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ROLE OF ULTRASOUND IN PROSTATE GLAND VOLUME ESTIMATION AND CORRELATION WITH POST VOID RESIDUAL, PROSTATE SPECIFIC ANTIGEN LEVEL & INTERNATIONAL PROSTATE SYMPTOMS SCORE IN MEN WITH LOW URINARY TRACT SYMPTOMS

Original Research

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ABSTRACT

Background: Lower urinary tract symptoms (LUTS) are frequently observed in aging men and are commonly associated with benign prostatic hyperplasia (BPH). Accurate estimation of prostate volume is essential in diagnosing and managing BPH and related conditions. Ultrasonography offers a non-invasive, accessible, and cost-effective method for evaluating prostate size and related urinary parameters such as post-void residual (PVR) urine, prostate-specific antigen (PSA) levels, and symptom severity as per the International Prostate Symptom Score (IPSS).

Objective: To evaluate the utility of transabdominal ultrasonography in estimating prostate volume in male patients with LUTS and its correlation with PVR urine, PSA levels, and IPSS.

Methods: This cross-sectional analytical study was conducted at the District Head Quarter Hospital, Chiniot, Pakistan, from February to June 2024. A total of 158 male patients aged above 40 years presenting with LUTS were included using non-probability sampling. Exclusion criteria included prior pelvic or prostatic surgery, urethral pathologies, and urinary tract stones. Transabdominal ultrasonography was performed using 2–5 MHz and 7.5–10 MHz probes to measure prostate volume and post-void residual urine. IPSS scores and serum PSA levels were also recorded. Data were analyzed using SPSS version 24.0.

Results: The mean age of participants was 55.48 ± 12.58 years. Average prostate volume was 65.39 ± 23.57 cc, mean PSA level was 6.2 ± 5.34 ng/mL, and mean PVR urine volume was 73.35 ± 37.81 mL. IPSS scores indicated 25.9% had mild symptoms, 41.8% moderate, and 32.3% severe. A weak correlation was found between age and prostate volume ($r = 0.104$, $p = 0.191$), while strong positive correlations were observed between prostate volume and IPSS ($r = 0.779$, $p < 0.001$), PSA ($r = 0.699$, $p < 0.001$), and a moderate correlation with PVR ($r = 0.575$, $p < 0.001$).

Conclusion: Ultrasonography proved to be a valuable tool in assessing prostate volume and its significant correlations with PSA levels, IPSS, and PVR urine. These associations support its clinical use in evaluating and managing LUTS in aging males.

Keywords: International Prostate Symptom Score, Lower Urinary Tract Symptoms, Post-Void Residual Urine, Prostate Volume, Prostate-Specific Antigen, Ultrasonography, Urologic Diseases.

INTRODUCTION

Lower urinary tract symptoms (LUTS) and benign prostatic hyperplasia (BPH) are common conditions affecting men, particularly as they age, and have become significant contributors to global urological consultations. Prostate volume measurement plays a pivotal role in the clinical management of these conditions, helping guide therapeutic decisions ranging from pharmacologic interventions to surgical approaches. BPH, characterized by the non-malignant enlargement of the prostate gland, often begins in the third or fourth decade of life, and its prevalence increases sharply with advancing age. Epidemiological data indicate that approximately 50% of men aged 51–60 and up to 90% of those over 80 years are affected by BPH (1). Despite not being life-threatening, BPH and associated LUTS can substantially impair quality of life, particularly through symptoms such as nocturia, urinary frequency, urgency, weak stream, and incomplete bladder emptying (2,3). The clinical evaluation of prostate health frequently involves assessment of prostate-specific antigen (PSA) levels and prostate volume, with PSA density (PSA-D)—calculated by dividing PSA levels by prostate volume—serving as an increasingly relevant marker in differentiating between benign and malignant prostate conditions (4). PSA-D has shown superior diagnostic accuracy over PSA alone, particularly in identifying clinically significant prostate cancer while reducing unnecessary biopsies (5). However, there remains a limited understanding of how prostate volume influences PSA-D's predictive power, representing a critical gap in current literature (6). This underscores the need to investigate the interrelationships among prostate volume, serum PSA, and other clinical markers.

