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Sonographic assessment of Prostate and Post void Residual Urine Volumes in patients with benign prostatic hypertrophy in Makurdi, North-central Nigeria

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Abstract

Background: Benign prostatic hypertrophy (BPH) is a major global public health problem and the most common benign prostatic disease in elderly men. Although rarely life-threatening, the increased morbidity significantly lowers men's quality of life, necessitating significant financial commitment to their annual health budgetary expenditure. We aim at determining the sonographic volumes of the prostate and post void residual urine in adult Nigerian men with BPH in Makurdi and to document any relevant relationship between the two values. **Materials and methods:** This was a 10-month prospective cross-sectional study conducted from June 2021 to April 2022. Transabdominal ultrasound (TAUS) was used to measure the prostate and post-void residual urine volumes of 78 men aged 40years and older, with normal levels of prostatic-specific antigen (PSA), who were referred to the ultrasound unit of radiology department of Benue State University Teaching Hospital (BSUTH), Makurdi. Collected data were analyzed using SPSS and Microsoft excel with $P<0.05$. **Results:** Postvoid residual urine volume (PVR) was observed to increase alongside the prostate volume (PV) from the 5th to the 6th decade of life; however, PVR began fluctuating from the 7th to the 8th decade, even though PV continued to increase steadily to its peak value at the 70-79 years of age, or the 8th decade. Overall, the mean prostate and post void residual urine volumes were 64.07±37.00ml and 76.44±110.34ml, respectively. A statistically significant (P=0.017) relationship existed between age and prostate volume but not between PV and PVR (P=0.128), where there was instead a weak, positive correlation. Although the bladder wall thickness (BWT) was greater than 5mm in more than half of the respondents 43(55.10%), there was no statistically significant (P=0.130) relationship between age and BWT. **Conclusion:** We established 64.07±37.00ml and 76.44±110.34ml respectively, as the overall mean sonographic volumes of the prostate and post void residual urine in adult Nigerian men with BPH in Makurdi. Despite the weak correlation between the two volumes, they can be used as a baseline for monitoring the progression of prostatic hyperplasia, bladder outlet obstruction and deciding on the best treatment option.

Keywords: Benign prostatic hypertrophy, Nigeria, Post-void residual volume, Prostate volume, Sonographic assessment.

INTRODUCTION

Benign prostatic hypertrophy (BPH), also known as benign prostatic enlargement, is the most common benign and progressive disease of the prostate in elderly men. Although rarely life threatening, it results in high morbidity with significant decrease in men's quality of life, necessitating the commitment of huge financial resources to their annual health budgetary expenditure [1,2].

The precise etiology of BPH is not completely clear. However, growth factors, inflammatory neurotransmitters, hormones (androgens, estrogens), and stromal epithelial interactions have been implicated in initiating prostatic growth [3]. Aside from age, other risk factors for BPH include family history, use of beta-blockers, metabolic syndromes such as diabetes, hypertension, and obesity, as well as race, with blacks being more affected than whites and whites more than Asians [4].

Even though, there is no universal agreement on what constitutes an increased post-void residual urine volume (PVR) [5], values of 50 ml or less are presumed to be normal, while values of 100 ml and above are acknowledged as reasonably high PVR [6].

The simultaneous and accurate estimation of both the prostate volume (PV) and PVR is very crucial in predicting the degree of prostatic hyperplasia, bladder outlet obstruction (BOO) and in deciding the preferred treatment option [7], for which PV evaluation is necessary whether it be pharmacological therapy (PV <40 ml), transurethral prostate resection (PV 40–80 ml), or open prostatectomy (PV >80 ml) [8].

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Competing imaging modalities currently used for evaluating prostate and PVR volumes include magnetic resonance imaging (MRI), computed tomography (CT), and ultrasonography [8,9]. However, some of these modalities are expensive and require years of specialized training for both image acquisition and interpretation. Furthermore, CT is unsuitable for routine volume measurements because of its high radiation dose.

