African Journal of Urology

ORIGINAL RESEARCH Open Access

Relationship between serum prostate-specific antigen and transrectal prostate sonographic findings in asymptomatic Ugandan males

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Abstract

Background: Prostate disorders are among the leading causes of morbidity and mortality in men above the age of 40 years globally. Serum prostate-specific antigen (PSA) levels may be used to screen men at risk of prostate cancer and determine choice of medical treatment in benign prostatic hyperplasia (BPH) and evaluation of patients with prostatitis, while prostate sonography determines prostate volume (PV) and detects nodules. BPH may exhibit distinct hypoechoic, isoechoic, or hyperechoic nodules in the transition zone, whereas hypoechoic nodules in the peripheral zone are diagnostic for prostate cancer in over 50% of cases. In this study, we aimed at determining the relationship between serum PSA levels and transrectal prostate sonographic findings among asymptomatic Ugandan males.

Methods: Ugandan males above 30 years of age or older without lower urinary tract symptoms were cross-sectionally enrolled into the study. Serum PSA determination and transrectal ultrasound were performed. Association between PSA levels and PV was assessed using Spearman's correlation coefficients (ρ).

Results: A total of 277 men were studied. The median serum PSA level was 1 (95% CI: 1–2). Most ($n = 217$, 78.3%) participants had serum PSA levels ≤ 4 ng/ml. The median sonographic PV was 26 (95% CI: 26–29) mls. One hundred and fifty-five (56.0%) participants had PV between 25 and 50 mls. Both PSA levels and PV progressively increased with age from 0.9 ng/ml and 22 mls in the 30–39 year age group to 7 ng/ml and 38 mls in the 60–69 year age group, respectively. PSA levels weakly correlated with PV ($\rho = 0.27$) ($p < 0.0001$). One hundred and thirty (47%) participants had prostatic nodules. Of these, 100 (77%) had features of benign nodules and 23% had suspicious nodules for prostate cancer. The median (range) serum PSA level in those with nodules was 2.0 (0.1–16.0) ng/ml and for those without nodules was 1.1 (0.1–8.0) ng/ml ($p < 0.0001$).

Conclusions: Serum PSA has a weak direct correlation with PV and not a reliable marker for the prediction of presence or absence of prostatic nodules in asymptomatic adult males.

Keywords: Prostate-specific antigen, PSA density, Prostate volume, Benign prostatic hyperplasia

1 Background

The morbidities of prostate diseases have increased sharply all over the world during the past several years especially benign prostatic hyperplasia (BPH) and prostate cancer [1]. BPH is the most common neoplasm and a significant cause of lower urinary track symptoms (LUTS) in the adult males [2]. Several community-based

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epidemiological studies have documented the prevalence of BPH ranging from 30 to 50% and 18.1 to 25.3% in hospital-based and community-based settings, respectively [3–5]. Although BPH is not life threatening, its clinical manifestation such as LUTS reduces the patient's quality of life [6]. On the other hand, prostate cancer is the second leading cause of cancer deaths (after lung cancer) in men at about 20.1 per 100,000 men per year [7]. Worldwide, over 1.3million new cases of prostate cancer were reported with 358,989 deaths (3.8% of all deaths caused by cancer in men) in 2018 [8].

In Uganda, prostate cancer is reported to be increasing at an average incidence of 5.2% annually and most of this increase is in the elderly men aged 65 or over [9]. Both prostate diseases, BPH and prostate cancer, are chronic diseases that take a long period for development from a small lesion to clinical manifestation of symptoms [10]. However, to detect or diagnose early prostate disease, serum PSA is one of the most widely acceptable screening tools, but the concentration levels vary widely in different populations [11]. Serum PSA levels may vary over time in the same man, but PSA levels of 4.0 ng/mL and lower are considered as normal [12]. However, more recent studies have shown that some men with PSA levels below 4.0 ng/mL may have prostate cancer and that many men with higher levels did not have prostate cancer [13]. The incidences of prostate cancer detection in Asian population were found to be 16.7% in low PSA group (2–4 ng/ml) and 23.7% in intermediate PSA group (4.1–10 ng/ml) [14].

