Measurements of Size and Weight of Prostate by Means of Transrectal Ultrasonotomography

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WATANABE, H., IGARI, D., TANABASHI, Y., HARADA, K. and SAITOH, M. Measurements of Size and Weight of Prostate by Means of Transrectal Ultrasonotomography. Tohoku J. exp. Med., 1974, 114 (3), 277-285. Size and weight of prostates were measured in 95 cases by means of transrectal ultrasonotomography. It was found that transrectal ultrasonotomography was the best method for this purpose. The measured sizes and weights of the prostate in normal subjects and in patients with several prostatic diseases were then compared. It was not always possible, however, to decide whether the prostate was normal only from these measurements.—— prostatic size; prostatic weight; ultrasonic measurement; transrectal ultrasonotomography

It is well known that ultrasonic technique is suitable for the precise measurement of the size of various organs. Ultrasonic measurement of the prostate, however, has formerly been impracticable because of the difficulties in ultrasonic visualization of the prostate itself. In a previous paper (Watanabe et al. 1971a) ultrasonotomograms of the prostate through the transrectal route using a special transducer and scanner were described. Over 400 human subjects with or without prostatic diseases have subsequently been examined by this technique in our laboratory (Watanabe et al. 1974a). It is the purpose of this paper to describe in detail the measurement of prostatic size and weight by means of the transrectal ultrasonotomography.

METHODS AND MATERIALS

An equipment consisting of a transducer assembly and a radial scanner attached to a specially designed chair (Watanabe et al. 1974a) was employed in this investigation. With this equipment, the horizontal ultrasonotomogram of intrapelvic organs could be obtained at any level between the anus and a point 10 cm deeper from the anus by means of radial scanning. The prostatic capsule was delineated clearly on the tomograms (Fig. 1). When the capsule echo pattern was too thick to read accurately, an application of the "Sensitivity graded tomogram pairs" technique was found to be effective (Watanabe et al. 1971c).

In practice, the tomograms were recorded every 0.5 cm on 35 mm black and white film in the usual manner.

The antero-posterior diameter (A-P diameter) and the lateral diameter of the prostate were measured directly on each tomogram printed actual size from the film (Fig. 2). The longest of these measurements was described as the diameter of the prostate.

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The supero-inferior diameter (S-I diameter) of the prostate was calculated from the distance moved by the transducer between the level on which the prostate first appeared and the level on which it disappeared. The calculation was usually made from a downward movement of the transducer. In a limited number of cases, the S-I diameter was also measured directly on the sagittal tomogram (Fig. 1) obtained by linear scanning (Watanabe et al. 1971b).

The prostatic weight was estimated as follows: The area of prostatic section on each tomogram taken at 0.5 cm intervals was measured by a roller planimeter. The area of section multiplied by 0.5 was taken as the volume of section of the prostate 0.5 cm in thickness. An approximate volume for the prostate was then calculated from the sum of the sections. The prostatic volume was taken as approximately equal to the prostatic weight, because the specific gravity of prostatic tissue ranged between 1.050 and 1.060 according to our determination on 20 surgically excised specimens.

Measurements were performed on 95 persons selected at random. They included 20 normal subjects (18–53 yr), 5 patients with Klinefelter’s syndrome (22–74 yr), 50 with prostatic hypertrophy (50–87 yr) and 20 with prostatic cancer (44–81 yr).

**RESULTS**

*Normal subjects (20 cases).* The measured prostatic sizes in normal subjects were 20–40 mm (mean, 28.0±5.2) at the S-I diameter, 21–34 mm (mean, 27.6±
3.7) at the A-P diameter and 39-53 mm (mean, 48.1±4.0) at the lateral diameter. The estimated prostatic weight was 12.9-37.1 g (mean, 21.0±5.6).

Klinefelter's syndrome (5 cases). The sizes in Klinefelter's syndrome were 10-30 mm (mean, 21.0±7.4) at the S-I diameter, 15-30 mm (mean, 20.0±5.9) at the A-P diameter and 28-50 mm (mean, 40.2±8.2) at the lateral diameter.

The weight was 2.9-20.2 g (mean 9.6±6.8).

Prostatic hypertrophy (50 cases). The sizes in prostatic hypertrophy were 13-60 mm (mean, 38.8±8.5) at the S-I diameter, 17-50 mm (mean, 33.8±7.2) at the A-P diameter and 40-79 mm (mean, 54.7±8.2) at the lateral diameter.

The weight was 19.6–99.3 g (mean, 45.8±20.9).

Prostatic cancer (20 cases). The sizes in prostatic cancer was 25–45 mm (mean, 35.5±5.8) at the S-I diameter, 26–48 mm (mean, 34.3±5.9) at the A-P diameter and 42–67 mm (mean, 53.7±6.3) at the lateral diameter.

