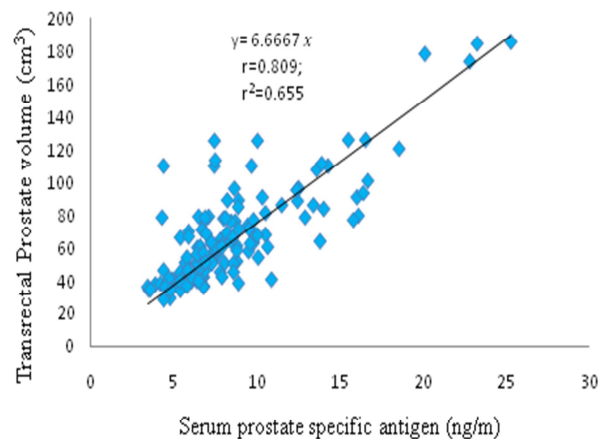
\*\* . Correlation is significant at the 0.01 level (2-tailed).



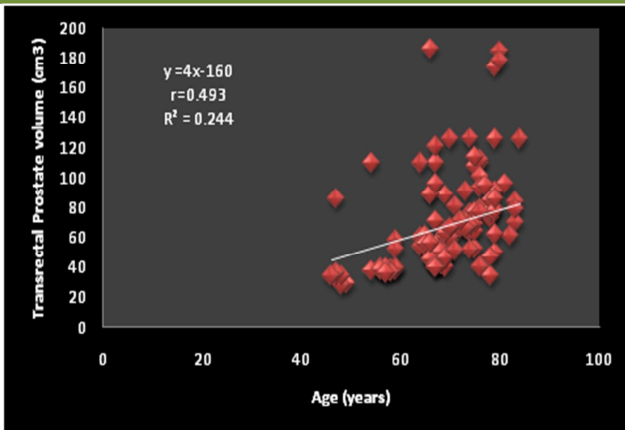
**Figure 1: A grey scale image of the antero-posterior and transverse diameters measurement of the prostate gland (A-B is antero-posterior diameter and C-D is transverse diameter)**



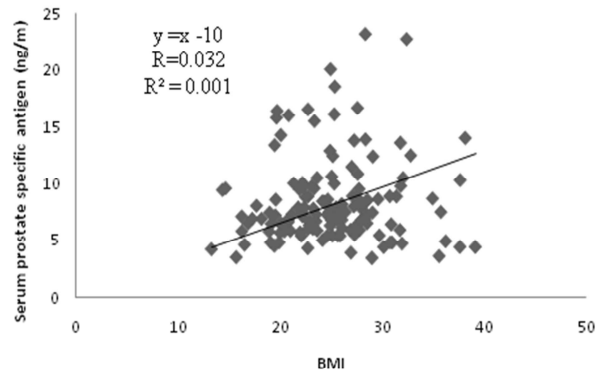
**Figure 2: A grey scale image of the cranio-caudal diameter measurement of the prostate gland (X-Y is cranio-caudal diameter)**



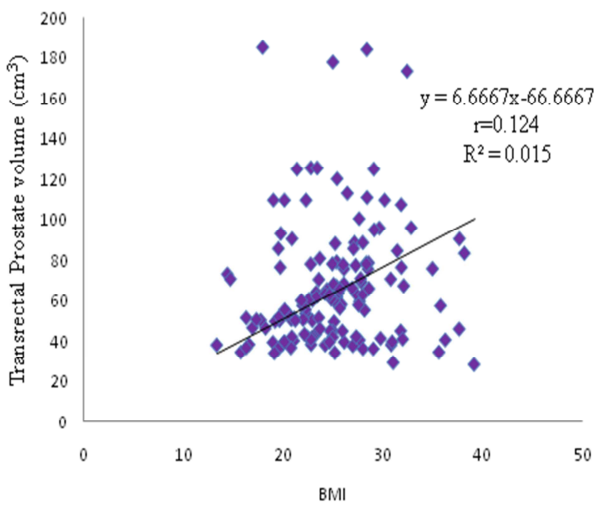
**Graph 1: Scatter plot showing the distribution of prostate volume against serum prostate specific antigen concentration.**