On the other hand, PV is an important determinant of BPH [15]. Ho et al. [16] stated that most prostate abnormalities are diagnosed by measuring their dimensions and the study further highlighted the relevance of prostate volume estimation in prostate cancer, of which ultrasonography proved very essential. Prostate cancer is usually seen as a hypoechoic lesion (60–70% of the lesions), commonly in the peripheral zone, but can also be hyperechoic or isoechoic (30–40% of the lesions) [17], whereas the typical sonographic feature of BPH is enlargement of the inner gland (transition zone) which can exhibit diffuse enlargement or distinct hypoechoic, isoechoic, or hyperechoic nodules [18]. PV varies widely throughout a man's lifetime, and in the course of different prostatic diseases. Transrectal ultrasound (TRUS) is a widely used imaging modality for prostate evaluation as it has good resolution and remains the gold standard for prostate volume measurement in the diagnosis and management of BPH and prostate cancer [19]. TRUS also has high sensitivity for detecting prostate nodules.

PV is reported to vary widely across different populations [20]. Currently, there is no study done in Uganda about the PV of asymptomatic adult males. Studies of serum PSA and PV have been largely done among white men. PV and its relationship to PSA are reported to be variable in different races [21], but PV and PSA levels among Ugandan adult males are not known, and there was no study done to find the prostate sonographic findings in Ugandan adult males without LUTS.

Given these considerations, the present study undertook to evaluate the relationship between serum PSA levels and transrectal prostate sonographic findings among asymptomatic Ugandan adult males attending a large-tertiary clinical center.

2 Methods

2.1 Study design

This was a single-center descriptive cross-sectional study.

2.2 Study setting

The study was carried out in the radiology department of Mulago National Referral Hospital in Kampala Uganda.

2.3 Study population

Ugandan adult males above 30 years of age who attended the hospital for prostate cancer screening and general medical checkup between December 2018 and July 2019 were recruited in to the study.

2.4 Participant selection criteria

All adult males above 30 years of age without LUTS as determined by the international prostatic symptom score (IPSS) were included into the study.

Exclusion criteria: The following exclusion criteria were used in participants' selection.

1. Adult males with contraindications to transrectal ultrasound like peri-anal infections and hemorrhoids.
2. Adult males who were not eligible to serum PSA testing, for example, those who have had a recent digital rectal examination, urethral instrumentation and perineal trauma within the previous two weeks.

2.5 Sample size estimation

Sample size was determined using the Kish Leslie (1965) formula,

$$n = \frac{Zp(1-p)}{d}$$

n = Sample size, $Z = 1.96$, the normal value corresponding to the 95% confidence interval, p = prevalence of males with no LUTS, and $d = 0.05$ the desired precision of estimation.

The prevalence rates for moderate and severe LUTS were estimated to be 40.5% and 20%, respectively, in

men > 55 years in Uganda as reported by Bajunirwe et al. [22] in 2018.

Meaning total prevalence of males with LUTS = 60.5%.

Therefore, prevalence of men without LUTS = 39.5%

$$n = \frac{1.96 \times 0.395 \times (1 - 0.395)}{0.05}$$

$n = 395$.

However, due to the costs of doing PSA levels, and the accessible population of adult males during the 7-month study period, the sample size was adjusted for an infinite population. The radiology department works on an average of about 20 to 30 adult males daily, and this number was estimated for the seven months period bringing an infinite population of about 1000.

$$\text{To adjust for the infinite population, } n = \frac{\text{no} \times N}{\text{no} + (N - 1)}$$

N = accessible population estimated to be 1000 males during the seven months study period, no = calculated sample size

$$n = \frac{395 \times 1000}{395 + (1000 - 1)},$$

$n = 282.8$ which is approximately 283 participants.

Therefore, the sample size was 283 participants. Participants were stratified in interval age groups of 30–39, 40–49, 50–59, 60–69, and 70 years and above.

2.6 Study procedure

Data were collected on socio-demographic characteristics using semi-structured questionnaires. Blood samples for serum PSA levels were drawn and taken to the laboratory and ultrasound scan done.

