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Ultrasound of the Normal Nongravid Uterus: Correlation with Gross and Histopathology

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Abstract: Accurate assessment of uterine size and significance of uterine enlargement are common clinical problems. We examined 156 patients by sonography prior to scheduled hysterectomy. Uterine volumes from normal-sized uteri were calculated from the sonograms using the equation of a prolate ellipsoid formula, and these calculated volumes were highly correlated with actual measured uterine volumes. Mean values and normal ranges of uterine weight were determined. These values are of particular value in postmenopausal patients in whom subjective evaluation of uterine enlargement is often difficult. When a sonographically enlarged, but otherwise normal uterus is discovered, it may contain a leiomyoma or other pathology not morphologically detectable by ultrasound. **Indexing Words:** Uterus, nongravid · Uterus size · Ultrasound

Accurate assessment of uterine size and significance of uterine enlargement are common clinical problems. Ultrasonography of the female pelvis is often utilized to assist in this evaluation. Variations in uterine size due to the patient's age, parity, stage in menstrual cycle, and hormonal status have been reported previously.[1–8] The ability of ultrasound to predict uterine size has been investigated recently.[9] We reassessed the validity of ultrasound in accurately predicting uterine size in the nongravid patient through correlation with hysterectomy specimens in a large heterogeneous patient population. We sought to establish mean and normal ranges for uterine size related to specific patient data (age, parity, and years postmenopausal), enabling ultrasound to suggest uterine pathology even without morphologic focal abnormalities. These data will enhance the role of ultrasound in uterine evaluation, especially in the perimenopausal and postmenopausal patient in whom subjective evaluation of uterine enlargement is often difficult.

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MATERIALS AND METHODS

One hundred fifty-six patients underwent sonography of the pelvis prior to hysterectomy. All of the examinations were performed within 3 months prior to the surgery, including 51 examinations the day prior to hysterectomy. Sonograms were performed on commercially available real-time machines utilizing either a 3.5 MHz or 5.0 MHz transducer. Three measurements were obtained directly from each ultrasound examination: maximum uterine length, anteroposterior diameter, and width (Figure 1). The cervix was included in the measurement of uterine length in order for the specimen data to match the in vivo data; however, it is possible that its inclusion could introduce some error in volume calculations.[10] Uterine volume based on the ultrasound data was calculated utilizing the formula for a prolate ellipsoid (volume $= 0.5233 \times D1 \times D2 \times D3$, where D1, D2, and D3 represent the maximum length, AP diameter, and width). Pathologic analysis following hysterectomy included determination of uterine weight, uterine volume determined by water displacement, and final gross and histologic diagnosis.

Uteri were separated into normal and abnormal sizes based on the histopathologic uterine evaluation. In order to fall into the normal group, a uterus could contain focal myomas ≤ 1 cm, minimal or in situ carcinoma, or focal adeno-