LUTS, once termed prostatism, can result from a spectrum of etiologies including BPH, bladder neck contractures, urethral strictures, and neurogenic factors like detrusor-sphincter dyssynergia (7). The International Prostate Symptom Score (IPSS) is widely used to quantify symptom severity, encompassing both storage and voiding symptoms. These include urgency, frequency, nocturia, weak stream, intermittency, straining, and sensation of incomplete emptying, along with a question addressing overall quality of life. The IPSS score provides a standardized means of symptom evaluation, ranging from 0 (asymptomatic) to 35 (severely symptomatic), and is essential for clinical decision-making (8). Ultrasound imaging has emerged as an essential, non-invasive tool for evaluating prostate volume, bladder wall thickness, and post-void residual volume (PVR), offering real-time, radiation-free assessments that are cost-effective and widely accessible (9). Transabdominal ultrasonography, using sector or convex transducers operating at 2–5 MHz, is particularly useful for visualizing the prostate and urinary bladder through the suprapubic approach (10). In clinical settings, this method allows simultaneous evaluation of prostate size, bladder capacity, and PVR—important metrics in the diagnostic workup of BOO (bladder outlet obstruction) and BPH-related LUTS (11). Measurement of PVR, in particular, serves as a key indicator of voiding efficiency and bladder function, and is often correlated with symptom severity (12).

Blood investigations, including PSA and complete blood count (CBC), also complement the diagnostic process. Elevated PSA levels may reflect prostatic enlargement, inflammation, infection, or malignancy, while CBC can identify infection or systemic inflammation related to urological conditions (13). Despite the advantages of ultrasonography, its diagnostic yield can be limited by patient anatomy, operator skill, and a restricted field of view (14). Nonetheless, studies have validated its clinical utility in assessing prostate-related pathology across diverse populations, including South Asian cohorts. For instance, data from Pakistan and India reveal a high burden of LUTS, with increasing severity correlating with advancing age and comorbid conditions such as diabetes, hypertension, and renal impairment (15,16). Given the rising incidence of prostate disorders among aging males, and the limitations in current diagnostic pathways, this study seeks to explore whether and how ultrasonography can be effectively used to estimate prostate volume and its correlation with PSA levels, IPSS scores, and PVR. The objective is to determine age-specific trends and establish how changes in these parameters relate to prostate gland maturation and disease progression. This research aims to fill a critical knowledge gap by providing region-specific data on prostate health, ultimately supporting improved clinical evaluation and management of male patients presenting with LUTS.

METHODS

A cross-sectional analytical study was carried out from February to May 2024 at the District Head Quarter Hospital, Chiniot, to investigate the correlation between prostate gland volume, serum prostate-specific antigen (PSA) levels, International Prostate Symptom Score (IPSS), and post-void residual (PVR) urine in adult males. A total of 158 male participants aged over 40 years were enrolled

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

through non-probability sampling. The inclusion criteria encompassed all males above 40 years, regardless of symptom presentation, while the exclusion criteria ruled out individuals with a history of pelvic trauma, urinary bladder stones, prior pelvic or prostatic surgery, urethral strictures, urethral infections, or urethral calculi. Written informed consent was obtained from all participants prior to data collection. The study received ethical approval from the institutional review board of District Head Quarter Hospital Chiniot. Transabdominal ultrasonography was employed as the imaging modality for evaluating the prostate gland and bladder. Each participant was advised to consume approximately 500 milliliters of water an hour before the examination to ensure adequate bladder filling for optimal visualization. During the procedure, patients lay in a supine position while a linear or convex transducer with a frequency range of 2–5 MHz or, when higher resolution was needed, 7.5–10 MHz was used. The transducer was placed transversely above the pubic symphysis and angled caudally at approximately 30 degrees. Gentle pressure was applied to reduce shadow artifacts and enhance clarity of the prostate's inferior regions (3,5).

The prostate gland was assessed in both transverse and sagittal planes. Transverse imaging provided measurements of the gland's width (W), symmetry, median lobe prominence, and intravesical extension relative to the bladder wall. Sagittal imaging was performed by rotating the transducer 90 degrees to measure the prostate's height (H) and length (L), also capturing the extent of any intravesical protrusion. In patients with higher body mass index or when technical difficulty limited full visualization, only height and width were recorded. Following voiding, post-micturition scans were conducted to determine PVR urine volume using the same transducer placement. Clinical data were collected using a structured, close-ended questionnaire, which included items on age, PSA levels, IPSS scoring, medical history, medication use, imaging findings, and PVR volume. The data were entered and analyzed using the Statistical Package for Social Sciences (SPSS), version 24.0. Descriptive statistics were applied to summarize the variables, while appropriate inferential tests were used to evaluate relationships between prostate volume and clinical parameters.