2.7 Equipment

The ultrasound equipment used was a SIUI (Shantou Institute of Ultrasound Instruments co., Ltd) ultrasound machine, Apogee model 3300 with an endorectal high-frequency probe of 7.5 MHz.

2.7.1 Scanning technique and measurements

All participants indicated willingness to participate in the transrectal scanning after explaining the procedure. They were requested to empty the urinary bladder prior to scanning. The participants were then positioned on the examination bed in a left lateral decubitus position with both knees flexed toward the chest. The transducer was covered with a transducer sheath (with gel on the inside) and a liberal amount of gel on the transducer end as well, and the transducer was introduced slowly through the anus, using gentle pressure until the prostate was clearly visible. The prostate width (maximal transverse diameter) and height (maximal antero-posterior diameter) were measured on an axial image, while prostate length (longitudinal diameter) was measured on the mid-sagittal image [23]. PV was automatically calculated by the ultrasound machine using the prolate elliptical formula, $\pi/6 \times \text{width} \times \text{height} \times \text{length}$. Prostate nodule and presence of other lesions were documented. PSA density was calculated by dividing PSA value by prostate volume and documented.

2.8 Data analysis

The data collected were entered into the computer using Microsoft Excel 2010, and analyses were performed using GraphPad Prism version 8.1 for Mac (GraphPad Software, La Jolla, California, USA). All tests were two-tailed, and $p < 0.05$ was considered statistically significant. Association between any two categorical variables was assessed using Pearson's Chi-square test of independence. Nonparametric Spearman's rank correlation (ρ) was performed to assess for strength of associations between two continuous, non-normally distributed data and Mann–Whitney U signed ranked tests was used to compare medians of nonparametric data.

3 Results

We enrolled 277 participants with a median (range) age of 52 (30–86) years. Participants were stratified into 10-year age groups (Table 1).

Overall, the median (range, 95% confidence interval of median) serum PSA level was 1.0 (0.1–16.0; 95% CI: 1–2) ng/mls. The serum PSA levels progressively increased within each 10-year age (Table 2).

There was a moderate positive correlation between participants' age and serum PSA levels ($\rho = 0.52$) (Fig. 1).

Overall, the median (range, 95% confidence interval of median) sonographic PV was 26 (13–99; 95% CI: 26–29) mls (Fig. 2). One hundred and eight (39.0%) participants had PV below 25 mls, 155 (56.0%) had volumes between 25 and 50 mls, and the remainder 5.0% of the participants

Table 1 Participants distribution by 10-year age groups

Characteristic Age	Frequency (%)
30–39	51 (18)
40–49	67 (24)
50–59	61 (22)
60–69	54 (20)
70 +	44 (16)

Table 2 Age-specific serum PSA levels of participants

Age group	30–39	40–49	50–59	60–69	≥ 70
Number of subjects	51	67	61	54	44
Serum PSA levels					
Minimum	0.1	0.1	0.1	0.2	0.1
Median	0.6	1	1	6	
Maximum	6	6	8	16	13
95% CI of median					
Lower confidence limit	0.4	0.7	0.9	4	2
Upper confidence limit	0.9	1	2	7	4

Table 3 Prostate volumes in 10-year age intervals

Age groups	30–39	40–49	50–59	60–69	≥ 70
Number of subjects	51	67	61	54	44
Prostate volume					
Minimum	13	13	14	14	22
Median	21	25	24	33	39
Maximum	42	45	38	99	88
95% CI of median					
Lower confidence limit	20	22	23	30	33
Upper confidence limit	22	26	26	38	42