Ultrasonography, can be performed through transperineal, transurethral, transabdominal, or transrectal routes with the transabdominal method virtually replacing urethral catheterization as the "gold standard" for measuring PVR [10]. It is fast with higher specificity and sensitivity, cost effective, easily accessible, patient-friendly, non-invasive, trauma-free, and has a lower risk of urinary tract infection [10,11]. Furthermore, transabdominal ultrasound (TAUS) imaging findings can suggest the precise abnormality in the prostate while also demonstrating evidence of kidney, ureter, and bladder complications [12].

To the best of our knowledge, extensive epidemiological research on this topic has not yet been reported in our community, leaving us to make the untenable and unreliable assumptions that our Nigerian population has the same prostate and PVR volume distribution as Western populations that have BPH. In order to obtain a better understanding of this issue, we embarked on this local research, aimed at determining the sonographic volumes of the prostate and post void residual urine in adult Nigerian men with BPH in Makurdi and to document any relevant relationship between these two values, which is important for the accurate monitoring of prostatic hyperplasia, bladder outlet obstruction and deciding on the best treatment option.

MATERIAL AND METHODS

This prospective study was reviewed and approved by the Benue State University Teaching Hospital (BSUTH) Institutional health research ethics committee (HREC) number BSUTH/MKD/HREC/2021/041. The goal of the study was to measure the sonographic volumes of the prostate and post-void residual urine in 78 adult men with BPH in our environment, and to document any significant correlations between the two volumes. The target population, who satisfied the requirements for inclusion, presented for transabdominal ultrasound scan at the radiology department of BSUTH, Makurdi between June 2021 and April 2022. The city of Makurdi, with a population of approximately 365,000 people in 2016, is located between latitudes 7.30 and 8.32 degrees on the south bank of River Benue [13] and is accessible by air, land and water.

The inclusion criteria were all adult men aged 40 years and above with symptoms of bladder outlet obstruction (BOO) due to BPH, requiring PVR measurement. Patients with a sensation of incomplete bladder emptying, recurrent urinary tract infection (UTI) and symptoms of overactive bladder manifested as frequency, urgency and nocturia were also included. Those who voluntarily agreed to participate in both the study and to do a full urinalysis and assessment of their prostatic specific antigen (PSA) with normal PSA laboratory values of ≤ 4ng/ml were also recruited.

The exclusion criteria were applicable to patients having causes of increased PVR other than from BPH or with no indication for PVR measurements. Also excluded were those with more than 10 minutes elapsed time after micturition and before PVR measurements or patients with elevated PSA levels >4ng/ml, inability to obtain informed consent or patient`s unwillingness to participate in the study. Patients with clinical evidence of prostate cancer, ultrasonographic finding of dilated upper urinary tract, acute UTI, morbidly obsessed patients, patients with neuropathic bladders, and those with other ultrasound scan-related allergies were also disqualified.

Before including patients in the study, informed consent was obtained from them. Individual participation in the study was strictly voluntary, and all personal data was obtained confidentially. There was no penalty for refusing consent or opting out.

The patient's age and other demographics were entered into a worksheet for analysis. Sonographic examination was done using Siemens Sonoline G-50 ultrasound machine fitted with a curvilinear 2.0-5.0MHZ transducer, from which an appropriate mode for performing transabdominal ultrasound was selected.

Transabdominal ultrasound scan began with the patient lying supine with a full bladder or after drinking approximately one liter of water, just enough to have a full but comfortably distended urinary bladder. To bridge the acoustic impedance between the skin and probe surface, coupling gel was used after draping a toilet paper sheet over the adequately exposed pelvic region.

Prostate volume was calculated from the measurements obtained (in cm) during the prostate scan using the ultrasound machine`s default computer algorithm based on the ellipsoid formula, PV (ml) = length(L) × width(W) × height(H) × 0.52 [14], where the length, width and height were the maximum craniocaudal, transverse and anteroposterior diameters, consecutively, as shown in figure 1.

The pre-void and post-void residual urine volumes were obtained by first measuring the width (W) and height (H) of the urine-filled bladder on the maximum transverse image on the mid-transverse view. The length (L) of the bladder was measured using the dome and the bladder neck as landmarks on the midsagittal view. PVR evaluation was commenced immediately after micturition, within delays of as little as 10 minutes, with voiding not done under duress, in the public glare or when the patient was in pains. The bladder volumes were calculated using the ellipsoid formula as in the case of the PV above= length(L) × width(W) × height(H) × 0.52 [14,15], in each case, accordingly as shown in figure 2 below, however by clicking on the machine's "report" knob, the calculated bladder volume was displayed automatically.

