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Original article

Impact of the static prostatic urethral angle on men with lower urinary tract symptoms

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ABSTRACT

Objective: The purpose of this study was to investigate the relationship between the prostatic urethral angle (PUA) and the peak urinary flow rate (Q_{max}), as well as the severity of lower urinary tract symptoms (LUTS) in men with benign prostate hyperplasia.
Materials and methods: The records of first-visit male patients with LUTS in the outpatient department of our institution were obtained. A transrectal ultrasound was performed on these patients after a detailed physical examination and medical history taking were performed. The International Prostate Symptom Score (IPSS) of the patients, the prostate size, the length of intravesical prostatic protrusion (IPP), and the PUA were evaluated. The patients also underwent uroflowmetry and bladder scan for residual urine.
Results: A total of 227 patients were included in this study. The mean PUA was 44.58 ± 12.87°. The mean prostate volume was 39.39 ± 19.79 mL, and the mean IPP was 4.82 ± 6.82 mm. After utilizing multivariate linear regression analysis, PUA was independently associated with IPSS ($p < 0.001$) and Q_{max} ($p < 0.001$). However, prostate volume and IPP were not associated with the above clinical items. None of the prostatic parameters were associated with the amount of postvoiding residual urine.
Conclusion: PUA has a remarkable correlation with Q_{max} and IPSS in men with LUTS. As PUA increased, IPSS also increased, and urinary flow rate decreased, exhibiting an inverse relationship.

1. Introduction

Benign prostatic hyperplasia is a major cause of lower urinary tract symptoms (LUTS) in males, and it affects about 210 million people worldwide.[1] However, the fact that prostate size has no remarkable association with the severity of the symptoms has been reported in several studies[2,3] There are some other anatomic factors that have also been considered as possible factors affecting the severity of the symptoms, for example, transitional zone index and the intravesical prostatic protrusion (IPP).[4–6] Kuo[7] also established a clinical prostate score by using the simple parameters of uroflowmetry and transrectal ultrasonography (TRUS) measurements that can conveniently diagnose benign prostate obstruction of male LUTS with a good sensitivity and specificity. Recently, the prostatic urethral angle (PUA) has been regarded as a possible factor affecting male LUTS.[8] As demonstrated by Cho et al,[9] the prostatic urethra is a bent-formed tube, and the kinetic energy of the voiding urine would decrease because of the angle during micturition. The greater the angle, the greater the amount of kinetic energy that would be lost.[9] A mathematical simulation has been created to demonstrate the relationship between the urinary flow rate and PUA.[8] The equation is as follows:

$$Q = \frac{\pi d^2}{4}\sqrt{\frac{2p}{e^{(1+2.22*10^{-3}\theta+4.04*10^{-6}\theta^{2.762})}}} \quad [1]$$

where d represents the prostatic urethra diameter, p represents the vesical pressure, Q is the urine flow rate, and θ is the PUA. As shown in the equation, the greater the angle of θ, the lower Q becomes—that is, the urinary flow rate is inversely associated with PUA. However, this hypothesis, which is based on mathematical simulation, requires further clinical observation in order to be confirmed. The purpose of our study was to clarify the influence of

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PUA on the peak flow rate (Q_{max}), the severity of LUTS, and the amount of postvoid residual urine.

2. Materials and methods

From October 2012 to February 2014, the records of first-visit male patients with LUTS who agreed to undergo TRUS and uroflowmetry prior to receiving treatment in our institution were obtained. These patients underwent a detailed medical history taking and physical examination. They were excluded if they had any evidence of neurologic disorder that could affect voiding function, uncontrolled diabetes mellitus, or any malignant disease. Those found to have a history of prostate surgery, presenting with indwelling urinary catheter, having dementia or any disability that could interfere with verbal communication were excluded as well. Patients who had already taken alpha blockers were also excluded. All the chosen participants were verbally informed of the purpose and the entire procedure involved in performing TRUS, uroflowmetry study, and International Prostate Symptom Score (IPSS) evaluation. A total of 227 patients were included in the study.

A transrectal ultrasound was performed on these patients by a single urologist using a single ultrasound machine (SSD-A6, ALOKA), with a 7.5-MHz biplanar transrectal probe. All patients in our study had a full bladder when undergoing TRUS examination. The ellipse formula (length × width × height × 0.52) was used to measure the size of the prostate volume. PUA, as illustrated in Fig. 1A, was defined as the angle formed by the proximal prostate urethra and distal prostate urethra, as suggested by Cho et al.[8] IPP, as illustrated in Fig. 1B, was measured from the tip of the protruding prostate into the bladder to the bladder circumference at the prostate base in the sagittal plane, as suggested by Nose et al.[10]

The IPSS[11] of the patients were also recorded by a single qualified urologist during the medical history taking. Uroflowmetry and a bladder scan for the postvoiding residual urine were performed on every patient. The Mann–Whitney test was used to compare the PUA according to IPSS and Q_{max}. Multivariate linear regression analysis was performed to analyze the independent association of the patients' parameters with Q_{max}, IPSS scores, and the postvoiding residual urine. SPSS version 15.0 (SPSS, Inc., Chicago, IL, USA) was applied for statistical analysis. All statistical tests were conducted with a significance level of $p = 0.05$.

