Prostate Volume Measurement by Transrectal Ultrasonography: Comparison of Height Obtained by Use of Transaxial and Midsagittal Scanning

Sung Bin Kim, In-Chang Cho, Seung Ki Min
Department of Urology, National Police Hospital, Seoul, Korea

Purpose: The purpose of this study was to compare prostate volume measured by transrectal ultrasonography (TRUS) between transaxial scanning and midsagittal scanning. We tried to determine which method is superior.

Materials and Methods: A total of 968 patients who underwent TRUS for diagnosis of any diseases related to the prostate were included in this study. When measuring prostate volume by TRUS, we conducted the measurements two ways at the same time in all patients: by use of height obtained by transaxial scanning and by use of height obtained by midsagittal scanning. Prostate volume was calculated by using the ellipsoid formula \((\text{height} \times \text{length} \times \text{width}) \times \frac{\pi}{6}\).

Results: For prostate volume measured by TRUS, a paired t-test revealed a significant difference between using height obtained by transaxial scanning and that obtained by midsagittal scanning in all patients (28.5±10.1 g vs. 28.7±9.9 g, respectively, \(p=0.004\)). However, there were no significant differences in the prevalence of prostate volume more than 20 g (known benign prostatic enlargement [BPE]) between the two methods by chi-square test (90.5% [n=876], 90.8% [n=879], respectively; \(p=0.876\)). When analyzed in the same way, there were no significant differences in the prevalence of prostate volume more than 30 g (generally, high-risk BPE) between the two methods (34.5% [n=334], 36.3% [n=351], respectively; \(p=0.447\)).

Conclusions: Although prostate volume by TRUS differed according to the method used to measure height, that is, transaxial or midsagittal scanning, we conclude that there are no problems in diagnosing BPE clinically by use of either of the two methods.

Keywords: Prostate; Prostatic hyperplasia; Ultrasonography

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is common in middle-aged men, is found in over half of 60-year-old men, and is found in almost all 80-year-old men [1]. Because BPH can lower the quality of life, active diagnosis and treatment are now being conducted. Many urologists routinely use transrectal ultrasonography (TRUS) to diagnose BPH. TRUS is useful in that it can evaluate the size, shape, presence of adenoma, and anatomy of the prostate relatively accurately and noninvasively. Three techniques are used to measure prostate volume: planimetry calculation, prolate ellipse volume calculation, and ellipsoid volume measurement [2]. Among them, prolate ellipse volume calculation is commonly used because it is fast and precise. It is calculated as follows: prolate ellipse volume \((\text{cm})=(\text{length} \times \text{width} \times \text{height}) \times \frac{\pi}{6}\). Length refers to the longitudinal diameter of the prostate. It is obtained by calculating the distance from the proximal external sphincter to the urinary bladder. Also, width refers to the transverse diameter of the prostate. It is obtained by calculating the maximal transverse diameter at the midgland level of the prostate [3].
Meanwhile, height refers to the anteroposterior diameter of the prostate. It can be obtained on two planes, axial and sagittal. It remains controversial which method is more accurate for measuring prostate volume. Even in the 9th edition of *Campbell-Walsh Urology*, the textbook of urology, the authors describe in the text that the anteroposterior diameter (height) of the prostate is measured on the axial plane. However, they describe at the same time in the figure legend that it is measured on the sagittal plane [4]. Thus, we aimed to compare the two methods of obtaining the height of prostate to determine which assessment of height is more accurate and useful for diagnosis of BPH.

**MATERIALS AND METHODS**

A total of 968 patients who underwent TRUS for diagnosis of any diseases related to the prostate from October 2012 to May 2013 were included in this study prospectively. When measuring prostate volume by TRUS, we conducted the measurements two ways at the same time in all patients: by using height obtained by transaxial scanning and by using height obtained by midsagittal scanning (Fig. 1). Prostate volume was calculated by using prolate ellipse volume \( (\text{cm}) = (\text{length} \times \text{width} \times \text{height}) \times \pi / 6 \). We analyzed the discrepancy of the volume and the prevalence of clinical benign prostatic enlargement (BPE) according to the two methods. TRUS was performed by use of high-resolution (linear 6–16 MHz transducer) units (Aloka Prosound α5; Aloka, Tokyo, Japan) by one skilled urologist. The prostate and seminal vesicle were examined via gray-scale ultrasonography in axial and sagittal planes, and their sizes were determined. Color Doppler examination was also performed to check the blood flow of the prostate. Statistical analysis was conducted by using a paired t-test to determine the difference between the volume measured by the two methods. The chi-square test was used to determine the difference in the prevalence of clinical BPE determined by use of the two methods. The level of statistical significance was set at a \( p < 0.05 \). All analyses were done by using PASW Statistics ver. 18.0 (SPSS Inc., Chicago, IL, USA).

