Original Article

Prostate volume measured by magnetic resonance imaging is not a predictor of lower urinary tract symptoms

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Abstract

Purpose: Prostate volume is frequently utilized to counsel patients presenting to family medicine physicians with voiding complaints. We evaluated the relation between International Prostate Symptom Score (IPSS) and prostate volume measured by phased-array surface coil magnetic resonance imaging (MRI). **Methods:** We performed an institutional review board (IRB)–approved retrospective study of all patients who received a prostate MRI between 2015 and 2017. Correlation between the overall IPSS, IPSS components, prostate volume stratified by prostate specific antigen (PSA) (<1.4 vs. ≥1.4 g/dL), and race (black vs. white) was examined. **Results:** In all, 592 patients had prostate MRIs performed between 2015 and 2017. Two hundred and twenty-nine of these patients had IPSS and prostate volume information available in their medical records. The mean age of the cohort was 64.67 (SD = ±7.82) and mean PSA was 7.75 (SD = ±8.3). The mean IPSS was 9.77 (SD ± 7.2), and mean prostate volume was 55.88 cubic cm (SD = ±38.9). The correlation coefficient between prostate volume and IPSS was 0.12789 (P = 0.05). The correlation between prostate volume and IPSS was also not significant in 128 men with prostate volume above 40 cubic cm. Stratifying analysis by race and PSA showed no significant correlation between volume and IPSS. Analysis of the correlation between the different dimension of prostate volume and IPSS revealed significant but weak associations. **Conclusions:** Even with more precise estimation with MRI, prostate volume does not predict obstruction complaints. This finding is of importance when treating males presenting with voiding dysfunction to primary care.

Keywords: International Prostate Symptom Score, magnetic resonance imaging, prostate volume

Introduction

Benign prostatic enlargement (BPE) is a common condition in older men. The prevalence increases from 40% to 50% in the sixth decade of life, to >80% in men in their eighth decade of life and older.[1] Men in the same age group also present with significant disabilities due to lower urinary tract symptoms (LUTS), which increase with age. It has been reported that up to 20% of men will present with bothersome LUTS during the fifth decade of life, and that these symptoms will progress as they age, with 46% reporting symptoms in the eighth decade of life.[2]

The association between prostate volume and LUTS has been previously examined using data from digital rectal examination and trans-rectal ultrasound (TRUS). However, not many studies have evaluated this using prostate volumes derived from multi-parametric magnetic resonance imaging (MRI). The importance of understanding this association is multifactorial. Many urologists and primary care physicians who manage benign prostatic hyperplasia (BPH) use prostate volume measurements

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from different modalities, including MRI, to counsel patients on the management of LUTS, bladder obstruction, and irritability. In addition, in the contemporary literature, and at centers of excellence, modalities that focus on the treatment of prostate volume as a risk factor or surrogate marker for LUTS are gaining popularity. For example, increasing numbers of patients are being offered prostate artery embolization (PAE) to reduce prostate volume, an end point used to predict improvement in bladder outlet obstruction.[3] Therefore, a careful examination of the association between prostate volume and the severity of LUTS, measured by validated tools like the International Prostate Symptom Score (IPSS), is of critical importance. This study aimed to test the hypothesis that prostate volume measured by MRI has an association with severity of LUTS, and to understand the effects of race and prostate specific antigen (PSA) level on this association. The findings from this study are meant to guide clinical management of patients with LUTS as well as inform study designs that employ reduction of prostate volume as an outcome surrogate of the effectiveness of treatment.