The weight was 14.9±52.3 g (mean, 32.7±9.8).

These results are shown in Table 1 and Fig. 3.


**TABLE 1. Prostatic size and weight measured by transrectal ultrasonotomography**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>S-I diameter (mm)</th>
<th>A-P diameter (mm)</th>
<th>Lateral diameter (mm)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal subject (20 cases)</td>
<td>20–40</td>
<td>21–34</td>
<td>39–53</td>
<td>12.9–37.1</td>
</tr>
<tr>
<td>Klinefelter’s syndrome (5 cases)</td>
<td>10–30</td>
<td>15–30</td>
<td>28–50</td>
<td>2.9–20.2</td>
</tr>
<tr>
<td>Prostatic hypertrophy (50 cases)</td>
<td>13–60</td>
<td>17–50</td>
<td>40–79</td>
<td>19.6–99.3</td>
</tr>
<tr>
<td>Prostatic cancer (20 cases)</td>
<td>25–45</td>
<td>26–48</td>
<td>42–67</td>
<td>14.9–52.3</td>
</tr>
</tbody>
</table>

( ): Mean value±s.d.

![Chart](chart.png)

**Fig. 3.** Prostatic weight in normal subjects and patients with prostatic diseases. K-F, Klinefelter’s syndrome; Normal, normal subject; P.K., prostatic cancer; P.H., prostatic hypertrophy.

**DISCUSSION**

Ultrasonic measurement of prostatic size was first reported four years ago from our laboratory (Watanabe et al. 1971a). Contact scanning from the abdominal surface has been also used to ascertain the prostatic size (Miller et al. 1973). Only enlarged prostates could be measured in this way, however, as the ultrasonic beam was normally interrupted by the pubic bone. Transperineal
contact scanning may be better than the transabdominal method (Watanabe et al. 1973).

It was found from our investigations that the transrectal route was the only way to get the representation of any prostate as a fine section with sufficient picture quality (Watanabe et al. 1973).

Tomograms of the prostate were recorded in 193 of 205 cases examined with a new equipment for transrectal scanning (Watanabe et al. 1974b). The cause of failure to record tomograms in the remaining 12 cases was not the procedure itself but mechanical trouble or misoperation.

The error at the ultrasonic measurement likely to be caused by direction of insertion of the transducer and differences in sonic velocity inside the prostate was originally estimated at 5%. This estimation was later confirmed over 5 cases where radical prostatectomy was performed (Watanabe et al. 1971a, 1974a) (Fig. 2).

Ultrasonotomographic estimations of prostatic weight were compared with specimens after subcapsular prostatectomy in 26 cases. Both the data coincided well (Watanabe et al. 1974a).

There seems to be some discrepancy between the values of measurements by ultrasonotomography and those of earlier measurements. Takagi (1911) examined 51 cadavers and stated that the normal sizes of the prostate in Japanese were 20–35 mm (mean, 22–30) at the S-I diameter, 12–21 mm (mean, 13–19) at the A-P diameter, 34–50 mm (mean, 36–44) at the lateral diameter and 9–25 g (mean 11–18) in weight (Table 2).

<table>
<thead>
<tr>
<th>Author</th>
<th>Method</th>
<th>S-I diameter (mm)</th>
<th>A-P diameter (mm)</th>
<th>Lateral diameter (mm)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takagi (1911)</td>
<td>Cadaver</td>
<td>20-35</td>
<td>12-21</td>
<td>34-50</td>
<td>9-25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(22-30)</td>
<td>(13-19)</td>
<td>(35-44)</td>
<td>(11-18)</td>
</tr>
<tr>
<td>Kuroda (1952)</td>
<td>X-ray and</td>
<td>20-30</td>
<td>35-55</td>
<td>30-40</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>calliper</td>
<td>(24.7±0.54)</td>
<td>(46.6±0.87)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tozuka et al. (1953)</td>
<td>Intrapelvic</td>
<td>15-30</td>
<td></td>
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<tr>
<td></td>
<td>phlebography</td>
<td>(23.2±4.28)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kazita (1959)</td>
<td>High voltage</td>
<td>within 30</td>
<td>within 50</td>
<td>41-60</td>
<td>No description</td>
</tr>
<tr>
<td></td>
<td>X-ray</td>
<td></td>
<td></td>
<td>(53)</td>
<td></td>
</tr>
<tr>
<td>The present authors</td>
<td>Ultrasonotomography</td>
<td>20-40</td>
<td>21-34</td>
<td>39-53</td>
<td>12.9-37.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(28.0±5.2)</td>
<td>(27.6±3.7)</td>
<td>(48.1±4.0)</td>
<td>(31.0±5.6)</td>
</tr>
</tbody>
</table>

( ): Mean value.

