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Ovarian development of the female child and adolescent: I. Morphology

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Abstract

Ovarian morphology of 180 randomly selected females, aged 8—21, was investigated, utilizing standard sector scanning ultrasound techniques, at −1 year (1 year before menarche), year 0 (menarche) and years +1 to +8 (1—8 years postmenarche). According to strict morphologic criteria, seven ovarian patterns were recognized which varied in dominance with age in reference to menarche. Prior to menarche a multifollicular ovarian pattern (Type 1) dominates which after menarche is substituted by a predominantly active ovarian pattern (Type 5). Approximately 20% of postmenarcheal females do not develop this active pattern.

In a relatively persistent percentage of females a microcystic (Type 2) ovarian pattern was recognized throughout all postmenarcheal years, suggestive of a normal transitional pattern from Type 1 to Type 5 ovaries. In contrast, multicystic (Type 3), hyperthecosis (Type 4), polycystic ("Mickey Mouse") (Type 6) and silent (Type 7) ovaries appear to represent abnormal ovarian developments. Based on percentage distributions, it is tempting to speculate that multicystic (Type 3) and/or hyperthecosis (Type 4) ovaries represent precursor ovaries to Type 6 (polycystic) ovaries. Confirmation of this hypothesis would have major clinical importance for the early diagnosis of the polycystic ovarian syndrome.

Keywords: Ovarian development; Ultrasound; Child; Adolescent.

Introduction

Endocrinologic changes during female puberty and adolescence have been well documented. Since ovarian surgical specimens from these age groups are rare, anatomical correlations with hormone profiles have remained very limited. The development of ultrasonography has made it possible to assess pelvic structures morphologically in a non-invasive fashion. Limited studies on ovarian development in young females, utilizing ultrasonography, have appeared in the literature [1—5]. None of these studies has, however, attempted to correlate in detail ovarian morphology with developmental stage and endocrine profile.

Such an attempt was made in a study which encompassed 180 Italian females between the

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ages 8 and 21. As a first part of this study, the sonographic evaluation of ovarian morphology is described. Other developmental features of these 180 females in relationship to their ovarian morphology will be the subject of a future paper.

Materials and methods

One hundred eighty females, ages 8—21, represented the study population. Ultrasound exams were performed on these females in 10 groups. Group −1 patients were examined 6—12 months before menarche. Group 0 were females examined +3 months from onset of their first menstrual period. Groups +1 to +8 were examined at 1—8 years +3 months after first menses.

Figure 1 demonstrates that mean ages of menarche of all groups were similar and not statistically different by analysis of variance. Figure 2 further demonstrates the homogeneity of each group by demonstrating a steadily increasing mean age for each group with relatively small standard deviations.

All patients underwent realtime ultrasound scanning at the Artemisia Medical Center, in Rome, Italy, utilizing Ansaldo scanners, models 940 and 920, Alohas SSD250, SSD256 and an ATL, mark 500. A variety of transducers was used including frequencies of 3, 3.5 and 5 MHz.

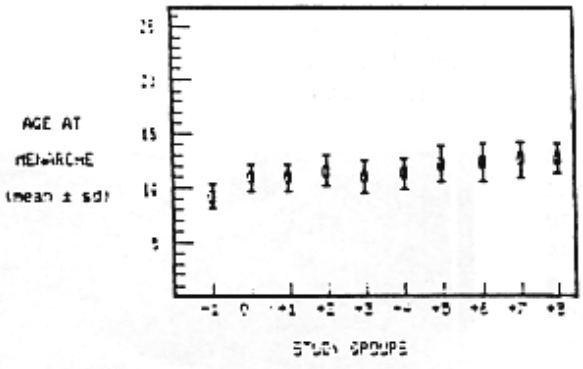

Fig. 1. Mean ages (+S.D.) for study groups (−1) to (−8) at time of menarche. Note that mean ages for the various groups were not statistically different (analysis of variance).

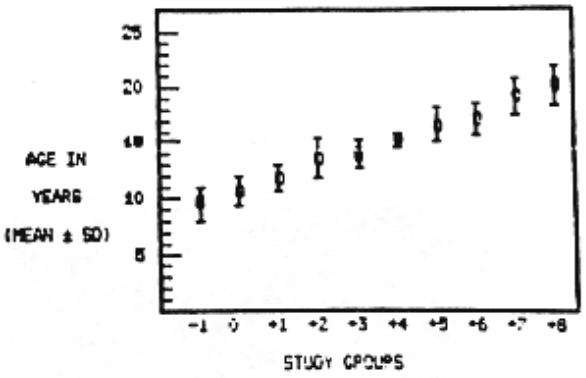

Fig. 2. Mean ages (+S.D.) for study groups at (−1) to (+8) years postmenarch. As expected a persistant rise in mean age can be observed.

