Original article

Factors correlated with prostate volume in middle-aged men with bothersome lower urinary tract symptoms

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ABSTRACT

Objective: The aim of this study was to investigate the predictive factors of prostate volume (PV) by analyzing potential predictors in a population of middle-aged men with bothersome lower urinary tract symptoms (LUTS) and use a prediction model for PV estimation to compare with digital rectal examination (DRE) alone.

Materials and methods: Patients between the ages of 40 years and 64 years who underwent transrectal prostate ultrasound as part of a self-paid medical check-up were enrolled. Participant demographics, medical history, and voiding symptoms were assessed by the International Prostate Symptoms Score (IPSS) questionnaire. A multiple linear regression with stepwise selection was used to analyze the correlations between PV and all potential predictors.

Results: Two hundred and twenty-eight men with bothersome LUTS (IPSS > 7) were enrolled as study participants at a mean age of 56.4 years. Patients with PV > 25 mL were significantly older and had higher serum prostate-specific antigen (PSA) levels and scores for total IPSS, storage, urgency items, and nocturia items. DRE, serum PSA, age, and urgency score were independent predictors for PV, especially for men with PV > 25 mL, for which the standardized regression equation was PV = 0.74 × (DRE estimation) + 0.10 × (age) + 0.12 × (serum PSA) + 0.079 × (urgency score) (adjusted R^2 = 0.80).

Conclusion: In the current study, we confirmed that serum PSA, age, and urgency score are significant predictors of PV. The prediction model including DRE, PSA, age, and urgency score was a better method to estimate PV than DRE alone, especially for men with a larger prostate (PV > 25 mL).

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1. Introduction

Middle-aged men often experience lower urinary tract symptoms (LUTS) secondary to benign prostatic hyperplasia (BPH).[1,2] Prostate volume (PV) estimation has become increasingly important, because of the association between PV, LUTS, BPH progression, and the need for surgery.[3-5] Moreover, PV estimation may help in predicting treatment response and selecting therapeutic options.[5,6] Transrectal prostate ultrasound (TRUS) was a validated tool for PV estimation,[7] but its invasiveness and costs limited the role of this procedure in a primary clinical setting.

Despite the development of sizing scales and three-dimensional relief models to accurately determine PV,[7] digital rectal examination (DRE) may underestimate PV,[8] and the correlation between DRE and TRUS in estimating PV has not been well established in previous studies.

Past research indicated that age and body weight, along with PSA, fit a prediction model for PV.[9] In this study, we aim to investigate the predictive factors of PV by analyzing potential covariates in a population of middle-aged men with significant LUTS, and use a prediction model for PV estimation compared to DRE alone.

2. Materials and methods

During January 2010 through to December of 2010, we consecutively enrolled patients age 40 years or older (40—64 years) who underwent transrectal ultrasound as part of a medical checkup at a single institute. Because the study group consisted of men who

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underwent healthy checkups, informed consent was obtained from all patients. Participant demographic characteristics, clinical symptoms, and medical histories were collected. Individuals were excluded if they had a history of prostate cancer or prostate surgery or were currently using medication known to interfere with voiding symptoms. Two hundred and twenty-eight men with bothersome LUTS [International Prostate Symptoms Score (IPSS) > 7] were enrolled after they completed the validated Chinese version of the IPSS questionnaire, and maximum flow rate (Qmax) was assessed.

Experienced urologists performed DRE with the ball scale or three-dimensional relief model, consisting of a board with several rubbery 0.5-cm-high models representing different PVs, to estimate PV in increments of 10 g. In addition, the shape, symmetry, firmness, and nodularity of the prostate were assessed.

PV was measured by one of the experienced urologists, mainly senior residents, using the LOGIQ P5 TRUS system (GE Healthcare, Milwaukee, WI, USA). The area of greatest transverse diameter in the transverse view, and anteroposterior and transverse dimensions of the prostate were measured. Sagittal scanning was subsequently performed, and the distance from the base to the apex in the median plane was measured along the longitudinal dimension. The formula anteroposterior dimension × transverse dimension × longitudinal dimension × $\pi/6$ was used for the calculation PV on TRUS.[10]

2.1. Statistical analysis

Continuous variables were analyzed with the Student t test and are presented as mean ± standard deviation (SD). Categorical variables were analyzed with the Chi-square test and were recorded as frequencies or percentages. The two-sided alpha level was 0.05. A p value of <0.05 was considered to be statistically significant.

Multiple linear regression analysis was used to examine the association between PV and potential predictors. Categorical variables, such as DRE, were modeled as a series of dummy variables. A stepwise selection method was chosen for the final model. The analyzed covariates included age, weight, height, body mass index, DRE estimation, serum PSA levels, the presence of metabolic syndrome or hypertension, serum cholesterol levels, serum high-density lipoprotein levels, fasting blood sugar levels, serum triglyceride levels, waist circumference, total IPSS scores, storage scores, voiding scores, and IPSS item scores. The Pearson or Spearman correlation coefficients (r) were used to assess the relationship between PV and potential predictors. All data in the present study were analyzed with a commercial statistical software package (SPSS version 13.0 for Windows, SPSS Inc., Chicago, IL, USA).