**FIG. 1.** Measurement of prostate volume by transrectal ultrasonography. (A) Height (arrow) was measured by transaxial scanning (2.94 cm), and prostate volume was calculated as 24.95 mL. (B) Height (arrow) was measured by midsagittal scanning (3.32 cm), and prostate volume was calculated as 28.16 mL.
RESULTS

The mean age of the patients was 58.4 years (range, 21.0-88.0 years). The average prostate volume measured by TRUS by using height determined from the transaxial scans was 28.5±10.1 mL and that measured by using height determined midsagittally was 28.7±9.9 mL. A paired t-test revealed a significant difference between the methods in all patients (p=0.004). When analyzed by age groups in the same way, there was a significant difference in men in their 50s (27.4±6.8 mL vs. 27.9±6.9 mL, n=500), but there were no significant differences in the other age groups (Table 1). There were no significant differences in the prevalence of prostate volume more than 20 mL (known BPE) between the two methods in all patients by chi-square test (90.5% vs. 90.8% [n=876] and 90.8% [n=879], p=0.876). When analyzed by age groups in the same way, there was a significant difference in men in their 80s (n=15) when analyzed by age group, there were no significant differences in the prevalence of prostate volume more than 20 g (Table 2).

Similarly, there were no significant differences in the prevalence of prostate volume more than 30 mL (generally, high-risk BPE) between the two methods (34.5% [n=334] and 36.3% [n=351], p=0.447) in all patients and by age groups (Table 3).

DISCUSSION

Generally, prostate volume is measured by digital rectal examination, TRUS, computed tomography, magnetic resonance imaging, and in real specimens after prostatectomy [5,6]. Among these methods, TRUS has been the most widely used imaging modality for estimating prostate size because it has been shown to be inexpensive, rapid, reproducible, and well correlated with actual prostate volume. There are several techniques for estimating prostate volume. These days, the prolate ellipse volume ([length×width×height]×π/6) is typically used and has been shown to be rapid, reproducible, highly correlated with actual prostate volume, and easily applied [7]. However, because the prostate is not a true oval, it remains controversial as to how we should measure the height of the prostate. Littrup et al. [3] claimed that the height of the prostate must be obtained on the transaxial plane, which means that height is measured maximally at the midgland level. By contrast, Dahnert [8] reported that the height measurement was corrected by sagittal projection in a plane perpendicular to the length measurement to avoid the salami effect (salami can be sliced in many different ways: to obtain larger slices, some prefer to cut it obliquely).

In our study, the average of prostate volume differed significantly between the two methods of measurement: by using height obtained on transaxial scanning compared with that obtained on midsagittal scanning. However, when analyzed by age group, there were no significant dif-

TABLE 1. The mean prostate volumes by the two methods according to age groups

| Age group | Transaxial (mL) | Midsagittal (mL) | p-value |
|-----------|----------------|-----------------|--------|
| All patients (n=968) | 28.5±10.1 | 28.7±9.9 | 0.004* |
| 20s (n=3) | 23.0±6.1 | 22.3±5.5 | 0.667 |
| 30s (n=8) | 22.8±6.5 | 24.5±8.4 | 0.144 |
| 40s (n=111) | 24.1±5.1 | 24.5±5.5 | 0.109 |
| 50s (n=500) | 27.4±6.8 | 27.9±6.9 | 0.000* |
| 60s (n=216) | 30.7±11.7 | 30.8±11.2 | 0.646 |
| 70s (n=115) | 32.7±16.4 | 32.3±16.1 | 0.105 |
| 80s (n=15) | 37.0±20.9 | 36.0±17.8 | 0.407 |

Values are presented as mean±standard deviation.
*p<0.05, significant.

TABLE 2. Comparison of diagnosis rate of benign prostatic enlargement (≥20 mL) between the two methods by age groups

| Age group | Method | Prostate size (mL) | p-value |
|-----------|--------|-------------------|--------|
| All patients | Transaxial | 92 | 876 | 0.876 |
| Midsagittal | 89 | 879 |
| 20s | Transaxial | 1 | 2 | 1.000 |
| Midsagittal | 1 | 2 |
| 30s | Transaxial | 4 | 4 | 1.000 |
| Midsagittal | 4 | 4 |
| 40s | Transaxial | 23 | 88 | 0.734 |
| Midsagittal | 20 | 91 |
| 50s | Transaxial | 39 | 461 | 0.905 |
| Midsagittal | 37 | 463 |
| 60s | Transaxial | 14 | 202 | 1.000 |
| Midsagittal | 14 | 202 |
| 70s | Transaxial | 8 | 107 | 0.633 |
| Midsagittal | 11 | 104 |
| 80s | Transaxial | 3 | 12 | 1.000 |
| Midsagittal | 2 | 13 |