Ovarian scans were performed utilizing Donald's technique [6]. The ovarian volume was calculated according to the formula developed by Lippe and Sample [7].

$$V = \frac{\text{length} \times \text{width} \times \text{thickness}}{2}$$

Averages of volumes were rounded up or down to the closest cubic centimeter. Both ovaries were averaged for each patient.

All ultrasound scans of menstruating females were performed between day 8 and 10 of the cycle.

Ovarian ultrasound patterns

Ovaries were sonographically classified into 7 types based on their predominant sonograhic morphologic characterization.

Type 1: Multifollicular ovary (Fig. 3). Ovary with increased (> 6 cm³) volume, characterized by the presence of numerous anechogenic areas, roughly round in shape and usually of less than 1 cm diameter. These sonolucent areas are seen throughout the ovary in both subcortical and intraparenchymal areas.

Type 2: Microcystic ovary (Fig. 4). Ovary with greatly increased (> 8 cm³) volume,

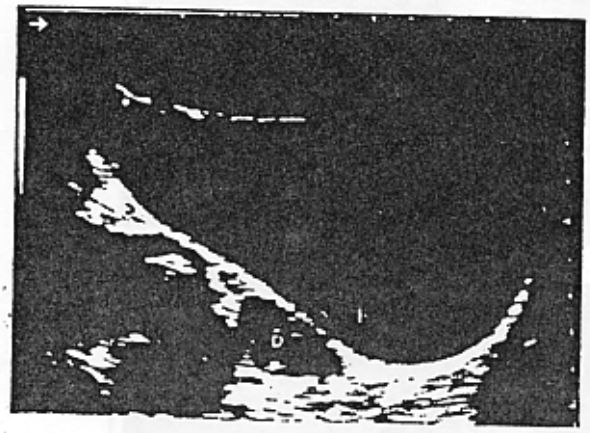

Fig. 3. Multifollicular ovary. Note the relatively large ovary (o) beneath the bladder (b) filled throughout with small round anechogenic (sonolucent) cystic spaces.

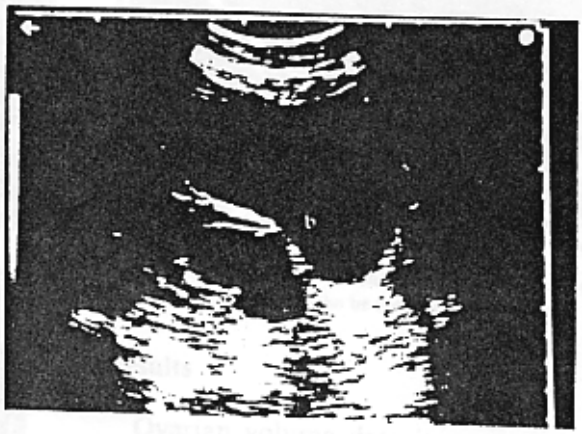

Fig. 5. Multicystic ovary. Ovary (o) below bladder (b). Note large cyst formations (arrows).

characterized by several anechogenic (sonolucent) round spaces of varying sizes (0.5—2.0 cm) which are primarily seen in subcortical areas.

Type 3: Multicystic ovary (Fig. 5). Ovary with unilateral scanning pattern characterized by voluminous cyst formation(s) of more than 3 cm^3.

Type 4: Hyperthecosis (Fig. 6A,B). Ovaries of this type demonstrate a prevailing stromal component, recognizable through strong intraparenchymal echoes (Fig. 6A) or anechogenic ridges (of possibly stromal secretion) (Fig. 6B). Both patterns can usually be seen concomitantly in Type 4 ovaries and can, in non-dominating fashion, also be found in Type 1, 2 and 6 ovaries.

Fig. 4. Microcystic ovary. Note the very large size of the ovary (o) beneath the bladder (b). Anechogenic spaces of varying sizes can be seen primarily in the subcortical area.

Type 5: Active ovary (Fig. 7). Ovaries with normal (4—6 cm^3) volume which are largely homogeneous in pattern but demonstrate functional activity such as the presence of one or more follicular (anechogenic) cysts in a subcortical location.