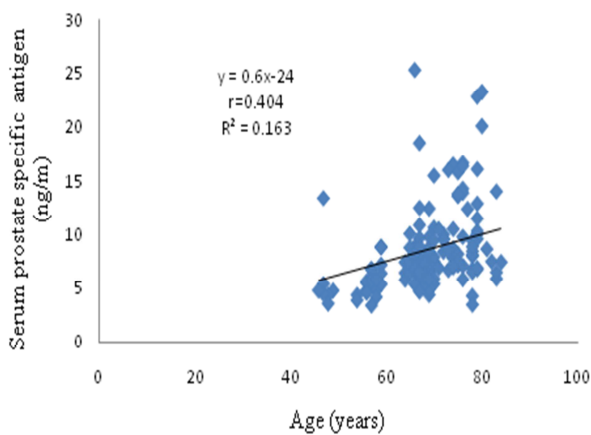
Graph 2: Scatter plot showing the distribution of prostate volume against age.



Graph 5: Scatter plot showing the distribution of prostate PSA against BMI



Graph 3: Scatter plot showing the distribution of prostate volume against BMI



Graph 4: scatter plot showing the distribution of prostate specific antigen concentration against age

### Discussion

Transrectal ultrasound prostate volume correlation with PSA has immensely contributed to the diagnosis and management of numerous prostatic conditions.<sup>[10]</sup> The prostate gland is a pyramidal shaped fibromuscular male reproductive gland having a peripheral, central and transition zones as well as a non-glandular isthmus.<sup>[3]</sup> With age, the transition zone hypertrophies while the central zone atrophies.<sup>[3]</sup> Prostate specific antigen (PSA) is a glycoprotein enzyme found in blood and tissue of men and it functions in dissolving the cervical mucus thereby allowing sperm entry into the uterus. It is a tumour marker which is significant in the diagnosis and management of patients with prostatic diseases. It is usually present in small quantity in the serum of men with non-pathologic prostate but often elevated in patients with prostate associated disorders such as prostatic enlargement with Benign prostatic hyperplasia (BPH) been the most common condition.<sup>[4]</sup> In the index study the transrectal Prostate Volume range from 28.19cm<sup>3</sup> to 185.57cm<sup>3</sup> with a mean (±SD) transrectal Prostate Volume (TPV) of 66.13±30.43cm<sup>3</sup>. The mean (±SD) transrectal Prostate Volume in the present study is higher than a Nigerian study by Ajayi et al.<sup>[9]</sup> In the study by Ajayi et al.<sup>[9]</sup> to correlate transrectal and transabdominal ultrasound measurement of transition zone volume with post-operative enucleated adenoma volume in benign prostatic hypertrophy with 46 patients showed a mean prostate volume was 58.79±40.98cm<sup>3</sup>. This result is slightly lower than that obtained in the present study. The differences in the mean ultrasound prostate volume between the two studies can be attributed to numerical bias.<sup>[11]</sup> The sample size is higher in the present study compared to the study by Ajayi et al.<sup>[9]</sup> The mean prostate volume in a study by Udeh et al.<sup>[11]</sup> was 72.79 ± 44.38 cm<sup>3</sup> using 120 patients with biopsy-proven BPH. The result of their study was higher than that obtained in the index study. The numerical bias

between the study by Udehet al<sup>[11]</sup> and the present study is relatively not too much, however, the histologic diagnostic precision with a biopsy in relation to other causes of prostatic enlargement like Prostatitis and prostate cancer may contribute to the disparity in the result.

The result from the present study is also higher than that obtained by Ibinaye et al<sup>[14]</sup> ( $46.62 \pm 12 \text{ cm}^3$ ) with a smaller study population and the difference between transabdominal and transrectal volume estimation could be the contributory factor.

Mosli et al<sup>[10]</sup> in a Saudi based study obtained a mean prostate volume of 35.2 ml while the study conducted by Mochtar et al<sup>[15]</sup> with 1859 patients complaining of lower urinary tract symptoms (LUTS) visiting the Department of Urology of the University Medical Centre Nijmegen; Netherlands showed a mean prostate volume of  $43.9 \text{ cm}^3$  which is at variance with the result obtained in the index study. The difference recorded between the studies conducted by Mochtar et al<sup>[15]</sup>, Mosli et al<sup>[10]</sup> and the present study may be attributed to the study population. The adopted study population in the present study is lower than that used in the study by Mochtar et al<sup>[15]</sup> and Mosli et al<sup>[10]</sup> and may be less representing of the population distribution. It may also be attributed to racial discrimination, geographic location or overestimation of the prostate volume.