3. Results

The subject characteristics of the patients are summarized in Table 1. A total of 227 patients were included in our study. The mean age of the patients was 65.88 ± 9.49 years. The mean total prostate volume was 39.39 ± 19.79 mL, and the mean PUA was 44.58 ± 12.87°. The mean IPSS, mean Q_{max}, mean voiding volume, and mean postvoiding residual urine volume were 17.05 ± 4.54 mL, 7.47 ± 2.60 mL/second, 222.41 ± 66.35 mL, and 32.40 ± 37.62 mL, respectively.

Table 2 outlines a comparison of PUA and IPP according to IPSS. We can see that the mean PUA of the patients whose IPSS scores are ≤ 20 is 40.83°, whereas that of patients whose IPSS scores are > 20 is 55.95°. There are significant differences between the two groups ($p < 0.001$). Meanwhile, the mean IPP of patients whose IPSS scores are ≤ 20 is 3.99 mm, whereas that of patients whose IPSS scores are ≥ 20 is 7.05 mm. There are significant differences between the two groups as well ($p < 0.001$). Table 3 shows a comparison of PUA and IPP according to Q_{max}. We can see that the mean PUA of the patients whose Q_{max} are < 10 mL/second is 45.28°, whereas that of patients whose $Q_{max} \geq 10$ is 41.18° ($p = 0.016$). There are significant differences between the two groups. Meanwhile, the mean IPP of the patients whose Q_{max} are < 10 mL/second is 5.15 mm, whereas that

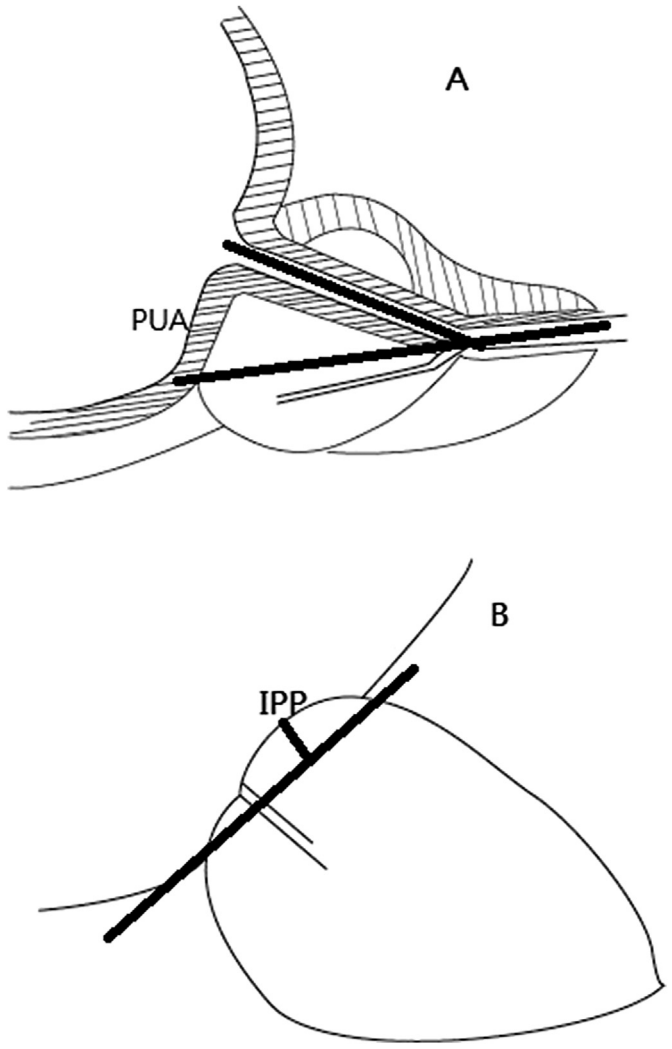

Fig. 1. The relationship between the prostatic urethral angle (PUA) and the length of intravesical prostatic protrusion (IPP). (A) PUA is defined as the angle formed by the proximal prostate urethra and distal prostate urethral. (B) IPP is measured from the tip of the protruding prostate into the bladder to the bladder circumference at the prostate base in the sagittal plane.

Table 1
Characteristics of the patients ($n = 227$).

Characteristics	Mean ± SD (range)
Age (y)	65.88 ± 9.49 (45–89)
BMI	24.91 ± 3.12 (43.22–18.21)
IPSS	
Total	17.05 ± 4.54 (9–26)
Voiding symptoms	9.25 ± 3.73 (4–19)
Storage symptoms	7.78 ± 2.21 (3–13)
Uroflowmetry	
Q_{max} (mL/s)	7.47 ± 2.60 (2–16)
Voiding volume (mL)	222.41 ± 66.35 (114–453)
Residual urine (mL)	32.40 ± 37.62 (0–381)
TRUS	
TPV (mL)	39.39 ± 19.79 (12.42–133.01)
PUA (°)	44.58 ± 12.87 (24–87)
IPP (mm)	4.82 ± 6.82 (0–31.31)

BMI = body mass index; IPP = intravesical prostate protrusion; IPSS = International Prostate Symptom Score; PUA = prostatic urethral angle; Q_{max} = peak flow rate; SD = standard deviation; TPV = total prostate volume; TRUS = transrectal ultrasonography.