Measurement of bladder wall thickness (BWT), by convention, was done, when the bladder was filled to at least 150 ml. We measured the BWT along the posterior wall on the sagittal view as depicted in figure 3, although it can be measured at a number of other different locations [16].

Data analysis

Information including age, other biodata and measurements were entered into the statistical package for social science (SPSS) version 23 software (IBM Inc., Chicago, Illinois, USA (2015) and Microsoft Excel 2007 for analysis, while the statistical significance was determined using a *P*-value <0.005. The data distribution was displayed as tables, figures, and percentages.

RESULTS

A total of 78 adult Nigerian men aged 40-92years, were recruited for the study, with a mean age of 63.5±11.9 years. They presented from five departments of our hospital, with a predominant age range of 60-69 years, representing 25 (32.1%) of the total population. Most, 30(38.5%) of the respondents presented with between 101-200ml pre-void urine volume with an overall mean of 190.5±129.7ml. The minimum and maximum prostate volumes were 30.0 and 210.8 ml, respectively, with an overall mean PV of 64.1±37.0ml. The overall mean PVR was 76.4±110.3ml, with only a few respondents, 3(3.8%) having a PVR >400ml. More than half,43(55.1%) of the respondents had bladder wall thickness (BWT) >5mm with an overall mean BWT of 5.1±1.3mm. Tables 1 and 2 depicts the information presented above.

Table 3 illustrates the distribution of age groups with mean Pre-void urine volume, PV, PVR, and BWT. Pre-void urine volume increases from the 5th to 6th decade, but sharply declines thereafter retrogressively to beyond the 8th decade. Mean PV increases steadily with age from the 5th to the 8th decade with a peak at the 8th decade and decreases thereafter. An initial increase in PVR with age was noted from the 5th to 6th decade, followed by a decrease at the 7th decade, with a peak increase at the 8th decade and then a disproportionate decrease afterwards. PVR is seen to increase with PV, from the 5th to the 6th decade, however, PVR starts to fluctuate from the 7th and 8th decade, even though PV continues to increase steadily to its peak value at the 8th decade. Both decline after the 8th decade, though not by the same proportions**.** Overall, there was very little age-related variation in bladder wall thickness**.**

The relationship between the volumes and the other research variables were examined using Spearman correlation coefficient (rho) as illustrated in table 4. A statistically significant correlation existed between age and prostate volume (*P* = 0.017), but not between prostate and post-void residual urine volumes (*P* = 0.128).

In general, the scatter plots of the volumes against some of the variables showed a curvilinear relationship, as represented in figures 4–7.

DISCUSSION

The age range in our study is 40-92 years, with a mean age of 63.5±11.9 years. The frequency of prostatic enlargement with age increased steadily from the 5th to the 8th decade and peaked at the 70-79 years age group or 8th decade. Our findings were in agreement with that of previous researchers [17,18], which reported that the peak incidence of BPH was the 8th decade of life, thus further corroborating similar documentation by other researchers [1,19], respectively that men aged 70-79 years were four to six times more likely to be affected.

The overall mean pre-void urine volume recorded in our study was 190.5±129.7ml, nearly half of the exact mean value, 369.8±107.0 ml, reported by another researcher [17]. Ozden et al [11], and Pathak et al [20], studied two groups of patients, those with mild to moderate bladder filling and those with full bladder filling. They reported that even in healthy young men, those with an uncomfortably full bladder had false-positive high PVR. Therefore, measuring pre-void urine volume is more appropriate when the patient has a mild to moderate feeling of bladder fullness [11,20].

BPH is more common in elderly men, and there is hardly any research, including the present study, that contradicted the positive relationship between aging and the development of BPH [1,21]. In our study, the overall mean PV of patients with BPH was 64.1±37.0ml. This was higher than the 44.4±35.1 ml, reported by another researcher [14], but significantly lower than the 91.7±89.1ml and 214.0±8.5ml, respectively reported by Udoh et al [12] and Ma'aji et al [22]. This may be related to a variety of factors, including the level of experience of the sonographer or sonologist and the patient's state of health at the time of transabdominal sonography [14].