TABLE 3. Comparison of diagnosis rate of benign prostatic enlargement (≥30 mL) between the two methods by age groups

| Age group | Method | Prostate size (mL) | p-value |
|-----------|--------|-------------------|--------|
| All patients | Transaxial | 634 | 334 | 0.447 |
| Midsagittal | 617 | 351 |
| 20s | Transaxial | 2 | 1 | 1.000 |
| Midsagittal | 3 | 0 |
| 30s | Transaxial | 6 | 2 | 1.000 |
| Midsagittal | 5 | 3 |
| 40s | Transaxial | 95 | 16 | 0.472 |
| Midsagittal | 90 | 21 |
| 50s | Transaxial | 345 | 155 | 0.380 |
| Midsagittal | 331 | 169 |
| 60s | Transaxial | 121 | 95 | 1.000 |
| Midsagittal | 120 | 96 |
| 70s | Transaxial | 60 | 55 | 0.895 |
| Midsagittal | 62 | 53 |
| 80s | Transaxial | 5 | 10 | 1.000 |
| Midsagittal | 6 | 9 |
ferences except among men in their 50s. The difference in prostate volume among men in their 50s was about 0.5 mL. However, we do not think that there is an effect by age. We suspect that because the number of patients was small except for the group of men in their 50s, there were no statistically significant differences in prostate volume in the other age groups. Moreover, we do not think the difference will influence medical treatment. We did not determine which age groups. Moreover, we do not think that there is an effect by age. We think that this may be because the prostate is less pressurized on the midsagittal plane by the ultrasound probe.

If we use an ellipsoid formula when estimating prostate volume by TRUS, we can guess that it will be more accurate to obtain the height of the prostate on midsagittal scanning. The important thing, however, when we diagnosis and treat BPH is that it is almost impossible to know the patient’s real prostate size. We can determine it by imaging study in most cases; thus, it is important that there are significant differences in prostate size between the above two methods. Because there was a significant difference in our study, we studied whether the difference could influence the diagnosis of BPE.

Prostate enlargement is a common finding among elderly men with BPH [13] and is considered an important risk factor leading to urinary retention [14]. There are many criteria of prostate size for diagnosing BPH. Garraway et al. [15] determined BPH when prostate size was over 20 mL, and Bosch et al. [16] determined BPH when prostate size was over 30 mL. Generally, there are many criteria for diagnosing BPH, such as maximum flow rate, International Prostate Symptom Score (IPSS), and prostate size measured by digital rectal examination, but these days, prostate size is thought to be important for treating BPH patients.

Generally, 5α-reductase inhibitors are used for BPH patients with a prostate volume over 40 mL in Western countries. However, we assume that Asian men may have smaller prostates than do western men. One Korean study claimed that a large prostate should be considered a volume over 35 mL [17]. Furthermore, according to study of Hong et al. [18], the failure rate of medical treatment for BPH patients was higher in men having a prostate volume over 32 mL. Moreover, there are many studies in Western men, also. According to the Olmsted County study [19], the probability of receiving medication or surgery was increased 2.3 times in BPH patients having a prostate volume over 30 mL. Also, Debruy et al. [20] studied the efficacy and safety of dutasteride on the basis of a prostate volume of 30 mL. Bosch et al. [21] claimed that men with growing prostates are at a greater risk of symptomatic deterioration and that men who have prostates that do not grow significantly are more likely to improve symptomatically.

On the basis of the evidence in these studies, we studied splitting the patients into two groups, those with prostate volume over 20 mL and those with prostate volume over 30 mL. In our study, although there was a significant difference in average prostate volume between the transaxial and midsagittal scanning measurements, the diagnosis rate of BPE (over 20 mL or 30 mL) did not differ between the two methods. We think that this result is meaningful because we can expect that there will be no problem in treating BPH patients no matter which method is used. In a double-blind, placebo-controlled, multicenter, randomized trial comparing the effects of doxazosin, finasteride, and doxazosin plus finasteride for an average of 5 years, combination therapy was the most effective therapy in terms of reduction of the risk of clinical progression [22]. Thus, regarding medical treatment for BPH patients, the accurate estimation of prostate volume is important.

The value of our study is that we measured prostate volume by TRUS by using the height determined by transaxial and midsagittal scanning in a large population. We then analyzed the data according to age groups. Prostate volume measured by TRUS was performed by one skilled urologist and with one set of ultrasonography equipment. Thus, we could reduce technical errors. However, the patients of our study were not prostate cancer patients; thus, it is a limitation of our study that we could not compare prostate volume measured by TRUS with real specimens. We suggest that an excellent study would be to compare prostate volume with real specimens, for example, a cadaver study. Another limitation of our study is that we did not assess the IPSS or lower urinary tract symptoms.

**CONCLUSIONS**

Although prostate volume by TRUS differed according to the method used to measure height (transaxial or midsagittal scanning), we suspect that prostate volume obtained on midsagittal scanning is more accurate but that there are no problems with diagnosing BPE clinically by use of either of the two methods. However, further study
is needed of the correlation between prostate volume measured by TRUS and that measured by use of real specimens.

CONFLICTS OF INTEREST
The authors have nothing to disclose.

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