Type 6: Polycystic ovary ("Mickey Mouse" pattern) (Fig. 8). Ovaries with remarkably excessive (> 10 cm^3) volume characterized by high acoustic impedance on their surfaces, which, in turn, allows a clearer than usual delineation of their boundaries from surrounding structures. In a transverse scan, a characteristic pattern is seen, mimicking the image of Mickey Mouse (!).

Type 7: Silent ovary (Fig. 9). Ovaries of smaller than normal (< 3 cm^3) size, homogenous in appearance, and lacking all signs of follicular activity.

Exclusion of patients

Amongst 180 patients who were fully scanned according to the above protocol, nine

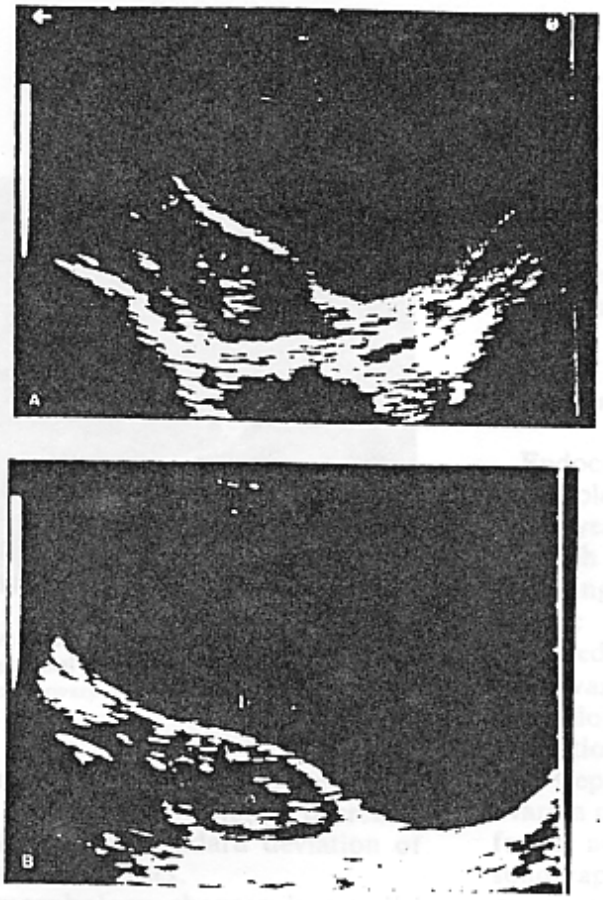

Fig. 6. Hyperthecosis. Prevailing stromal component can be seen in the ovary (o); bladder (b). Stromal component can be seen as strong intra-parenchymal echoes (small arrows) (A) or anechogenic ridges (small arrows) (B), possibly representing stromal secretions.

were excluded from analysis because of accidently detected additional pathology or incapability to obtain a proper ovarian ultrasound scan. In four patients, ovaries were not properly visualized. These patients had pathology, including one ovarian teratoma, one sactosalpinx and one incidence of endometriosis. Two other patients, who were excluded, had Turner Syndrome and primary amenorrhea with utero-ovarian hypoplasia, respectively.

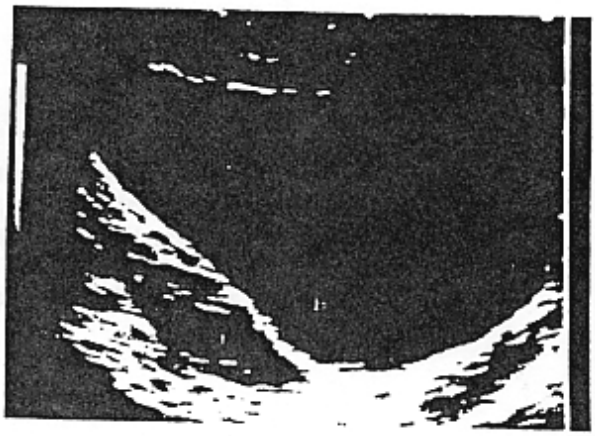

Fig. 7. Active ovary. Normal size ovary (o) below bladder (b). A single follicle (f) can be seen within the ovary.