Methods

In an institutional review board (IRB)–approved retrospective study, we examined all local standard prostate MRI studies between 2015 and 2017 (592 patients), and identified the patients who had complete, contemporaneous IPSS data recorded (229 patients). All patients were imaged on one of two 3.0T MRI systems: GE Discovery 750 (GE Healthcare, Waukesha, WI, USA), using a 32-channel phased array coil, and Philips Ingenia (Philips Healthcare, Best, the Netherlands), using a 32-element anterior torso phased array coil coupled with an integrated posterior 20-element array in the tabletop. A near-identical imaging protocol was employed, including large field of view (FOV) (32 cm or greater) 2D fast spin-echo (FSE) T2-weighted images with fat suppression and 3D T1 gradient-echo (GRE) with Dixon fat-water separation (fat, water, in-phase, out-of-phase reconstructions); small FOV (18 cm) FSE T2 images of the prostate in the axial, sagittal, and coronal planes; axial diffusion weighted images (DWI) in small FOV (Philips, 18 cm) and large FOV (GE, 30 cm); small (22 cm) FOV bolus IV gadolinium chelate dynamic contrast enhanced T1 GRE series (20 serial post contrast phases, temporal resolution <10 sec); and a final large FOV pelvic post contrast T1 GRE Dixon (water reconstruction) series. Examinations were interpreted and parameters, including prostatic dimensions and three-dimensional volumes, were analyzed using DynaCAD (InVivo, Gainesville, FL, USA). A fellowship-trained radiologist with expertise in prostate imaging interpreted all MRI studies.

The IPSS values for each patient, as determined before the MRI study was performed, were collected. The relationship between the IPSS and prostate volume, stratified by PSA and race, was examined using correlation coefficient and analysis of variance (ANOVA). Further analysis of correlation between the six IPSS variables (Incomplete Emptying, Frequency, Intermittency, Urgency, Weak Stream, Straining, and Nocturia) and overall prostate volume, urethral length, prostate transverse diameter, and anteroposterior dimension was additionally performed.

Results

The characteristics of the patients included in this study stratified by prostate volume and race are illustrated in Table 1. The correlation coefficient between prostate volume and IPSS was 0.12789 ($P = 0.05$), which is positive, yet insignificant. The correlation between volume and IPSS in patients with prostate volume >40 cubic cm was 0.02778 ($P = 0.7556$), similarly not significant. Furthermore, stratifying analysis by race and PSA showed no significant correlation between volume and IPSS [Table 2]. The analysis of the correlation between the six IPSS components (Incomplete Emptying, Frequency, Intermittency, Urgency, Weak Stream, Straining, and Nocturia) and prostate volume showed mostly significant, but overall weak correlation [Table 3]. Finally, prostate anteroposterior dimension was not associated with a high IPSS score, and urethral length and prostate transverse diameter were significant but weak correlates of more severe LUTS. Stratification of analysis by race (White vs. Black) and PSA level (<1.4 vs. ≥1.4 ng/dL) did not strengthen any of these correlations.

Discussion

In this retrospective study, we examined the correlation between LUTS measured by IPSS and prostate volumes measured by MRI and demonstrate weak correlation between increasing prostate volume and higher IPSS. We further investigated the relationship among different components of IPSS and individual prostate dimensions and found no clinically relevant trends. Limiting analysis to prostate volume above 40 cubic cm and stratifying analysis by a PSA threshold of 1.4 ng/dL did not increase any of the correlation coefficients to above 0.5, and these results applied equally to both black and white patients.

Table 1: Results of the analysis of the correlation between different prostate dimensions and the International Prostate Symptom Score stratified by race and prostate specific antigen

Prostate Dimension CM	Overall population		Patients with prostate volume >40 gm		Black		White		PSA >1.4	
	CC*	*P*	CC*	*P*	CC*	*P*	CC*	*P*	CC*	*P*
Transverse	0.14	0.03	0.01	0.98	0.33	0.02	0.12	0.13	0.16	0.02
Anteroposterior	0.11	0.10	-0.10	0.28	0.21	0.13	0.13	0.10	0.12	0.07
Urethral Length	0.19	0.01	0.09	0.33	0.30	0.03	0.18	0.03	0.20	0.01

*Correlation coefficient

Table 2: Results of the analysis of the correlation between different components of the International Prostate Symptom Score and prostate volume stratified by race and prostate specific antigen