RESULTS

The study analyzed data from 158 male participants at a government hospital in District Chiniot, Punjab, to assess the relationship between prostate volume, serum PSA levels, IPSS scores, and post-void residual urine. The average age of participants was 55 ± 7 years. In terms of age distribution, 15.2% were under 40 years, 17.1% were between 41–50 years, 38.0% between 51–60 years, 20.9% between 61–70 years, and 8.9% were above 70 years. Regarding symptom severity, 25.9% of the participants had mild symptoms according to the International Prostate Symptom Score (IPSS), 41.8% had moderate symptoms, and 32.3% had severe symptoms. Prostate volume (PSV) assessment revealed that 3.2% had volumes between 0–30 cc, 43.7% had 31–60 cc, 40.5% had 61–90 cc, and 12.7% had volumes exceeding 90 cc. The mean prostate volume was 65.39 ± 23.57 cc. PSA level distribution showed that 47.1% had levels between 0–4 ng/mL, 38.6% between 4.1–10 ng/mL, 9.8% between 10.1–20 ng/mL, and 4.6% above 20 ng/mL, with a mean PSA level of 6.2 ± 5.34 ng/mL. Post-void residual (PVR) urine measurements demonstrated that 37.3% had volumes between 0–50 mL, 41.1% had 51–100 mL, 19.0% had 101–150 mL, and 2.5% had values above 150 mL. The average PVR was 73.35 ± 37.81 mL.

Correlation analysis using Pearson's coefficient revealed a weak, non-significant correlation between age and prostate volume ($r = 0.104$, $p = 0.191$). However, prostate volume showed strong positive correlations with IPSS ($r = 0.779$, $p < 0.001$), PSA levels ($r = 0.699$, $p < 0.001$), and PVR ($r = 0.575$, $p < 0.001$). A very strong correlation was noted between prostate volume and PSA levels in a separate analysis ($r = 0.842$, $p = 0.000$), further validating their interdependence. Additionally, PSA levels demonstrated strong correlations with IPSS ($r = 0.676$, $p = 0.000$) and PVR ($r = 0.727$, $p = 0.000$), while IPSS and PVR also shared a notable positive relationship ($r = 0.599$, $p = 0.000$). A negligible correlation was observed between age and IPSS ($r = 0.038$, $p = 0.320$), indicating no significant association in this context. Subgroup analysis based on age stratification revealed notable trends across clinical parameters. The mean PSA levels, prostate volumes, IPSS scores, and PVR values increased progressively with age. Participants aged under 40 years had the lowest mean PSA (3.2 ng/mL), prostate volume (40.2 cc), and IPSS (12.4), while those above 70 years exhibited the highest mean PSA (8.1 ng/mL), prostate volume (76.0 cc), and symptom burden with a mean IPSS of 23.2. Post-void residual urine volume also followed a similar trend, increasing from 45.2 mL in the youngest group to 92.3 mL in the oldest, indicating declining bladder emptying efficiency with age. When comparing symptomatic and asymptomatic individuals, symptomatic patients showed significantly higher mean PSA levels (7.4 ng/mL), prostate volumes (69.2 cc), IPSS scores (21.5), and PVR volumes (81.3 mL) compared to their asymptomatic counterparts, who had mean PSA levels of 4.1 ng/mL, prostate volumes of 54.7 cc, IPSS scores of 8.4, and PVR volumes of 53.2 mL. These differences underscore the impact of symptom presentation on clinical markers of prostate health and urinary function.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Table 1: CORRELATIONS BETWEEN DIFFERENT VARIABLES

		AGE/SEX	IPSS	PSA	PSV	PVR
AGE/SEX	Pearson Correlation	1	.038	-.004	.104	.296**
	Sig. (2-tailed)		.639	.962	.191	.000
	N	158	158	158	158	158
IPSS	Pearson Correlation	.038	1	.841**	.779**	.599**
	Sig. (2-tailed)	.639		.000	.000	.000
	N	158	158	158	158	158
PSA	Pearson Correlation	-.004	.841**	1	.699**	.711**
	Sig. (2-tailed)	.962	.000		.000	.000
	N	158	158	158	158	158
PSV	Pearson Correlation	.104	.779**	.699**	1	.575**
	Sig. (2-tailed)	.191	.000	.000		.000
	N	158	158	158	158	158
PVR	Pearson Correlation	.296**	.599**	.711**	.575**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	158	158	158	158	158