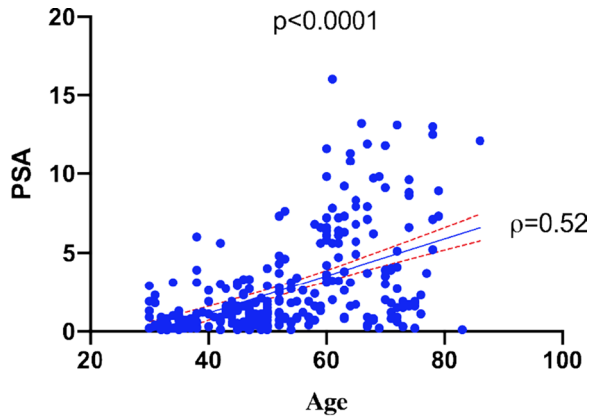

Fig. 1 Scatter plot showing the correlation between serum PSA levels and participants age

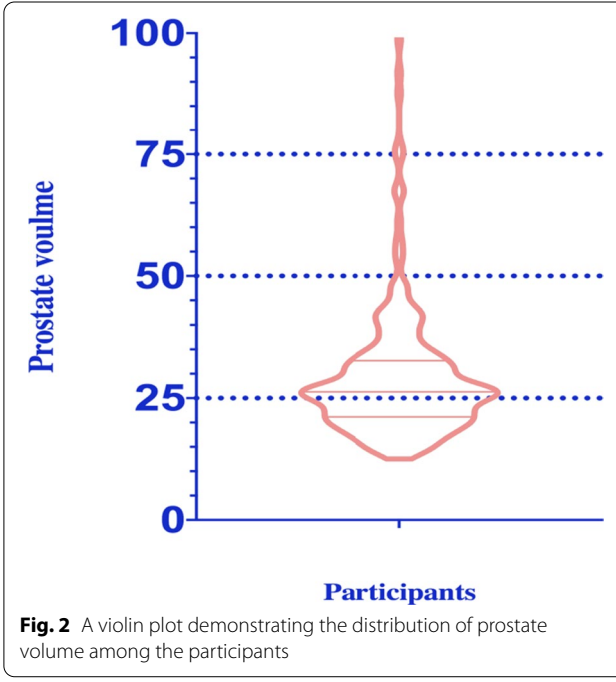

Fig. 2 A violin plot demonstrating the distribution of prostate volume among the participants

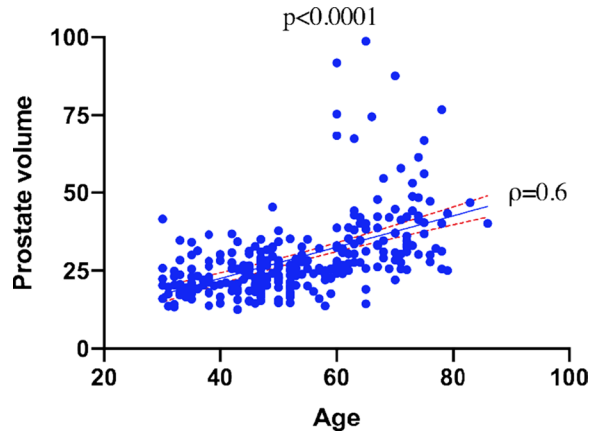

Fig. 3 Scatter plot showing the correlation between prostate volume and participants' age

had volumes above 50 mls. PV progressively increased within each 10-year age group (Table 3).

There was a strong positive correlation between participants' age and prostate volume ($\rho = 0.6$) (Fig. 3).

Both serum PSA levels and prostate volume increased progressively with age from 0.9 ng/ml and 22 mls in the 30–39 year age group to 7 ng/ml and 38 mls in the 60–69 year age group, respectively. There was a very weak positive correlation between participants serum PSA levels and prostate volumes ($\rho = 0.27$) (Fig. 4). One hundred and thirty (47%) participants had prostatic nodules. Of this, one hundred (77%) participants had nodules with benign features, while 23% had suspicious nodules for prostate cancer.