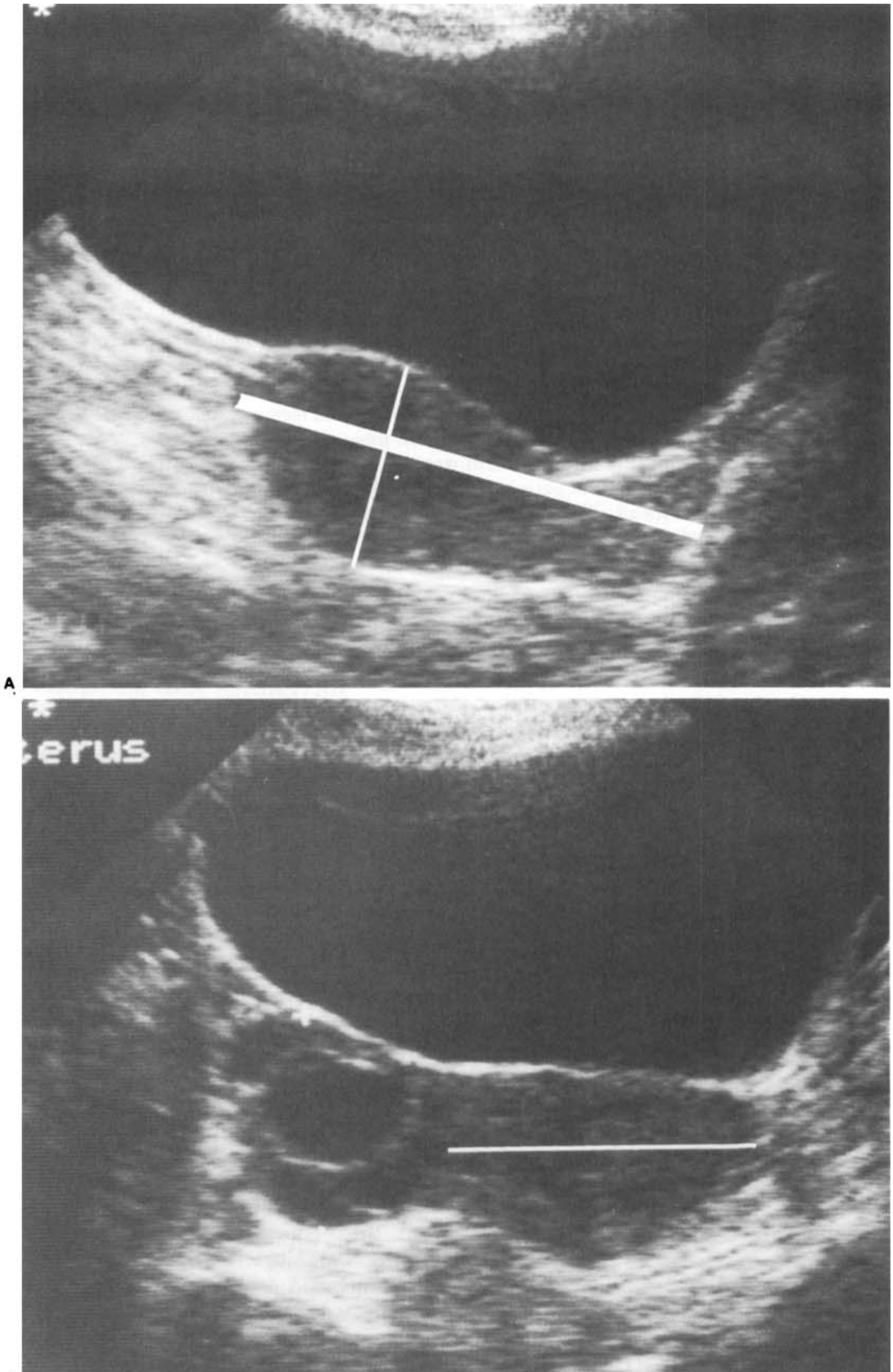

FIGURE 1. Uterine measurements. **(A)** Sagittal sonogram of uterus, with lines illustrating technique for measurement of maximum uterine length *and anteroposterior* diameter. **(B)** Transverse sonogram of uterus illustrating maximum transverse uterine diameter. Note is made of a right ovarian endometrioma. This enlarged uterus (120 grams) for a nulliparous patient contained multiple leiomyomata not sonographically visible.

myosis, in addition to being totally normal. Eighty-nine of the 156 uteri were categorized as normal by these criteria. The remaining 67 patients had abnormal uteri by gross inspection and histologic criteria, with the most common abnormality being leiomyomata. These patients were excluded from the normal data presented in this article.

Because there were only 28 postmenopausal patients in the group with correlative sonography, an additional 48 postmenopausal patients with normal uteri without preoperative sonography were included. This allowed us to describe the distribution of the normal uterine weight more completely. The most common indications for hysterectomy in these patients were uterovaginal prolapse, pelvic relaxation (history of stress incontinence), chronic infection, and carcinoma of the ovary or fallopian tube with no uterine involvement. Statistical analysis of data was performed with variance analysis, multiple regression analysis, and the paired t-test where appropriate. Clinical data obtained for all patients included age, parity, and, when applicable, years postmenopause.