IPSS criteria	Prostate Volume ml		Prostate Volume >40 gm		Prostate Volume in African American		Prostate Volume in White people		Prostate Volume in PSA >1.4	
	CC*	*P*	CC*	*P*	CC*	*P*	CC*	*P*	CC*	*P*
Incomplete Emptying	0.20	0.02	0.01	0.10	0.17	0.30	0.18	0.09	0.21	0.02
Frequency	0.21	0.01	0.05	0.65	0.21	0.19	0.20	0.05	0.23	0.01
Intermittency	0.23	0.01	0.02	0.84	0.40	0.01	0.29	0.01	0.33	0.01
Urgency	0.18	0.03	0.07	0.52	0.26	0.11	0.17	0.10	0.20	0.02
Weak Stream	0.22	0.01	0.07	0.51	0.42	0.01	0.16	0.12	0.25	0.01
Straining	0.18	0.03	0.01	0.90	0.28	0.09	0.15	0.13	0.26	0.01
Nocturia	0.06	0.51	0.08	0.49	0.04	0.82	0.08	0.44	0.09	0.27

*Correlation coefficient

Table 3: Patient, prostate dimensions, and lower urinary tract symptom characteristics stratified by prostate volume and race/median and range in prostate dimension, age, and IPSS (and its subgroups)

	Overall	Prostate Volume >40	African American	White	PSA >1.4
Age (Mean, ±SD)	65.5 (59.1-69.6)	66.9 (61.6-71.8)	61.5 (57.7-68.9)	66.2 (60.6-70.2)	65.3 (59-69.6)
Prostate Volume (Mean, ±SD)	44 (29.9-67)	64 (50-93)	44.5 (29.8-79.4)	45.5 (30-67.7)	45.1 (31-68)
Anteroposterior prostate dimension in cm (Mean, ±SD)	4.3 (3.7-4.9)	4.8 (4.4-5.4)	4.4 (3.8-5.3)	4.3 (3.7-4.9)	4.4 (3.8-4.9)
Urethral length in cm (Mean, ±SD)	4.5 (3.8-5.4)	5.2 (4.7-6.2)	4.3 (3.8-5.4)	4.6 (3.9-5.4)	4.6 (3.9-5.4)
Transverse prostate dimension in cm (Mean, ±SD)	5 (4.6-5.7)	5.6 (5.1-6.2)	5 (4.7-6.1)	5.1 (4.6-5.7)	5.1 (4.7-5.8)
International Prostate Symptom Score (median, range)	8 (4-14)	9 (5-14)	8 (5-14)	8 (3-13)	8 (4-13)
Incomplete Emptying (Median, range)	1 (0-2)	1 (0-3)	1 (0-2)	1 (0-2)	1 (0-2)
Frequency (Median, range)	2 (1-3)	2 (1-3)	2 (1-3)	2 (1-3)	2 (1-3)
Intermittency (Median, range)	1 (0-2)	1 (0-3)	1 (0-2)	1 (0-2)	1 (0-2)
Urgency (Median, range)	1 (0-2)	1 (0-3)	1 (0-2)	1 (0-2)	1 (0-2)
Weak Stream (Median, range)	1 (0-2)	2 (1-3)	1 (0-2)	1 (0-2)	1 (0-2)
Straining (Median, range)	0 (0-1)	0 (0-1)	0 (0-0)	0 (0-1)	0 (0-1)
Nocturia (Median, range)	1 (1-2)	2 (1-2)	2 (1-2)	1 (1-2)	1 (1-2)