The median (range) PSA level in participants with nodules was 2(0.1—16) ng/ml and for those without nodules was 1.1(0.1–8) ng/ml (Fig. 5). The difference between medians of serum PSA levels between participants with nodules and those without was 0.9 (2.0 vs. 1.1: $p < 0.0001$). The median (range) PSA density in participants with nodules was 0.07(0.0–1) ng/ml/ml and for those without nodules was 0.05 (0.0–2) (Fig. 6). The PSA

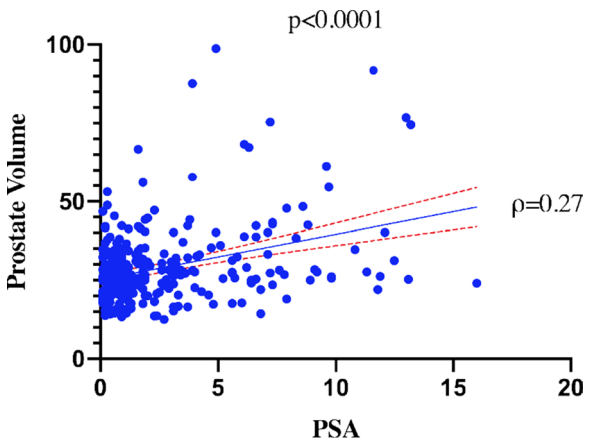

Fig. 4 Scatter plot showing the correlation between prostate volume and serum PSA levels

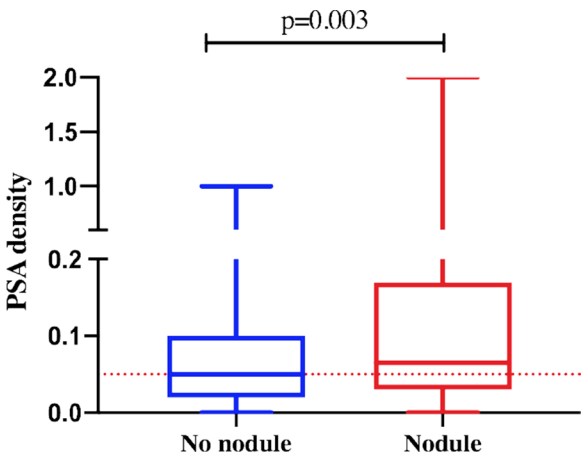

Fig. 6 Box and whisker plot demonstrating participants' PSA density for those with nodules and those without

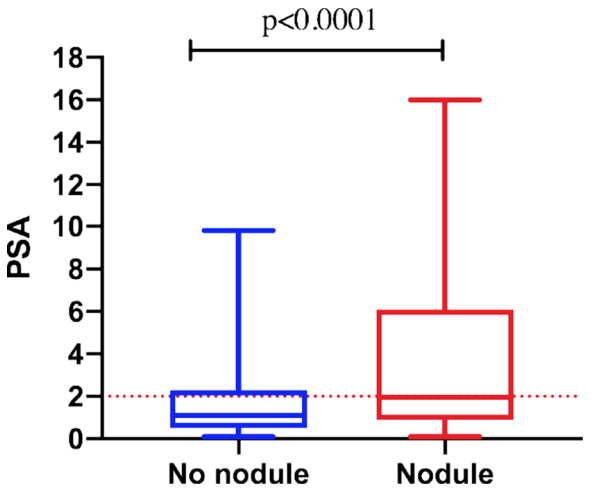

Fig. 5 Box and Whisker plot demonstrating participants' PSA levels for those with nodules and those without

density was significantly higher in participants with nodules compared to those without ($p=0.003$).

4 Discussion

Serum PSA is the most commonly used oncogenic marker for screening for prostate cancer, and there is general agreement among clinicians that the PSA test has the highest predictive value for prostate cancer [24]. However, its levels can be affected by many factors such as age, race, and ethnicity [25, 26]. The total serum PSA values as well as the age-specific serum PSA values described for men in the western world have been generally used in the evaluation of men with prostate cancer; however, these may not be the appropriate values for our community. In the present study to determine the PSA levels in asymptomatic adult males in Uganda, we found the median PSA as low as 1.0 ng/ml which was slightly lower than the median PSA levels in the Nigerian population of 1.33 ng/ml [27]. While in the community-based study among Korean men, the median PSA level was 0.98 ng/ml [28], similar to the median PSA levels in our population.