RESULTS

Mean dimensions of the premenopausal nulliparous uterus (9 patients) for length, width, and anteroposterior diameter were 7.1 ± .8 cm, 4.6 ± .6 cm, and 3.3 ± .8 cm, respectively. The premenopausal parous uterus (52 patients) was larger, with dimensions of 8.9 ± 1 cm, 5.8 ± .8 cm, and 4.3 ± .6 cm, respectively. Postmenopausal uterine dimensions (76 patients) were 7.9 ± 1.2 cm, 4.9 ± .8 cm, and 3.2 ± .7, cm respectively.

From the uterine volume and weight data, an estimate of density (weight in grams/volume in mL) was obtained for each uterus. These density values were averaged to obtain a mean density of 1.03. This mean density was compared to 1 with a t-test, there was no statistically significant difference. Thus uterine weight can be determined from an estimation of uterine volume with 1 mL approximately equal to 1 g of uterine tissue.

To test the validity of the prolate ellipsoid formula, sonographic uterine volume was compared with actual volume. The difference in these two volume measurements was determined for each uterus and expressed as a percentage of the true volume. These signed percentage deviations were averaged, and the standard deviation was also calculated. The mean value obtained was 1.6% (systematic error) while the standard deviation was ±13% (random error). The systematic error of +1.6% was compared to zero with a t-test and was found not to be statistically significantly different. Mean sonographic volume calculated with the prolate ellipsoid method was 92 mL, while mean actual (pathologically measured) volume was 94 ml. These two volumes were compared with a paired t-test, and no statistically significant difference was found.

Uterine weight in the premenopausal group was analyzed based on age and parity status. Multiple regression analysis, evaluated using one-way analysis of variance with an F-test, revealed an underlying statistically significant relationship between parity and uterine weight ($p < 0.01$) with patient age being relatively unimportant. To ascertain the most important factors in this significant relationship between parity and weight, multiple pair wise comparison tests (Newman–Keuls Multiple Comparison Test) were performed using the mean weight values for each parity group. This analysis revealed the nulliparous uterine weight to be statistically significantly different from all other parity groups ($p < 0.01$). Less sizeable weight differences were noted among the parous uteri based on exact parity status and statistically significant differences were not found. Data on uterine weight based on parity status for the premenopausal uterus is presented in Table 1.

Postmenopausal normal uterine weight was analyzed based on parity and years postmenopause (YPM) by using one-way analysis of variance with an F-test. This statistical analysis found a significant relationship between uterine weight and YPM ($p < 0.05$), while no highly significant relationship between postmenopausal uterine weight and parity was found. To enhance the clinical usefulness of our data, tables correlating uterine weight and YPM (Table 2), as well

TABLE 1
Mean Values and Suggested Upper Limits of Normal for Premenopausal Uterine Weight as a Function of Parity

Parity	N	Uterine Weight*	Two Standard Deviations above Mean Uterine Weight
		g	g
0	9	60 ± 20	100
1	9	109 ± 26	161
2	18	108 ± 28	164
3	12	121 ± 35	191
≥4	13	130 ± 35	200
Total	61	109 ± 37	

*Mean ± SD.

TABLE 2
Mean Values and Suggested Upper Limits of Normal for Postmenopausal Uterine Weight as a Function of Years Postmenopause

Years Postmenopausal	N	Uterine Weight*	Two Standard Deviations above Mean Uterine Weight
		g	g
0–5	15	84 ± 22	128
5–10	18	58 ± 21	100
10–20	19	56 ± 27	110
>20	24	43 ± 18	79
Total	76	58 ± 26	

*Mean ± SD.

as uterine weight and parity (Table 3), are presented for the postmenopausal group.