Results

Ovarian volume data is presented in Fig. 10. As may be seen from this figure, a maxi-

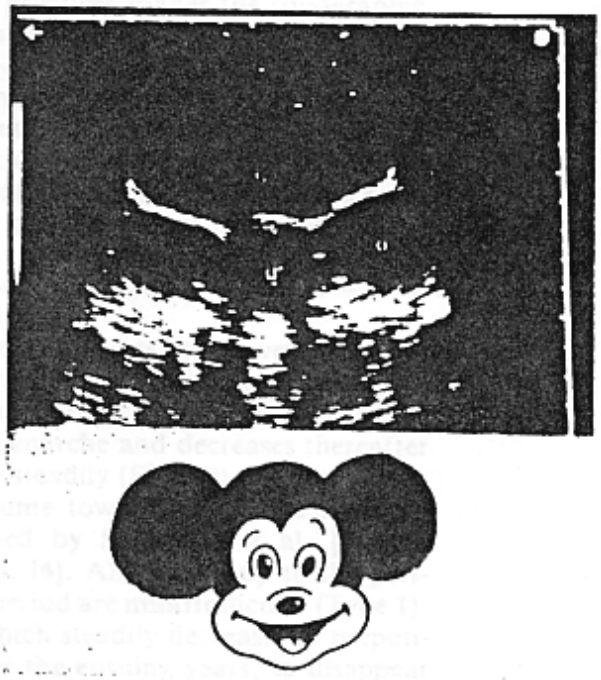

Fig. 8. Polycystic ovary ("Mickey Mouse"). Note the enlarged ovaries (o) on both sides of the uterus (u) in a transverse scan; bladder (b). Acoustic impedance of ovaries delineates both ovaries very clearly from surrounding structures.

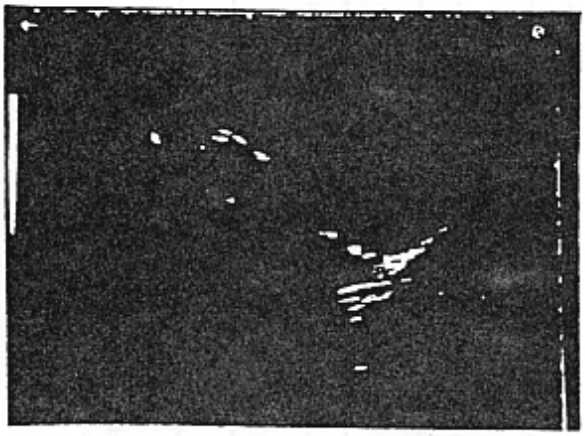

Fig. 9. Silent ovary. Longitudinal scan of small homogenous ovary (o) in longitudinal scan below bladder (b). No activity can be seen within the ovary.

mum ovarian volume is reached at menarche. Thereafter, the ovarian volume decreases progressively and the standard deviation of the mean volume increases.

Ovarian morphology changes in parallel (Fig. 11). The young ovary is predominantly a Type 1 (multifollicular) ovary. The preponderance of multifollicular morphology gradually gives way to that of a Type 5 (active) ovary. Interestingly, from +1 year on, almost steady percentages of Type 2 (microcystic) ovaries persist throughout year +8. This observation suggests that Type 2 ovaries

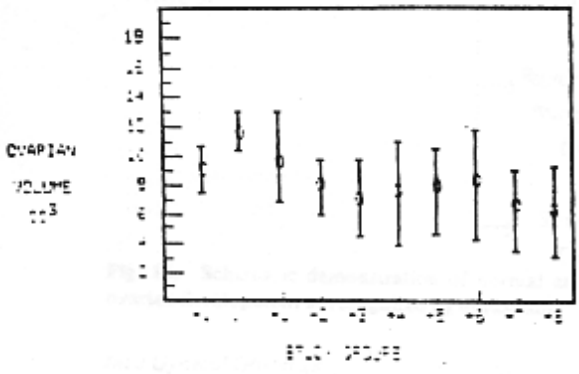

Fig. 10. Ovarian volume (+S.D.) at years (−1) to (+8) after menarche.

may represent a normal transition phase from Type 1 to Type 5 ovaries. Other minority patterns were also intermittantly recognized (Fig. 11); however, none persisted throughout year +8 in uninterrupted fashion as was seen with Type 2.