Age is one of the key factors for serum PSA levels. Serum PSA was found to be elevated with age. The serum PSA levels progressively increased from 0.9 ng/ml among participants in the 30 s age group to 7 ng/ml among those in the 60 s which is consistent with various studies conducted among Asian populations such as Chinese, Koreans, and Japanese [29–31]. In addition, there was a moderate positive correlation between participants' age and serum PSA levels ($\rho=0.52$). Previous studies have also demonstrated a positive correlation between age and PSA levels [32, 33]. Oesterling et al. [34] found that serum PSA concentration correlated directly with patient's age ($r=0.33$). However, their study found a weak positive correlation because the study population included only men aged 50 years and above. Our PSA rise was most prominent in 60 s age group compared to other age groups, and the PSA of those in the 60 s was higher than the level of those in the 70 s (7 ng/ml vs 4 ng/ml). This study could not establish the cause of this sharp rise among those in the 60 s; however, the participants in the 70 s were relatively few which could have contributed a selection bias.

Age-specific serum PSA was introduced in prostate cancer screening to improve the sensitivity and specificity of the PSA test [35]. These age-specific reference ranges for serum PSA would therefore possibly detect

potentially curable early organ-confined prostate cancer in younger men, while also detecting less clinically insignificant cancers in older men who might have life expectancy of < 10 years. Different races have their own age-specific PSA reference ranges because of the influence of geographic and ethnic differences [36]. Our age-specific serum PSA values were generally comparable though lower than the suggested age-specific reference ranges that are 0.0–2.5 ng/mL (40–49 year), 0.0–3.5 ng/mL (50–59 year), 0.0–4.5 ng/mL (60–69 year), and 0.0–6.5 ng/mL (70–79 year) [6] (Table 4).

The difference in our values could be due to a smaller study population of asymptomatic participants as compared to large populations upon which reference ranges were established.

Our age-specific serum PSA values were similar to the reference ranges for black men that were found to have sensitivity priority over specificity by maintaining a sensitivity of 95 percent, which were: 0 to 2.0 ng/mL for men in their 40s, 0 to 4.0 ng/mL for men in their 50s, 0 to 4.5 ng/mL for men in their 60s, and 0 to 5.5 ng/mL for men in their 70s [37]. In the Nigerian population, the normal age-specific serum PSA levels for men of age groups 40–49, 50–59, and 60–70 years were 0–4.78 ng/mL, 0–5.47 ng/mL, and 0–8.93 ng/mL, respectively [27], which were significantly higher than our age-specific serum PSA levels. Our study therefore suggests that men in our population have a lower total PSA and age-specific PSA levels compared to those of the Nigerian population. A study among African-American men also reported higher age-specific PSA levels of 0–2.7 ng/mL, 0–4.4 ng/mL, 0–6.7 ng/mL, and 0–7.7 ng/mL aged 40–49, 50–59, 60–69, and 70–79 years, respectively [38].

The assessment of the size of the prostate is of paramount importance to the surgeons in planning for appropriate urological surgical interventions [19], an important predictor of BPH progression and also a useful parameter for assessing response to treatment in patients with prostatic carcinoma [39, 40]. However, the average size of the prostate was shown to vary between different communities when men of the same age group were compared [20]. In this study, PV varied widely from 13 to 99 mls with the median of 26 mls. This wide variation in PV is similar to the findings from a study done among Ethiopian men above 40 years where the volume ranged from 7.1 to 169 mls with median volume of 35 mls [7]. This suggests that the PV for our men is smaller than that of the Ethiopian men.

In another study, the PV was found to range from 1.41 to 118.61 mls in a Nigerian population aged 9 to 100 years [41], while in Japan, the PV varied from 7.9 to 36 mls with a median of 17.4 mls in 104 adult men aged 40–79 years [42]. Our population had significantly larger prostates than the Japanese men.

The wide variation in PV indicates that asymptomatic adult males can have large prostates measuring up to 99 mls in volume as in this study and still have no LUTS. Previous studies have found a low correlation between prostatic volumes and LUTS in men when assessed using IPSS [43].