Table 2: Correlation Between Prostate Volume and Prostate-Specific Antigen (PSA) Levels in Study Participants

		Prostate Volume	PS Antigen
Pearson Correlation	Prostate Volume	1.000	.842
	PS Antigen	.842	1.000
Sig. (1-tailed)	Prostate Volume	.	.000
	PS Antigen	.000	.
N	Prostate Volume	153	153
	PS Antigen	153	153

Table 3: Correlation Matrix Among IPSS Score, Prostate Volume, PSA Levels, and Post-Void Residual Urine in Study Participants

		Prostate Score	Prostate Volume	PS Antigen	Residual Vol
Pearson Correlation	Prostate Score	1.000	.645	.676	.482
	Prostate Volume	.645	1.000	.842	.613
	PS Antigen	.676	.842	1.000	.727
	Residual Vol	.482	.613	.727	1.000
Sig. (1-tailed)	Prostate Score	.	.000	.000	.000
	Prostate Volume	.000	.	.000	.000
	PS Antigen	.000	.000	.	.000
	Residual Vol	.000	.000	.000	.
N	Prostate Score	153	153	153	153
	Prostate Volume	153	153	153	153
	PS Antigen	153	153	153	153
	Residual Vol	153	153	153	153

INSIGHTS-JHR
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Table 4: Correlation Between Age and International Prostate Symptom Score (IPSS) in Study Participants

		AGE/SEX	IPSS
Pearson Correlation	AGE/SEX	1.000	.038
	IPSS	.038	1.000
Sig. (1-tailed)	AGE/SEX	.	.320
	IPSS	.320	.
N	AGE/SEX	158	158
	IPSS	158	158

Table 5: Correlation Between International Prostate Symptom Score (IPSS) and Post-Void Residual Urine Volume in Study Participants

		IPSS	PVR
Pearson Correlation	IPSS	1.000	.599
	PVR	.599	1.000
Sig. (1-tailed)	IPSS	.	.000
	PVR	.000	.
N	IPSS	158	158
	PVR	158	158

Table 6: Subgroup Analysis of Age Groups vs PSA, PSV, IPSS, and PVR

Age Group	Mean PSA (ng/mL)	Mean Prostate Volume (cc)	Mean IPSS	Mean PVR (mL)
<40	3.2	40.2	12.4	45.2
41-50	4.5	55.3	15.1	60.1
51-60	6.8	67.8	19.3	78.4
61-70	7.5	72.4	21.7	85.6
>70	8.1	76	23.2	92.3

Table 7: Comparison of Symptomatic and Asymptomatic Individuals

Group	Mean PSA (ng/mL)	Mean Prostate Volume (cc)	Mean IPSS	Mean PVR (mL)
Symptomatic	7.4	69.2	21.5	81.3
Asymptomatic	4.1	54.7	8.4	53.2

