Ovarian and Uterine Ultrasonography in Healthy Girls between Birth to 18 Years

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The aim of our study was to determine the pattern of female reproductive organ growth in Indian girls from birth to 18 years of age and to correlate the uterine length, mean ovarian volume (MOV) and Fundo Cervical Ratio (FCR) with chronological age, bone age and pubertal breast staging. A cross sectional study was performed on 218 girls from birth to 18 years of age. Height, weight, stage of puberty, X-ray for bone age and transabdominal ultrasounds were performed on all girls. Higher chronological age, bone age and increase in breast stage significantly predicted higher MOV ($P<0.001$) and higher uterine length ($P<0.001$). The MOV, uterine length and FCR are positively correlated with chronological age, bone age, height, weight and breast staging. Data from present study may be useful in screening cases of precocious puberty and other disorders that may need further evaluation.

Key words: *Bone age, Ovary, Puberty, Uterus.*

PELVIC ultrasound is safe, non-invasive, and accurate method to investigate pathology and physiological changes of the female reproductive system(1). Pelvic examination is difficult in young girls and ultrasonography can be used instead(2). With the global trend of precocious puberty in girls, pelvic ultrasound has acquired great importance(3). There is a wide variation in the results of several studies concerning sonographic findings in children and adolescents(4,5). The aim of our study was to determine the normal pattern of female reproductive organ growth in Indian girls from birth to 18 years of age. We correlated the uterine length, ovarian volume and fundo cervical ratio (FCR) with chronological age (CA), bone age (BA) and breast staging.

Subjects and Methods

A cross-sectional study was performed on 218 girls from birth to 18 years. Study population consisted of normal sisters (with no endocrine disorders) of patients attending paediatric outpatient clinic. Girls were considered as normal if the height and weight was between the 3rd and 97th centile as per Agarwal charts and BA was within normal range (±2 SD according to the Tanner White-house atlas)(6,7). Girls who had a BA discrepancy were excluded from analysis. Neonates were randomly selected from babies delivered at the hospital. At least 10 girls were present in each age group, 119 girls were prepubertal and 95 girls had attained puberty. Our ethical committee approved the research

project and written informed consent was obtained from parent.

Stage of puberty was classified according to Tanner and date of menarche was recorded. Presence of thelarche (onset of breast development) was the criterion used to distinguish pubertal from prepubertal girls(8). Transabdominal ultrasounds were performed (using the Aloka 3500 and 4000, with 3.5 Mega Hz convex probe and 7.5 Mega Hz linear probe) with the conventional full bladder technique. At each scan the uterus (length from base of cervix to the apex of the fundus, AP diameter of fundus, AP diameter of cervix and thickness of the endometrium), FCR (FCR= anteroposterior diameter of the fundus/ anteroposterior diameter of the cervix), ovaries (volumes [3 readings were taken for each ovary], using modified formulae for the prolate ellipsoid as advocated by Sample and Lippe [0.5*L*W*H](9)) and presence and size of follicles were studied. Ultrasounds were performed and interpreted by two experienced observers. For reproducibility of measurements made at ultrasound, 25 ultrasounds were performed in duplicate with the 2nd examiner being blind to the results of the first. The coefficient of variation was <4.6% for ovarian volume and <3.6% for uterine length.

A hand and wrist *X*-ray was performed for BA on girls who were more than two years of age (as the Tanner Whitehouse method does not allow BA calculation under 2 years(10)). BA was performed by the same pediatric endocrinologist on all *X*-rays and the coefficient of variation was <2.3%. Girls who were menstruating had an ultrasound examination done during the first 10 days of the menstrual cycle(11).

The scans were divided as per the age group of the girls and also by breast staging. Data was presented as mean (SD) for each age group and breast stage. Mean values for measurements made at each pubertal stage were compared using analysis of variance (ANOVA, Tukey's *post hoc* test). MOV and uterine length were log transformed to achieve normality. To test the relation between age, MOV and uterine length, the Pearson's correlation coefficient was calculated in the whole group. Multiple linear regression analysis was used to predict MOV and uterine length in the cohort and P <0.05 was considered significant. SPSS for windows version 11.0 (Chicago, Ill) was used for analysis.

Results

Four girls were excluded from analysis as data was incomplete in three and the bone age was advanced >2 SD in the fourth, One hundred nineteen girls were prepubertal while 95 were at various stages of puberty. The mean volumes of the right and left ovaries were not significantly different (1.73 *vs* 1.87 cm^3, P = 0.09) hence mean volume of both the ovaries was considered (MOV).

The ovaries and uterus were visualized in all girls. *Table I* shows the groups as per the age, number in each group, the mean, SD, and median of ovarian volume, uterine length, and FCR. The increment in the MOV from 0.62 at 7-8 years to 1.22 at 8-9 years and from 1.64 at 11-12 years to 2.97 at 12-13 years was significant (P <0.01). The increment in uterine length from 3.02 to 3.23 and the increase in the FCR from 1.16 to 1.35 occurred at 8-9 years of age (not statistically significant).