Discussion

Endocrinologic changes during puberty and adolescence have been well described. In recent years there have also been attempts to establish the morphologic picture of ovaries in young female [1—5]. Systematic sonographic studies have, however, remained restricted to premenarcheal girls [3,4]. The wide availability of ultrasound in modern day gynecologic practices makes the sonographic evaluation of ovaries relatively simple. As a first step in an attempt to correlate between ovarian morphology and hormonal profile of female adolescents, a detailed description of sonographic ovarian scanning patterns from one year prior to first menses to 8 years postmenarche is presented here. In a subsequent publication we will attempt to correlate the observed ovarian patterns (Types 1—7) to hormonal profiles.

This study suggests that very distinct ovarian morphologies can be expected in relationship to menarche. Ovarian volume peaks at time of menarche and decreases thereafter more or less steadily (Fig. 10). An increase in ovarian volume towards menarche has also been reported by Stanhope et al. [3] and Salardi et al. [4]. All ovaries up to the perimenarchal period are multifollicular (Type 1), a pattern which steadily decreases in preponderance over the ensuing years, to disappear completely at year +8. A multicystic ovarian pattern in the premenarcheal period has also been described by others [3—5]. In parallel to the decreased incidence of Type 1 ovaries, an increasing incidence of active ovaries (Type 5) can be observed, peaking at approximately 75% in year +8.

A most important observation of this study is the recognition that as early as year +1,

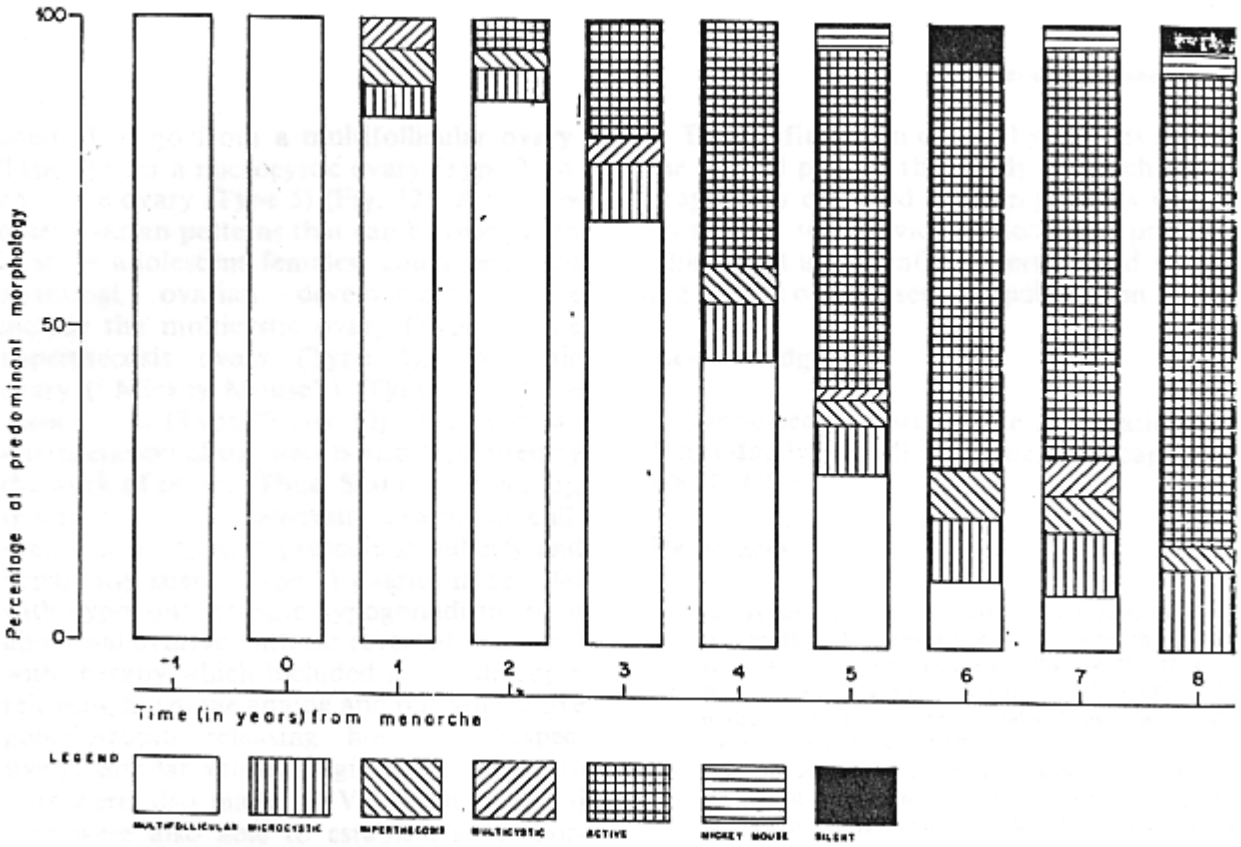

Fig. 11. Distribution of sonographic ovarian types (1—7) in years (− 1) to (+ 8) after menarche.