His data thus give a smaller value than those of the ultrasonic measurement described here in both size and weight, although a considerable correlation can be observed between both sets of results. His report, however, was published 63 years ago and since then a remarkable increase has generally been observed in the
physical sizes of Japanese. The discrepancy, accordingly, might be interpreted as a result of a similar increase in the prostatic size.

Fenwick (1926) designed a special bougie-like apparatus to assess diameters of the prostate but did not publish any results. Peirson and Wilson (1941) and Boone (1952) independently published methods for estimation of size using a bag catheter.

Kuroda (1952) on the other hand was able to take urethrovescicograms when a finger with a metal marker on its tip was inserted just behind the bottom of the prostate through the anus. The S-I diameter was determined from the distance between the neck of the urinary bladder and the marker after the proper adjustments for the scale of the film. The A-P and lateral diameters were estimated using a specially prepared calliper.

Despite the apparent difficulties of this method the values obtained by Kuroda were astonishingly accurate, as shown in Table 2. He also found that the border of the S-I diameter was 30 mm irrespective of whether or not the prostate was pathologically enlarged.

Tozuka et al. (1953) and Kazita (1959) used intrapelvic phlebography and high voltage roentgenography respectively for the assessment (Table 2). The latter found that in normal subjects the A-P diameter was within 50 mm. According to our data, this was an overestimation.

As regards the assessment of prostatic weight, a roentgenological method by Thumann (1951) has been widely used. He devised a formula to estimate the weight ($W$) from the average of a horizontal and a vertical diameter ($R$) on the urethrovescicogram, given as $W=2R^3$. The horizontal diameter was found by the lateral width of the prostatic mass and the vertical one was calculated from the distance between the vermontanum and the superior extent of the prostatic mass.

We evaluated this method on the basis of results from 45 cases examined by transrectal ultrasonotomography (Watanabe et al. submitted for publication). The relationship between the results of the ultrasonotomography and roentgenological methods is demonstrated in Fig. 4. The reliability of Thumann’s method was generally low and there was a tendency for the weight of bigger prostates to be underestimated.

The prostate in patients with Klinefelter’s syndrome was reduced in size. Although most of them were not palpable by digital examination, transrectal ultrasonotomography revealed a clear contour of the prostate.

A wide distribution was observed in the weight of the prostate in patients with prostatic hypertrophy. In most of the cancer cases, however, the weight fell within a range of 20–50 g. A remarkable reduction of the prostate was recognized in these cases of cancer after hormone treatment (Watanabe et al. submitted for publication).

A distinct difference in the size and weight of the prostate in normal and hyperplastic cases could not, however, always be observed. There were many
Fig. 4. Relationship between prostatic weight estimated by Thumann’s method and that by transrectal ultrasonotomography.

borderline cases in which it was impossible to assess whether or not the prostate was pathological simply from measurements of these two factors.

For example, Fig. 5 shows a tomogram taken from a normal subject aged 22 without any micturition disturbance. The size of the prostate was 35 mm at the S-I diameter, 33 mm at the A-P diameter, 53 mm at the lateral diameter and the weight was 37.1 g. The next case demonstrated in Fig. 6 was a patient 63 years old diagnosed as typical prostatic hypertrophy in the second stage. There was residual urine of 50 ml and all micturition symptoms disappeared completely after prostatectomy. In this case, however, the S-I diameter was 40 mm, A-P diameter 28 mm, lateral diameter 47 mm and the weight was 30 g. The size and weight of the prostate were thus rather smaller than in the normal subject.

Diagnostic criteria for transrectal ultrasonotomogram were mentioned in a previous paper (Watanabe et al. 1974a). It was emphasized that changes in the shape of the prostate in horizontal section were important for the differentiation of prostatic hypertrophy from the normal prostate. The cross section of the normal prostate generally resembled a thin triangle. On the other hand, the hyperplastic prostate had a semilunar or round cross section. The bigger the prostate, the rounder the cross section is.

This rule was also applicable to the above-mentioned two cases. The cross section of the former case was triangular, while that of the latter case was semilunar. It seems more likely that the pathogenesis of prostatic hypertrophy
Fig. 5. Horizontal tomogram in a normal subject. The cross section of the prostate is triangular.

Fig. 6. Horizontal tomogram in a case of prostatic hypertrophy. The cross section of the prostate is semilunar.
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Derives neither from the size nor the weight but from the deformity of the prostate. Further investigation of the problem will, however, be necessary, as it covers some of the key points in the pathophysiology of urination.

In conclusion it has been found that transrectal ultrasonotomography can be considered as a final method for prostatic measurement on the grounds of its accuracy, facility and reliability.

Acknowledgment

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References