In our index study, there was age-related increase in the mean prostate volume of 14,5 and 19 ml per decade after the 5th, 6th and 7th decades, in that order, followed by a decrease of 13ml per decade after the 8th decade. However, data from the Krimpen and Baltimore longitudinal study of aging (BLSA) cohorts suggested that older men's prostates grew at a rate of 2.0 to 2.5% per year [23]. Nevertheless, larger prostate volume with aging does not always imply worsening symptoms, but it does increase the risk of BPH clinical progression, urinary retention, the need for surgery, and other direct or indirect effects on the length and quality of a man's life [1,23,24]. A statistically significant (*P*=0.017) correlation was found between age and PV in our research.

The mean PVR for the age groups in our study ranged from 18.8±1.6 to 94.5±131.6ml. This was generally lower than the values documented in a similar study by Udoh et al [12] and Amole et al [25]. However, the overall mean PVR of 76.4±110.3ml, in the present study was higher than the 48.0±0.0 and 69.3±39.8ml, respectively obtained by other researchers [26, 27]. Although there may be considerable intra-individual disparity in PVR values, the variations are less pronounced when mean PVR values are less than 100.0±0.0ml [17]. Furthermore, what constitutes an increased PVR volume is a topic on which clinicians do not always agree, however values of 50 ml or less are considered normal, while values of 100 ml and above are considered reasonably high PVR [6].

In the current study, an analysis of the association between mean PV and PVR in men with BPH reveals a statistically non-significant (*P*=0.128) but weak positive correlation, as depicted in figure 7. This corroborated reports by Orelu et al [17], in which there was positive but weak correlation between PV and PVR. However, other researchers reported a somewhat stronger correlation between PV and PVR [27,28], which has been linked to a number of factors, such as insufficient urinary output and incomplete bladder emptying in such men [17].

Our overall mean BWT was 5.1±1.3mm, which compared favorably with Ayhan et al 's findings of 5.3±1.8 mm [29]. Our value was however, lower than Udoh et al's 9.2±3.6mm [12], despite being higher than another researcher's reported BWT of 3.7±0.0mm [30]. The disparities could be attributed to the pattern of patient selection, operator dependence of ultrasound scan, machine type, population being studied, and duration of the obstruction. There is currently no agreement on the cut-off value of BWT that is directly used as a diagnostic point for bladder outlet obstruction (BOO). However, like other researchers, the 5mm cut-off point we used, appears to be the best for diagnosing BOO with a high sensitivity and specificity [12,29,30], though BWT results should be interpreted with caution, as a few conditions, such as bladder infection and tumors, can influence them [12]. A statistically non-significant (*P*=0.161) negative correlation was found between PV and BWT in our present research.

Limitations of the study

Our study's primary reliance on clinical suspicion of benign prostatic enlargement rather than histological confirmation was a major research setback, as it was possible that some of the patients may have had prostate cancer without our knowledge. Furthermore, the cost of performing PSA testing in the study center could have contributed to the small sample size**.** Above all, the findings of the study were primarily hospital-based and did not accurately reflect what happens in the community, therefore extrapolations to other climates should be done with caution.

CONCLUSION

We have been able to show a stronger association between prostate volume and age but a weak positive correlation between PV and PVR, as earlier documented by some researchers. The study also found that it was best to estimate pre-void urine volume when the patient only experienced a mild to moderate sense of bladder fullness, because doing so when the bladder was uncomfortably full could cause a false-positive high PVR, even in healthy young men, with subsequent errors in the accurate evaluation of such patients. We also discovered that the mean BWT reported in the literature varied significantly among BPH patients, with a BOO probability of 87.0% for a BWT greater than 5 mm compared to 63.0% for a BWT less than 5 mm. Age was the best predictor of prostate volume in our index study, followed by pre-void urine volume and then PVR. As a result, age-specific reference values should be the best local reference values to use as a baseline in our environment when monitoring the progression of benign prostatic hypertrophy.