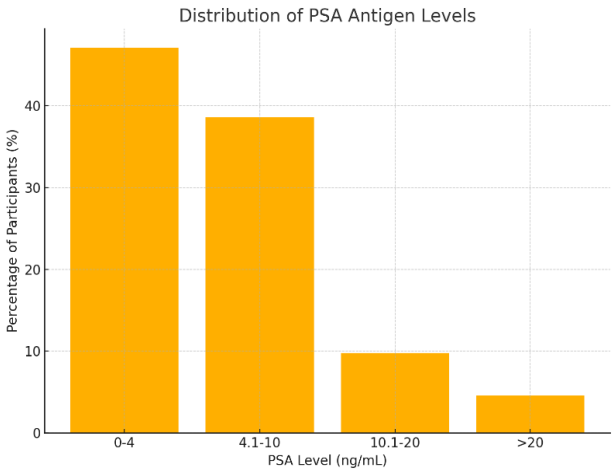

Figure 1 Distribution of PSA Antigen Levels

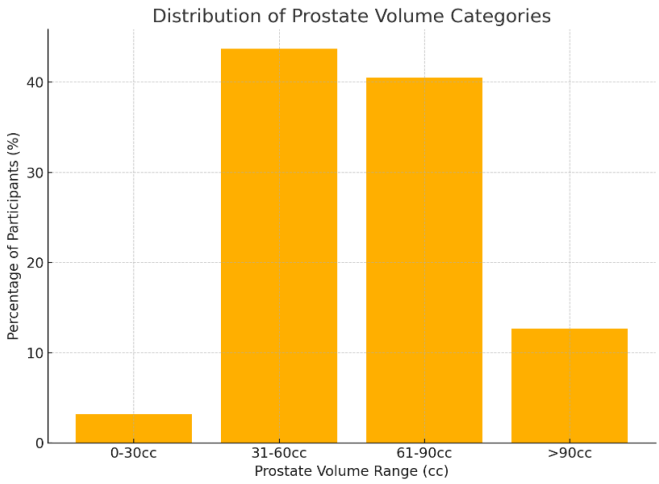

Figure 2 Distribution of Prostate Volume Categories

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DISCUSSION

This study explored the relationship between prostate volume, PSA levels, IPSS scores, and post-void residual urine in patients with lower urinary tract symptoms (LUTS) at a tertiary care center in Pakistan. With an average age of 55.48 ± 12.58 years and a minimum of 35 years, the study population represented a relatively younger demographic than that reported in some international datasets. The findings revealed clear trends indicating that prostate volume increases with age and is associated with elevated PSA levels, higher symptom burden, and greater urinary retention. These observations are consistent with previously published evidence suggesting that benign prostatic hyperplasia (BPH) progresses with aging and contributes to worsening LUTS parameters (17,18). The study demonstrated a strong correlation between prostate volume and IPSS, which aligns with existing research showing that increasing prostate size is linked to more severe urinary symptoms. Similarly, PSA levels were positively correlated with both prostate volume and IPSS, reinforcing the utility of PSA as a marker of prostatic activity and volume. These associations gain further support from previous investigations which established that patients with larger prostate volumes tend to report more significant symptomatology and may also have a higher risk of progression to prostate cancer in specific PSA ranges (19). A previously conducted study reported that within PSA ranges of 10–19.9 ng/mL, men with prostate volumes below 60 cc had substantially higher rates of prostate cancer detection than those with larger prostates, highlighting the clinical significance of volume in cancer risk stratification (20).

Despite the strength of associations observed in this study, the correlation between age and IPSS was weak, suggesting that symptom severity may not always directly reflect patient age but rather is influenced by the interplay of multiple factors including prostate size, residual urine volume, and serum PSA levels. These findings reflect patterns seen in broader urological research, where age alone was not always a strong determinant of symptom severity but did contribute to an overall risk profile when considered alongside prostate parameters (12,19). The inclusion of both symptomatic and asymptomatic individuals further underscored this variability, with symptomatic patients exhibiting significantly higher PSA levels, prostate volumes, IPSS scores, and PVR, indicating greater clinical burden. While the study presented valuable insights, it was not without limitations. The relatively small sample size restricted the statistical power and generalizability of findings to wider populations. Potential measurement inaccuracies in PSA assessment and ultrasound-based prostate volume estimations may have influenced the results. Moreover, uncontrolled confounding variables such as existing comorbidities, medication use, or lifestyle factors were not systematically evaluated and may have contributed to outcome variability. The limited duration of data collection also precluded any longitudinal assessment, which is necessary to understand progression patterns over time. Nevertheless, this study contributed important region-specific data on prostate health parameters and their inter-relationships in men presenting with LUTS. It emphasized the clinical relevance of prostate volume estimation not only in managing benign prostatic hyperplasia but also in risk stratification for prostate cancer. The use of ultrasound, a non-invasive and accessible imaging modality, further strengthened the practicality of the study approach. For future research, expanding the sample size and incorporating multi-center recruitment strategies would enhance representativeness. Longitudinal studies are warranted to capture the evolution of prostate parameters over time and their potential causal relationships. Further exploration of the role of prostate volume in modulating PSA levels and LUTS severity, while controlling for underlying metabolic or systemic conditions, would also provide deeper clinical insights.

CONCLUSION

This study concluded that prostate volume is meaningfully associated with key clinical indicators including symptom severity, PSA levels, and post-void residual urine, reinforcing its central role in evaluating and managing lower urinary tract symptoms. Although its correlation with age appeared weak, strong and consistent associations with IPSS and PSA highlight its diagnostic and prognostic significance in prostatic conditions. The moderate relationship between prostate volume and residual urine further supports its relevance in assessing bladder function. These findings emphasize the value of incorporating prostate volume measurements into routine clinical practice to aid in early diagnosis, guide treatment planning, and improve patient outcomes in the context of benign prostatic hyperplasia and related disorders.

INSIGHTS-JHR
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Author Contribution

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Loqman Shah*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Awais Qurni	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Andleeb Fatima	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Iqra Saeed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
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Tahreem Iqbal	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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