On comparison of MOV with American and British data the ovaries were smaller at a younger age and continued to remain so till around 12-13 years after which they attained a similar volume as their American and British counterparts. Similarly, the mean uterine length of our population was smaller till nine

TABLE I–*Ovarian Volume, Uterine Length and FCR According to Chronological Age (n = 214)*

Age group	n	Ovarian volume (cm^3)		Uterine length (cm)		FCR	
		Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median
<30 days	10	0.25 (0.25)	0.15	2.98 (0.25)	2.95	0.79 (0.28)	0.66
4-8 months	10	0.21 (0.19)	0.13	2.72 (0.61)	2.75	0.86 (0.19)	0.81
1-2 yr	10	0.24 (0.23)	0.14	2.50 (0.44)	2.40	1.00 (0.20)	1.00
2-3 yr	10	0.28 (0.15)	0.27	2.56 (0.46)	2.45	0.91 (0.19)	0.93
3-4 yr	10	0.36 (0.22)	0.26	2.48 (0.63)	2.55	0.99 (0.21)	1.06
4-5 yr	10	0.50 (0.32)	0.36	2.84 (0.37)	2.85	1.03 (0.25)	1.00
5-6 yr	10	0.51 (0.13)	0.53	2.83 (0.47)	2.85	0.91 (0.22)	0.92
6-7 yr	15	0.51 (0.35)	0.37	3.01 (0.27)	3.00	1.03 (0.34)	1.00
7-8 yr	10	0.62 (0.54)	0.52	3.02 (0.21)	3.00	1.16 (0.58)	1.10
8-9 yr	10	1.22 (0.59)	1.24	3.23 (0.41)	3.25	1.35 (0.51)	1.18
9-10 yr	11	1.23 (1.50)	0.90	3.71 (0.88)	3.30	1.30 (0.57)	1.20
10-11 yr	15	1.34 (0.54)	1.51	3.59 (0.69)	3.40	1.21 (0.30)	1.22
11-12 yr	15	1.64 (1.32)	1.42	4.80 (1.69)	5.30	1.28 (0.33)	1.22
12-13 yr	15	2.97 (1.57)	2.97	5.50 (1.27)	5.30	1.48 (0.33)	1.50
13-14 yr	11	3.38 (1.51)	3.03	6.06 (0.42)	6.00	1.56 (0.39)	1.63
14-15 yr	10	4.29 (2.73)	4.17	6.16 (0.81)	6.25	1.71 (0.39)	1.53
15-16 yr	12	4.44 (1.85)	4.00	6.94 (1.12)	7.10	1.73 (0.43)	1.68
16-17 yr	10	4.51 (1.41)	4.96	7.03 (0.9)	7.20	1.80 (0.40)	1.68
17-18 yr	10	5.42 (2.25)	4.97	8.00 (1.65)	7.55	1.56 (0.31)	1.58

years of age when compared to European data and caught up after this age(1,12,13).

Increase in breast stage from 1 to 5 predicted increase in MOV, uterine length and FCR (*Fig.1*). The distribution of girls according to breast staging is depicted in *Table II*. MOV, uterine length and FCR were smaller in girls without thelarche (breast stage 1) than with thelarche (0.37 *vs* 2.73, 2.83 *vs* 5.64 and 0.96 *vs* 1.41 respectively, P <0.001 for all). There was an increase in mean follicular size with increasing breast stage.

CA, BA, height, weight and breast staging were positively correlated with MOV, uterine length and FCR (P <0.001 for all). CA, BA and breast stage were the significant predictors of MOV (P <0.001). CA, BA, height and breast stage were the significant predictors of uterine length (P <0.001).

Fifty-six girls (Mean age-14.9 yrs, range-9.9-17.9) of the 95 pubertal girls were menstruating regularly. The mean age at menarche was 12.5 yrs (9.1-17.5), mean breast stage was 4.9 (3-5), MOV was 4.1 cm^3 (0.8-11.5), uterine length was 6.9 cms (4.8-10.2) and FCR was 1.6 (0.7-2.7).

Discussion

The present study is original in that we present data of neonatal, prepubertal and

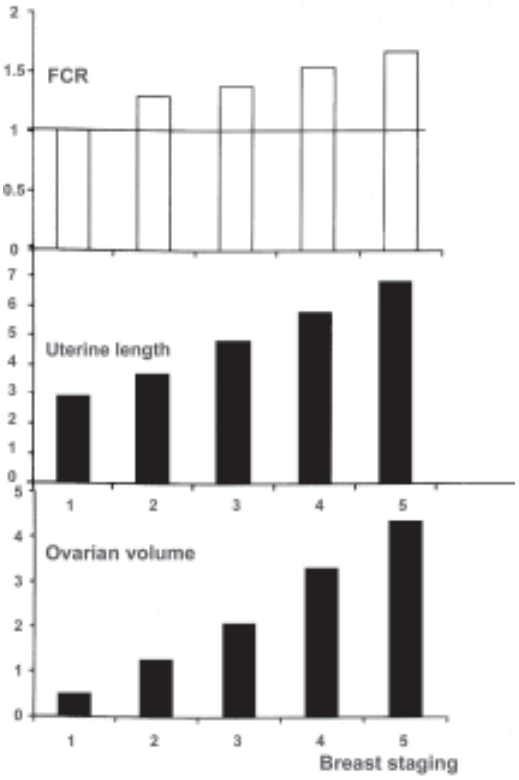

Fig.1. Bar chart showing MOV, uterine length and FCR as per breast staging.