3. Results

Table 1 lists clinical and demographic characteristics of all study participants. The mean age of study participants was 56.4 years (range 40–64 years). Mean prostate volume measured by TRUS was 32.2 mL (range 4.7–86.3) and mean serum PSA was 1.56 ng/mL (range 0.13–11.3). The average total IPSS, storage, and voiding scores were 14.1 ± 5.22, 5.50 ± 2.57, and 8.60 ± 4.06, respectively. The percentage of metabolic syndrome among study participants was 21.5%. Ninety-eight patients (43.0%) had lower flow rate (Qmax <15 mL/s).

Study participants were further categorized by PV in Table 2. Compared to the PV ≤ 25 mL group, the larger PV group (PV > 25 mL) had significantly higher age and serum PSA level, and suffered more from total IPSS, storage score, item "urgency" and "nocturia" score.

Table 1
Demographic characteristics of study participants ($N = 228$).

	Mean ± SD (range)
Age (y)	56.4 ± 7.30 (40–64)
Body height (cm)	170 ± 5.72 (152–188)
Body weight (kg)	72.1 ± 9.79 (47.7–100)
Prostate volume (mL)	32.2 ± 14.1 (4.7–86.3)
Serum PSA (ng/dL)	1.56 ± 1.69 (0.13–11.3)
IPSS	
Total	14.1 ± 5.22 (8–32)
QoL score	3.26 ± 1.08 (1–6)
Storage score	5.50 ± 2.57 (0–13)
Frequency	2.64 ± 1.37 (0–5)
Urgency	1.29 ± 1.28 (0–5)
Nocturia	1.57 ± 1.02 (0–5)
Voiding score	8.60 ± 4.06 (0–20)
Incomplete emptying	2.54 ± 1.50 (0–5)
Intermittency	2.23 ± 1.52 (0–5)
Weak stream	2.46 ± 1.70 (0–5)
Straining	1.36 ± 1.38 (0–5)
DRE (n, %)	
Prostate size estimation	
<20 mL	41 (18.0)
20–30 mL	86 (37.7)
30–40 mL	67 (29.4)
40–50 mL	20 (8.8)
>50 mL	14 (6.1)
Palpation findings	
Benign	219 (96.1)
Asymmetry	2 (0.9)
Focal hardness	7 (3.1)
Nodularity	0
Qmax < 15 mL/s	98 (43.0)
Metabolic profiles	
BMI (kg/m^2)	25.0 ± 2.73 (18.4–32.2)
Waist circumference (cm)	89.8 ± 7.38 (70–111)
Presence of metabolic syndrome	49 (21.5)
Presence of hypertension	102 (44.7)
Serum glucose AC	96.0 ± 17.3 (75–243)
Serum HbA1C	5.77 ± 0.64 (4.4–10.2)
Serum triglyceride	124 ± 67.0 (23–564)
Serum cholesterol (mg/dl)	198 ± 32.9 (116–278)
Serum HDL cholesterol (mg/dl)	46.0 ± 10.1 (26–83)

Numeric data are expressed as mean ± SD (range) and categorical data are expressed as n (%).
BMI = body mass index; DRE = digital rectal examination; HDL = high-density lipoprotein; IPSS = International Prostate Symptom Score; PSA = prostate-specific antigen; SD = standard deviation.

Table 3 shows potential predictors of PV using stepwise multiple linear regression analysis. DRE estimation, serum PSA, age, and "urgency" score were significantly correlated with the PV measured by TRUS (all $p < 0.05$). The adjusted R^2 of DRE for four dummy variables was 0.01, 0.11, 0.10, and 0.43, respectively, and total contribution was 0.65. The presence of metabolic syndrome and components including hypertension, serum high-density cholesterol, fasting blood sugar, serum triglycerides, and body mass index were not independent predictors of PV estimation.

Table 4 listed the results of regression model categorized by PV. Potential predictors including DRE, age, serum PSA and "urgency" score were included in the model. For the smaller PV group, only DRE was an independent predictor in the regression model. For PV >25 mL group, DRE estimation, serum PSA, age, and urgency score were independent predictors for PV, and the standardized regression equation was: PV = 0.74 × (DRE estimation) + 0.10 × (age) + 0.12 × (serum PSA) + 0.079 × (urgency score) (adjusted $R^2 = 0.80$). In the regression model for PV ≤ 25 mL group, DRE estimation was the only independent predictor (adjusted $R^2 = 0.45$). Furthermore, the correlation coefficients with PV in DRE estimated size <20 mL, 20–30 mL, 30–40 mL, >40 mL was 0.041 ($p = 0.69$), 0.453, 0.397, and 0.588, respectively (all $p < 0.001$, table not shown).