The fact that Caucasians have better health seeking behaviour and present much earlier in clinics than Africans may also be a contributory factor to the difference in result Udeh et al.<sup>[11]</sup>

Shim et al<sup>[16]</sup> documented a mean prostate volume of  $22.6 \text{ cm}^3$  in 3,431 Korean men, whereas Chung et al<sup>[17]</sup> in another Korean multi-center based study reported a mean PV of  $36.9 \text{ cm}^3$ . The differences obtained could be due to the method of evaluation of the prostate among other factors like race and geographic settlement. It is documented that there is an advantage of better contrast and clarity with transrectal ultrasound prostate volume estimation when compared with transabdominal route Ajayi et al<sup>[9]</sup>. Meanwhile, their study adopted the transabdominal approach while the index study was transrectal.

The mean serum prostate specific antigen concentration with standard deviation in this study was  $8.50 \pm 3.95 \text{ ng/ml}$  while in a similar study by Udeh et al<sup>[11]</sup> in Nigeria showed a mean PSA of  $12.44 \pm 15.49 \text{ ng/ml}$ . The mean PSA recorded in the study by Udehet al<sup>[11]</sup> is higher than that obtained in the index study.

The result obtained in the Nigerian studies were also higher than that obtained in other studies conducted outside Nigeria as shown by the study recorded by Chung et al<sup>[17]</sup> and Mochtar et al<sup>[15]</sup> with a mean PSA of 2.2 ng/ml and 3.1 ng/ml respectively.

The variation in result could be as a result of variation in study population, geographic location, laboratory overestimation and early clinical presentation by Caucasians.

Analysis of collected data revealed a positive correlation between transrectal ultrasound prostate volume and Serum Prostate Specific Antigen Concentration with a Pearson's Correlation Coefficient (r) of 0.862 (  $p < 0.01$ ). This is in consonance with a Nigerian based study by Udeh et al<sup>[11]</sup> that recorded a positive significant correlation between serum PSA and prostate volume (Pearson's correlation coefficient (r) of 0.3365 at  $P < 0.05$ ). The index study is also in agreement with the study conducted by, Gupta et al<sup>[12]</sup>, Shim et al<sup>[16]</sup> and Chung et al.<sup>[17]</sup> The PSA concentration can be used to predict the prostate volume (Shim et al<sup>[16]</sup>). The index study is also in keeping with the findings of Hochberg et al<sup>[18]</sup> which showed that patients with BPH, PSA and prostate volume had a statistically significant correlation. A study by Morsli et al<sup>[10]</sup> also demonstrated a significant positive correlation between ultrasound PV and PSA (  $p < 0.0001$ ;  $r = 0.441$ ). It was also documented that the level of significance between PV and PSA varies with race<sup>[10]</sup>.

There was a weak positive statistical correlation between transrectal ultrasound prostate volume and age was seen in this index study with a Pearson's Correlation Coefficient (r) of 0.493 (  $p < 0.01$ ). The correlation obtained in the index study is similar to that documented by LIU et al<sup>[19]</sup>. Although the study by LIU et al<sup>[19]</sup> recorded a strong positive scientific correlation which could be attributed to specificity of assessing the transitional zone volume (TZV) in different age groups of benign prostatic hyperplasia. Basawaraj et al<sup>[20]</sup> reported that there was no significant correlation between prostate volume and age which is not in accordance with the index. This variation may be attributable to variation in study population, intraobserver measurement bias or due to geographical variation.

Serum PSA Concentration correlation with age and BMI of participants showed weak positive statistical correlation with age whereas BMI did not show any significant correlation. Pearson's Correlation Coefficient (r) obtained for age and BMI are 0.404 and 0.032 respectively (  $p < 0.01$ ). This result was closely in agreement with the study by Abbiyesuku et al<sup>[21]</sup> where a strong significant correlation was established between age and PSA ( $r = 0.523$   $p = 0.001$ ).

There is paucity of literature concerning the correlation of transrectal ultrasound prostate volume and Serum PSA concentration with age and BMI in patients with prostatic enlargement in our environment, thus this study is to bridge this gap. Although, in order to conclusively affirm the findings further studies on the correlation of ultrasound prostate volume and serum PSA concentration may be required.

## Conclusion

This study showed a significant positive correlation

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between transrectal ultrasound prostate volume measurements and serum prostate specific antigen concentration in patients with prostate enlargement. Therefore, in the absence of reliable direct biochemical measurement of serum prostate specific antigen concentration, sonographic measurement of transrectal prostate volume is a very valuable tool.

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