Recommendations

As the demand for pharmacological rather than surgical management of BPH patients rises TAUS is recommended for the evaluation of PV and PVR. Unlike urethral catheterization, it is free from urinary tract injury or infection. Furthermore, because ultrasound is operator dependent, employers should endeavor to offer their professional staff sufficient competency-based training in order to maximize productivity.

Table 1: Distribution of respondents' demographics (n=78)

Variable	**Frequency**	**Percentage (%)**
Age Group(years)		
40-49	12	15.4
50-59	19	24.4
60-69	25	32.1
70-79	19	24.4
80-89	2	2.6
90-99	1	1.3
Total	78	100.0
Departments		
GOPD	45	57.7
UROLOGY	12	15.4
SOPD	11	14.1
A&E	6	7.7
MOPD	4	5.1
TOTAL	78	100.0
Prevoid urine volume(ml)		
<50	2	2.6
50-100	20	25.6
101-200	30	38.5
201-300	12	15.4
301-400	8	10.3
>400	6	7.7
Total	78	100.0
Prostate volume(ml)		
30-40	19	24.4
41-50	18	23.1
51-60	12	15.4
61-70	9	11.5
71-80	7	9.0
81-90	2	2.6
>90	11	14.1
Total	78	100.0
PVR (ml)		
0-20	32	41.0
21--40	11	14.1
41-60	7	9.0

61-80	3	3.8
81-100	2	2.6
101-120	10	12.8
121-400	10	12.8
>400	3	3.8
Total	78	100.0
Bladder wall thickness(mm)		
<5mm	35	44.9
>5mm	43	55.1
Total	78	100.0

Table 2: Distribution of descriptive statistics of the respondents' parameters

Parameter	N	Minimum	Maximum	Mean	Median	Mode	Std.dev
Age(years)	78	40.0	92.0	63.5	64.5	80.0	11.9
Pre-void urine volume(ml)	78	49.4	808.3	190.5	152.8	262.5	129.7
Prostate volume (ml)	78	30.0	210.8	64.1	51.1	36.5	37.0
PVR	78	0.0	620.0	76.4	28.2	0.0	110.3
Bladder wall thickness (mm)	78	2.6	8.8	5.1	5.1	4.1	1.3

Table 3: Distribution of age groups with mean Pre-void urine volume, prostate volume (PV), post-void residual urine volume (PVR), and bladder wall thickness (BWT)

Age group(years)	Mean pre-void urine volume(ml)	Mean PV (ml)	Mean PVR (ml)	Mean bladder wall thickness (mm)
40-49 (n=12)	138.0 ±85.5	45.3±19.9	59.3±85.4	4.6±1.2
50-59 (n=19)	219.7±92.6	59.5±27.2	82.5±76.0	4.8±2.0
60-69 (n=25)	215.1±176.9	64.2±25.6	76.2±137.0	5.7±1.4
70-79 (n=19)	177.9±117.8	83.5±58.5	94.5±131.6	5.1±1.0
>80 (n=3)	116.5±46.9	70.5±51.7	18.8±1.6	6.4±0.7
∑X63.5±11.9 (n=78)	190.5±129.7	76.4±110.3	64.1±37.0	5.1±1.3

Table 4: The distribution of Spearman's correlation (rho) with the volumes and other selected research variables (n=78).

Variable	Spearman's correlation (rho)	P-value
Age vs Prostate volume	0.269	0.017
Age vs Bladder wall thickness	0.173	0.130
Age vs Pre-void urine volume	-0.084	0.462
Age vs PVR	0.017	0.883
Prostate volume vs Pre-void urine volume	0.243	0.032
Prostate volume vs PVR	0.174	0.128
Pre-void vs post-void urine volume	0.206	0.070
Prostate volume vs Bladder wall thickness	-0.160	0.161