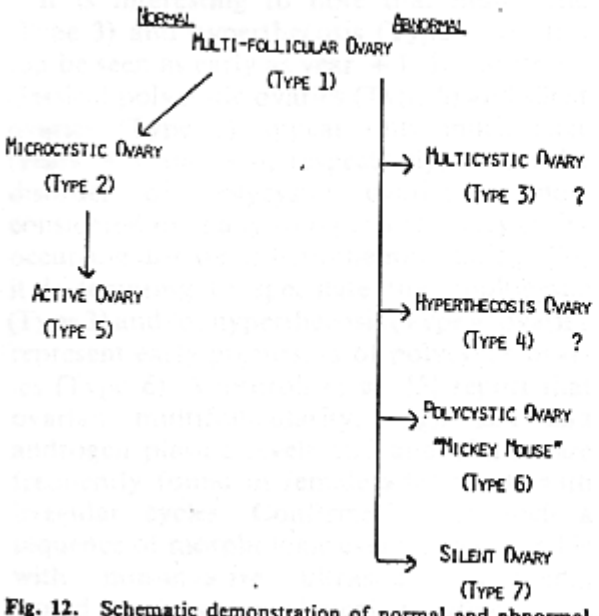

Fig. 12. Schematic demonstration of normal and abnormal ovarian development as recognized by ultrasound.

microcystic (Type 2) ovaries can be observed. This pattern persists in a rather stable proportion through year + 8.

If it is accepted that normal ovarian development entails a transition from type 1 (multifollicular) ovaries to Type 5 (active) ovaries, then other observed ovarian patterns have to represent either transitional stages or abnormal developments. As Fig. 11 demonstrates, quite a variety of ovarian types can be recorded at years + 1 to + 8; however, only Type 2, the microcystic ovary, represents a persistant feature from year + 1 to year + 8. It therefore seems reasonable to assume that the microcystic ovary (Type 2), in contrast to other minority patterns, represents a normal transition stage for each ovary. Normal ovarian development can therefore be

assumed to go from a multifollicular ovary (Type 1) over a microcystic ovary (Type 2) to an active ovary (Type 5) (Fig. 12). All of the other ovarian patterns that can be recognized in some adolescent females, could represent abnormal ovarian development. These include the multicystic ovary (Type 3), the hyperthecosis ovary (Type 4), polycystic ovary ("Mickey Mouse") (Type 6) and the silent ovary (Type 7) (see Fig. 12). Such an interpretation of our data is also supported by the work of others. Thus, Stanhope et al. [3], reported large megalocystic ovaries in children with idiopathic precocious puberty and apparently silent (Type 7) ovaries in females with hypogonadotropic hypogonadism. Both abnormal ovarian patterns reversed to normal with therapy which included a gonadotropin releasing hormone analog and pulsatile native gonadotropin releasing hormone, respectively. Similar morphologic observations to ours were also made by Venturoli et al. [5] who were also able to establish some hormonal correlations.

It is interesting to note that multicystic (Type 3) and hyperthecosis (Type 4) ovaries can be seen as early as year +1. In constrast, classical polycystic ovaries (Type 6) and silent ovaries (Type 7) appear only much later (years +5 and +6, respectively). Since the disorder of polycystic ovaries is now considered by many to represent a very early-occurring disease of hypothalmic etiology [8], it is tempting to speculate that multicystic (Type 3) and/or hyperthecosis (Type 4) ovaries represent early precursors of polycystic ovaries (Type 6). Venturoli et al. [5] report that ovarian multifollicularity, high LH and androgen plasma levels and anovulation are frequently found in female adolescents with irregular cycles. Confirmation of such a sequence of morphologic events, recognizable with non-invasive ultrasound scanning, would have major clinical significance. It would facilitate the diagnosis of adolescent females at risk for polycystic ovarian disease long before clear clinical symptomatology arises.

The confirmation of this hypothesis awaits the second part of this study in which sonographically obtained ovarian patterns will be correlated to individual hormone profiles. This effort is presently underway and will be the subject of a subsequent publication.

Acknowledgment

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