pubertal girls, we have studied the internal reproductive organ morphology within six months of menarche and a comparison with Western data is made. CA, BA and breast staging were the significant predictors of MOV, while CA, BA, height and breast stage were the significant predictors of uterine length.

In the present study the MOV, uterine length and FCR were positively correlated with chronological age, bone age, height, weight and breast staging, as has been found in other studies(2,13).

The MOV was 0.25 cm^3 at birth, 0.21 cm^3 at 4-8 months and then increased gradually throughout childhood. As seen in our study, other observers have also reported the significant sudden increment in MOV at 8 years and at 12 years of age(14). Chronological age, bone age and breast staging were the significant predictors of MOV independent of the height and weight.

The reduction in the uterine length in the post neonatal period can be attributed to

TABLE II–*Age, Number, Ovarian Volume, Uterine Length, FCR and Endometrial Thickness According to Breast Stage*

Breast staging	n	Age (yr)	Ovarian volume (cm^3)		Uterine length (cm)		FCR		Endometrial thickness Mean (Range) mm
		Mean	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	
1	119	5	0.52*(0.45)	0.36	2.90*(0.53)	2.90	1.01*(0.40)	1.00	0.1 (0-3)
2	17	10	1.29 (0.57)	1.37	3.7 0(0.82)	3.30	1.29 (0.40)	1.28	1.1 (0-2)
3	12	12	2.09 (1.39)	1.78	4.81 (1.28)	4.85	1.38 (0.30)	1.31	2.0 (0-5)
4	10	12	3.32 (1.80)	2.74	5.87 (1.34)	5.65	1.54 (0.30)	1.55	3.1 (0-6)
5	56	15	4.34 (2.01)	3.93	6.84 (1.18)	6.60	1.67 (0.40)	1.61	5.2 (0-9)
p			<0.001	<0.001	<0.001				

p significantly different for measurements at each breast staging, * Significantly different than breast staging 2,3, 4 and 5 at $p<0.001$.

Key Messages

- Growth of internal reproductive organs was studied in healthy girls (0-18 years of age) and data generated may be used as a reference.
- A strong correlation was found between mean ovarian volume and uterine length with age, bone age and breast staging.

waning of maternal hormones. Chronological age, bone age, height and breast stage were the significant predictors of uterine length.

Increase in breast stage from 1 to 5 predicted increase in ovarian volume, uterine length and fundo-cervical ratio. There was also an increase in mean endometrial thickness and mean follicular size with increasing breast stage.

The pattern of growth of the reproductive organs appears to be different from that of Caucasian counterparts and a possible explanation for this observation may be that as a result of chronic intergenerational malnutrition, at a younger age nutrition is diverted to those organs, which are essential for survival, and a selective promotion of reproductive organ growth occurs at the time when the endocrine changes of puberty take place(15).

Girls who achieved menarche within 6 months of the study date had a mean age of 12.5 at menarche (mean height - 153.8 cm), which is very similar to 12.6 years (mean height - 153.0 cm) as reported by Agarwal, *et al*. in 1992. Stabilization of age at menarche has also been reported in the United States and the United Kingdom(3,16).

Precocious puberty is one of the commonest reasons for referral to a pediatric endocrine unit. With urbanization, sedentary life style and improving nutrition, there is a sharp rise in obesity in urban India, which may also be contributing to the rising incidence of precocious puberty(17). There is a 4 to 5 times higher preponderance of central precocious puberty (CPP) in females(18).

The length of the uterus is considered a more reliable and reproducible parameter for assessment of the uterine size than the volume. Change in the shape of the uterus with it adopting a pear shape has been reported to be a better marker of puberty than other uterine dimensions(1,5,19). The presence of six or more follicles seems to be correlated with pubertal stimuli(4).

Our study has its limitations in that it is done on smaller number of individuals (larger multicentric trials are necessary) and it uses cross sectional data whereas longitudinal data would be more meaningful but is hard to obtain.

In India, where endocrine tests are not always easily available, but ultrasound facilities are, normative ultrasound data on internal pelvic reproductive organs will prove to be useful in screening cases that may need further evaluation.

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Ultrasound examinations, the data was analyzed by SSD, AVK and VVK, bone age was performed by VVK and all drafted the manuscript. VVK will act as guarantor of the study.

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