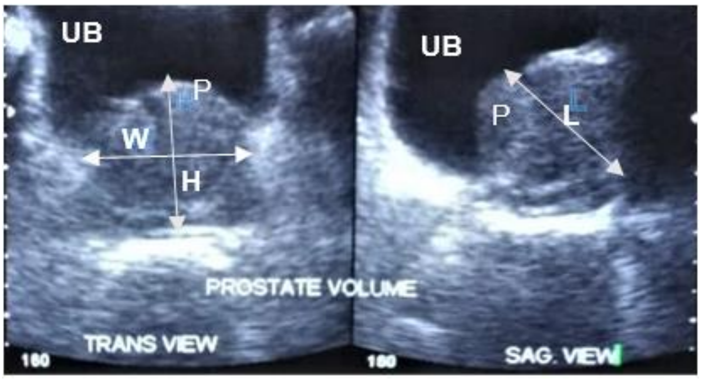

Figure 1: Transabdominal ultrasound scan of the prostate in transverse and longitudinal(sagittal) planes, showing the technique for the measurements of width(W), height(H) and length(L) of the prostate gland(P). UB is urinary bladder

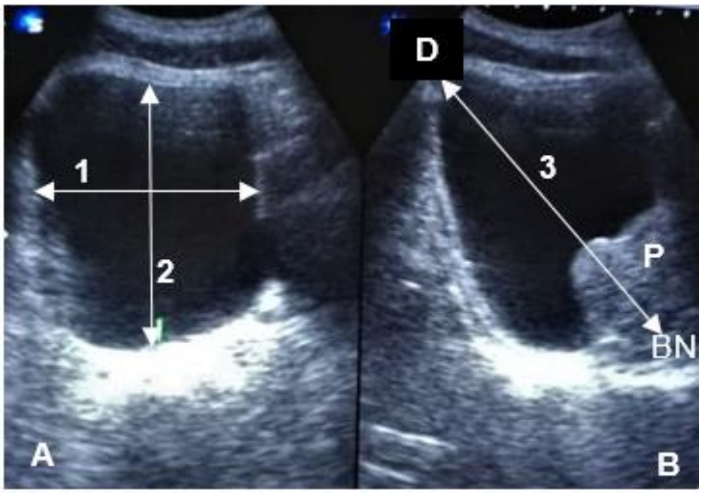

Figure 2: Pre-void urine volume measurement, with same principle in measurement of PVR

A) Transverse image of the bladder with measurements of the width (1) and height (2) of the bladder

B) Sagittal image of the bladder with length of the bladder (3) from the dome (D) to the bladder neck (BN). P is the prostate gland

Figure 3: Bladder wall thickness (BWT), measured (*arrows*) along the posterior wall on sagittal bladder view, which was 6.8 mm thick

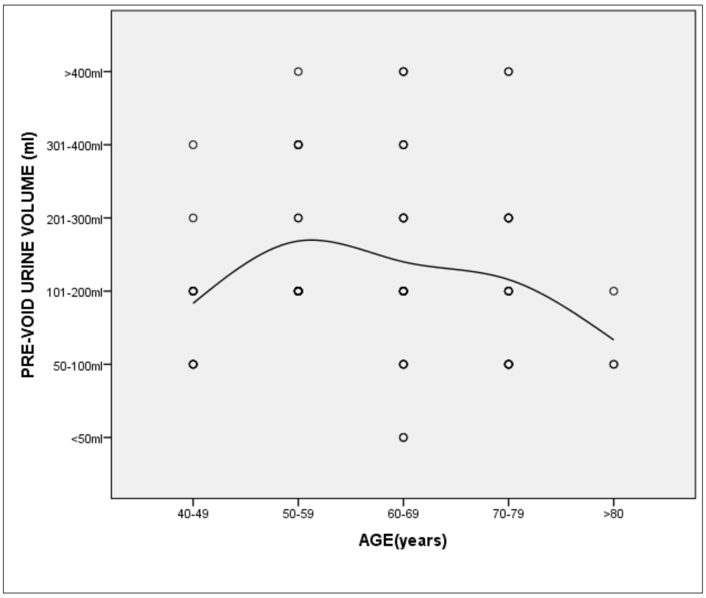

Figure 4: Scatter diagram showing a negative correlation between age and pre-void urine volume