DISCUSSION

The uterus is known to change in size during various clinical stages and conditions, making subjective evaluation of uterine enlargement often difficult. Langlois, in a clinical/pathologic correlative study without the use of ultrasound, attempted to establish normal uterine size data, especially for the premenopausal women.[2] A limited number of studies have attempted to utilize ultrasound for the evaluation of uterine size.[3–10] These studies primarily concentrated on premenopausal patients. Size analysis of the perimenopausal and postmenopausal uterus has been largely limited to reports of a few cases.[1] Our data suggest that ultrasound can accurately assess uterine size, and, through subsequent comparison to established normal reference groups, can detect abnormally enlarged uteri. This data may be of considerable value for those patients in whom subjective evaluation of uterine size is often difficult, such as in the perimenopausal or postmenopausal woman.

Our method for estimating uterine size based on sonography was to utilize the prolate ellipsoid formula and measurements obtained directly from the ultrasound examination. Flickinger et al. recently reported the ability of ultrasound to accurately predict uterine size.[9] We have found that the calculated uterine volume obtained via the prolate ellipsoid formula can be directly transformed into uterine weight.

TABLE 3
Postmenopausal Uterine Weight as a Function of Parity

Parity	N	Uterine Weight*
		g
0	8	40 ± 21
1	7	53 ± 28
2	28	56 ± 26
3	14	58 ± 25
≥4	19	70 + 26
Total	76	58 ± 26

*Mean ± SD.

In clinical practice, sonographic determination of uterine weight should be compared with a reference group of clinically similar normal patients to identify abnormally enlarged uteri. Only patients with normal uteri on gross inspection with minimal histologic changes were included in our data set used to establish mean and normal ranges of uterine size. Patients with very small leiomyomata or minimal endometrial pathology were included in the normal group, since these conditions do not significantly enlarge the uterus.

We have found that parity is the most important factor determining uterine weight in the premenopausal patient. Langlois, in his discussion of uterine size, also suggested that parity is the principal factor determining uterine weight prior to menopause.[2] Analysis of our data on uterine size based on parity revealed a statistically significant weight difference between the nulliparous patients and the multiparous patients ($p < 0.01$) (Table 1). There was a statistical trend toward greater uterine weight as parity increased among the parous uteri; however, statistical significance was not achieved.

We believe uterine size evaluation may have its greatest value in the peri- and postmenopausal patient. Changes in uterine dimensions and size related to puberty have been well described previously.[3–5] The more clinically useful uterine changes, related to menopause, have not been extensively studied or well quantified.[1] We believe these patients merit greater attention because of the difficulty of subjective evaluation of uterine size and the relative lack of established guidelines for size analysis.

Our data demonstrate the well established decline in uterine size after menopause. This reduction in uterine size was not demonstrated to a significant degree in the nulliparous patients. In fact, they seem to be a somewhat distinct subgroup as their uterine weight was noted to vary little with age or years postmenopause (Tables 1 and 3). Previous reports have estimated the upper limits of normal size for a nulliparous uterus to be from 50 to 130 grams.[11] Our data suggest that a normal nulliparous uterus should be expected to weigh less than 85 grams (Figure 1).

Determining the optimal method for presenting the postmenopausal data was difficult. Statistical analysis showed a highly significant relationship between years postmenopause and weight (Table 2). However, this information may not always be available and may be inaccurate. A second table correlating parity and weight (Table 3) for the postmenopausal uterus is presented to enhance the clinical usefulness of the data, particularly in this patient population. The most rapid decline in uterine size occurred within the first 10 years after menopause, with a more gradual decline in size in women greater than 10 years postmenopause (Table 2).

In conclusion, we have utilized ultrasound to accurately assess uterine size. We have sought to establish expected uterine sizes based on specific patient history which will enable detection of abnormally enlarged uteri. Abnormally enlarged uteri based on examinations that were otherwise sonographically normal are suspicious for uterine pathology, most often leiomyomata. Uterine evaluation in these types of patients cannot be subjectively reported as abnormal without the type of data available from this study.

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