PV increases with age [19]. In our study, the PV progressively increased in each 10-year age group and almost doubled from 22 in 30–39 years to 42 mls in those 70 years and above. There was a strong positive correlation between participants' age and prostate volume ($\rho = 0.6$). A similar study in Nigeria also found a strong positive correlation between age and PV ($r = 0.638$) [41]. Fukuta et al. [42] conducted a cross-sectional community-based study to investigate the changes in total PV in Japanese men aged 40–80 years and found there was an increase in prostate volume in each 10-year age group and doubled from 5.5 ml in 40–49 years to 11.1 ml in 70–80 years.

Both PSA and PV have an age-dependent increase though the rate of increase in each decade being higher for PSA than PV, at 35.9% and 12.4%, respectively [44]. In this study, both serum PSA levels and PV increased progressively with age from 0.9 ng/ml and 22 mls in the 30–39 year age group to 7 ng/ml and 38 mls in the 60–69 year age group, respectively, but there was a

Table 4 Comparison with published age-specific reference ranges

Age groups	Age-specific serum PSA levels					
	Mulago/current study	Suggested reference ranges	Nigerians	Indian men	African American	Japan
30–39	0.4–0.9	–	–	0.61–0.76	–	–
40–49	0.7–1	0.0–2.5	0–4.78	0.72–0.85	0–2.7	0.0–2.0
50–59	0.9–2	0.0–3.5	0–5.47	0.93–1.13	0–4.4	0.0–3.0
60–69	4–7	0.0–4.5	0–8.93	1.16–1.45	0–6.7	0.0–4.0
70 +	2–4	0.0–6.5	–	1.42–2.35	0–7.7	0.0–5.0

very weak direct positive correlation between participants serum PSA levels and PV ($\rho = 0.27$). Studies from Western countries have reported correlation coefficients ranging between 0.37 and 0.6 [45–47]. The studies performed in Asian countries reported somewhat higher coefficient values between PSA level and PV than those performed in Western countries. A study in Sweden found both prostate volume and serum PSA increased progressively from 27.5 to 1.5 ng/ml, respectively, in the < 54 years age group to 48.2 ml and 5.4 ng/ml, respectively, in the < 80 years age group with a positive correlation($r = 0.54$, $p < 0.0001$) [20]. Basawaraj et al. [48] reported a significant correlation between PV and serum PSA level ($r = 0.415$, $p < 0.0001$). Chang et al. [49] reported a Pearson correlation value of 0.369 for the correlation between PV and PSA level in patients with biopsy-proven BPH in Taiwanese men. Our correlation between serum PSA and PV in asymptomatic men was lower than what's reported from other studies. However, many of the aforementioned studies were performed in patients who visited the hospital because of BPH or LUTS. Oesterling et al. [6] examined PSA and PV in a community of men regardless of their urologic symptoms. Furthermore, history of medication use, which can affect PSA levels, was not assessed and the growth of the prostate is known to be highly dependent on testosterone [50]. Racial variations in serum levels of hormones, including testosterone, also affect the prostatic growth disparity [51]. This was another limitation as we could not adjust for the testosterone level among enrolled men.

While the sensitivity of TRUS for nodule detection is high, the specificity of TRUS is disappointingly low, and therefore, the modality has limits to differentiate benign and malignant lesions. The ultrasound characteristics that were used included unilaterality, location, echotexture, outline definition, shape, and vascularity and contour bulging [52]. Previous studies have concluded that a prostate with an irregular contour, unclear borders between inner and outer glands, a hypoechoic nodule in the peripheral zone, or asymmetric blood flow in conventional TRUS was more likely to be malignant [53, 54]. In this study, one hundred and thirty (47%) participants were found to have nodules, and of these, one hundred (77%) participants had nodules with benign features, while 23% had suspicious nodules for prostate cancer. These nodules can be due to varying prostatic disease processes including prostate cancer, BPH, inflammatory prostatitis, among others; however, they were not correlated with histological diagnosis. There was little or no previous literature that has documented the histological causes of prostatic nodules in asymptomatic men.