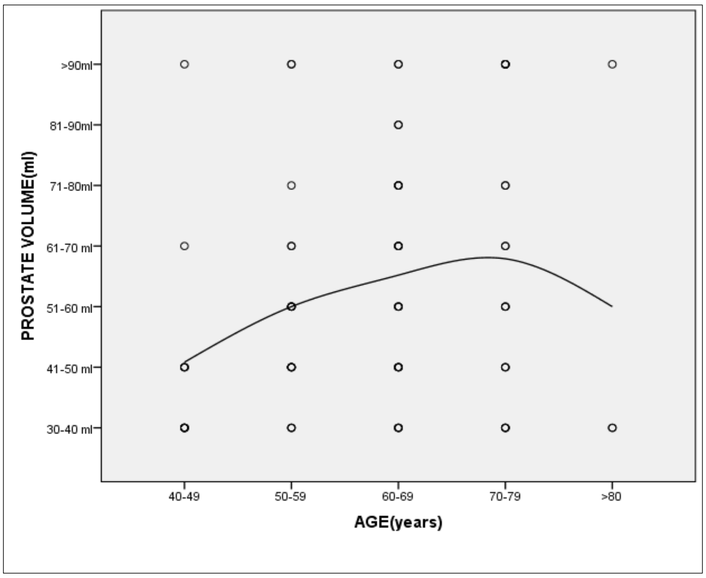

Figure 5: Scatter diagram showing positive correlation between age and prostate volume

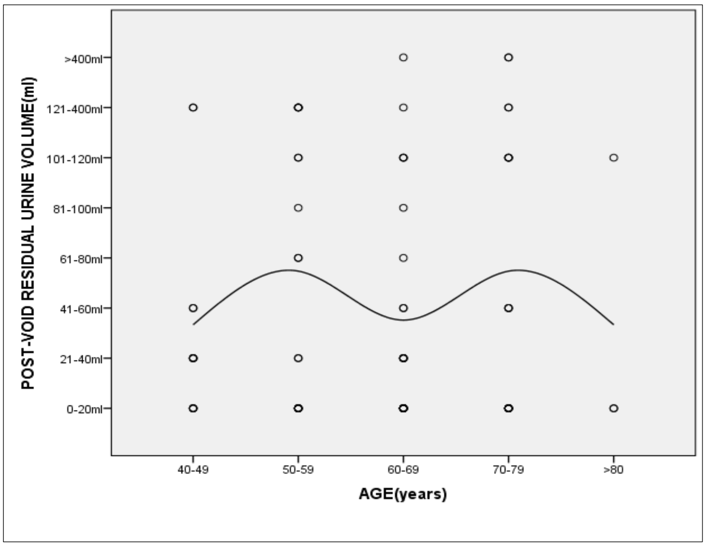

Figure 6: Scatter diagram showing correlation between age and PVR

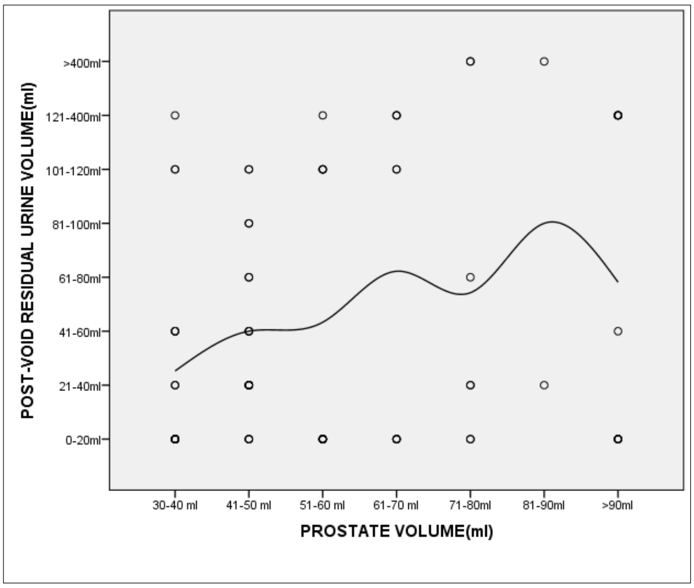

Figure 7: Scatter diagram showing correlation between prostate volume and PVR

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Conflict of Interest

The authors have made no declarations.

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