Our results are supported by many primary care providers who counsel patients regarding an association between LUTS and BPE. While this may be true in some cases, it does not appear to be universal. A study performed by Barry *et al.* measured the relationship of LUTS and prostate size measured by TRUS, demonstrating no significant correlation of severity, peak flow rate, average flow rate, and post-void residual urine volume with prostate size and PSA level.[4] A second study by Simon *et al.* examined the rate of developing incident LUTS in men with BPE on placebo treatment, versus men with BPE being treated with Dutasteride, a drug that inhibits the conversion of testosterone to dihydrotestosterone. This study solely included men with mild to no urinary symptoms that were followed for 3 or more years. The authors concluded that prostate size was a poor predictor for the development of LUTS. Furthermore, as Dutasteride treatment mitigated the association of large prostate size and LUTS, and the rate of LUTS development was not very different between patients in the placebo and treatment arms, they also concluded that many patients could be developing LUTS due to reasons unrelated to prostate volume.[5] In another recent study, Yang *et al.* concluded that there is an association between prostate volume and voiding complaints. The authors' results were that prostate volume ≧25 vs. <25 mL (odds ratio [OR] = 1.38; 95% confidence interval [CI] = 1.04–1.82) was significantly associated with the presence of moderate/severe LUTS. However, prostate volume in Yang *et al.*'s study was measured by ultrasound and "digital rectal examination were performed by experienced urologists," which is now as accurate as prostate MRI, and the authors did not provide a breakdown of the volumes measured via ultrasound versus digital rectal examination.[6]

Recently, different approaches focused on decreasing the prostate volume, including PAE, have gained attention in the management of LUTS.[4] The therapeutic endpoints rely on baseline central gland and whole prostate volumes, as well as zonal volumetry indices, as predictors of clinical outcomes in patients undergoing treatment.[1] It has been suggested that PAE results in a great reduction of prostate size, and that gland necrosis is the cause for reduction in prostate volume.[7,8] In one study, a patient had 47% volume reduction at 6 months following bilateral PAE, while another showed 28% reduction after unilateral PAE.[7] However, PAE has also been shown to successfully treat LUTS without reduction in prostate volume. In a prospective study, Martins *et al.* demonstrated a clinical success rate of 81.9% at 1 month, independent of reduction in organ volume. In fact, 9% of the patients with clinical failure had significant reduction in prostate volume, which led the authors to conclude that the clinical success of PAE cannot be predicted by reduction in prostate volume.[9]

As our data show no significant correlation between IPSS and increasing prostate volume, this suggests that further investigations are needed to clarify the mechanism by which PAE reduces LUTS and to find better predictors of response to treatment. Our findings question the consideration of prostatic volume, separate from symptoms, as a rationale for any surgical or medical treatment of BPE, including less invasive approaches like PAE. Currently, the American Urologic Association lists multiple thermal therapies as part of the minimally invasive approach to treat BPE/LUTS and calls for action to evaluate different phenotypes of BPE/LUTS in order to better understand the disease process. Our study clearly addresses this issue, showing that BPE and LUTS are at most weakly associated and that treatments based solely on decreasing the prostate volume may have limitations.[10] PAE is not discussed in the most recent guidelines and is largely available in research settings in countries outside the United States.[11] It is the authors' practice to reserve PAE for treatment of patients with hemorrhagic prostatic conditions, in collaboration with Interventional Radiology.

There are many strengths of this study. MRI is gaining favor as an accurate tool to characterize the prostate and, to our knowledge, may provide the most precise measurement of prostate size. The validity of our MRI-based prostate measurement is further enhanced by the use of updated equipment, a unified imaging protocol, and the availability of high-level expertise in interpretation of prostate MRI. Another strength of this study is the inclusion of race in the analysis, allowing our findings to be more generalizable. There are few studies with sufficient inclusion of black patients in this clinical domain, and our patient population allowed us to collect a broad, racially diverse sample. Our results also have limitations. The study population is derived from a group of patients who did not have MRI ordered specifically for management of LUTS; thus, patients being treated for LUTS with PAE could represent a functionally or anatomically different group. Another limitation is the sample size. LUTS are common, and many studies examining these problems included a sufficiently large number of patients that statistical power would not be an issue. However, MRI of the prostate may be expensive and/or may not be covered by insurance in many cases, reducing the number of patients with LUTS that are available for a study such as this.

Conclusion

Larger prostate volume measured by MRI has no correlation with increasing IPSS. This holds true for different PSA levels and across major racial groups. The functional component of LUTS deserves more attention when considering treatment of patients presenting for management of voiding complaints.

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Conflicts of interest

There are no conflicts of interest.

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