Elevated serum PSA can be detected with either benign or malignant nodules of the prostate. In this study, the median serum PSA level was significantly higher for participants with nodules compared to those without (2.0 vs 1.1: $p < 0.0001$); however, there was a great overlap in the ranges of PSA levels in men with prostatic nodules and those without. Therefore, PSA levels may predict the presence of nodules but does not discriminate the presence or absence of nodules. Besides, different nodules cause varying levels of PSA elevation depending on the histological disease process. Sershon et al. [55] examined two groups of patients: group 1 with histologically confirmed BPH and group 2 with confined cancer of the prostate. The median serum PSA value for group 1 was 3.9 ng/ml (range 0.2–55 ng/ml), whereas the median serum PSA level for group 2 was 5.9 ng/ml (range 0.4–58 ng/ml). Although this difference was statistically significant ($p < 0.001$), the distribution of serum PSA values for group 1 overlapped considerably with the distribution for group 2. It is this lack of discrimination between these two prostate diseases by PSA that defines the diagnostic dilemma clinicians' face when treating prostate disease. This is because the PSA test lacks high sensitivity and specificity for PCa and PSA levels are frequently elevated in benign conditions, including BPH [56].

PSA density though suggestive is also not definitive for the presence of nodules. In this study, the median PSA density was significantly higher for participants with nodules compared to those without ($p = 0.003$), but there was also a great overlap in the ranges of PSA density of those with nodules and those without. Bare et al. [57] compared mean PSAD values of the cancer versus non-cancer (benign prostatic tissue, BPH, and prostatitis) groups and found a significant statistical difference ($p < 0.019$); however, there was a great overlap in individual values. Therefore, PSAD though improves detection rate and does not also entirely discriminate between presence or absence of prostate cancer.

Several limitations of the current study should be mentioned. Our study was not a community-based one, and our aim was not to correlate the serum PSA and prostate sonographic findings with the histological diagnosis. The small sample size in this study is also a limitation in generalizing the findings to the population. However, this is the first study to attempt to assess correlation between PSA and PV among asymptomatic Ugandan men. This study provides a baseline data for future studies aimed at screening for prostate disorders among this population in our community.

5 Conclusion

Both serum PSA levels and PV progressively increased with age, but there was a weak direct correlation between serum PSA levels and PV. There was a great overlap in serum PSA levels of those with nodules and those without.

Hence, serum PSA cannot predict the presence or absence of prostatic nodules. Therefore, serum PSA levels should be interpreted together with age and transrectal prostate sonographic findings in asymptomatic males.

Abbreviations
PSA: Prostate-specific antigen; PV: Prostate volume; PSAD: PSA density; BPH: Benign prostatic hyperplasia; TRUS: Transrectal ultrasound; MHz: Megahertz; Ng: Nanograms; LUTS: Lower urinary tract symptoms; IPSS: International Prostatic Symptom Score.

Acknowledgements
The authors thank Dr. Erem Geoffrey, Dr. Okello Omara Richard, and Dr. Muyinda Zeridah and all the lecturers and residents at the department of radiology and radiotherapy, College of Health Sciences, Makerere University, for their valuable technical assistance.

Authors' contributions
All authors contributed to the development of this work. OM did the proposal development, data collection and management, and manuscript writing. BS was involved in proposal development, reviewing of all the ultrasound images, and manuscript editing. AF did image acquisitions, management, and manuscript writing and editing. DH was involved in proposal development, participants' recruitment and flow, and manuscript writing. BF did the data management and analysis and manuscript writing. All authors read and approved the final manuscript.

Funding
The study was supported by Uganda Cancer Institute through the Uganda Cancer Institute—African development bank (UCI-AfDB) scholarship program which provides limited funding to students' research.

Availability of data and materials
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Approval to carry out the study was sought from the Makerere University School of Medicine Research Ethics Committee (REC REF 2018-169). Informed written consent was sought from all participants. Privacy and confidentiality of the participants were protected. Participants found to have lower urinary tract symptoms during the screening were sent for urologist review in the urology clinic of Mulago hospital for full clinical assessment.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interest.

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Received: 21 December 2020 Accepted: 29 March 2021
Published online: 07 April 2021

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