

ANATOMICAL CHANGES OF THE OVARIES IN POLYCYSTIC OVARIES

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Abstract: *Polycystic ovary syndrome features distinctive ovarian anatomical changes, including increased ovarian volume, elevated antral follicle count, stromal hyper-echogenicity, and cortical remodeling. This IMRAD-structured review synthesizes ultrasound and histomorphological data, phenotype-specific variability, and links with endocrine markers. Diagnostic limitations, device-dependent thresholds, and integrative clinical interpretation are emphasized.*

Keywords: *polycystic ovary syndrome, ovarian morphology, antral follicle count, ovarian volume, stromal hyperplasia, Doppler, AMH.*

Introduction

Polycystic ovary syndrome (PCOS) is a widespread and clinically diverse disease in women's reproductive health, based on ovulatory dysfunction, hyperandrogenism, and specific changes in ovarian morphology. Although the morphological expression is historically called "polycystic," its essence is characterized by the abundance of small antral follicles and the restructuring of the stroma; that is, the process is not a "cyst," but is associated with the cessation of follicle development and hyperplasia of stroma-theca elements. As noted in the Rotterdam Consensus, "the presence of 12 or more follicles with a diameter of 2–9 mm and/or an ovarian volume of >10 ml" is accepted as the main criterion for polycystic ovarian morphology (PCOM) [1]. However, this definition is being re-evaluated as equipment resolution increases; the 2018 international guideline recommends a higher limit for the number of antral follicles in new-generation high-frequency transducers [2]. In this regard, this article analyzes the anatomical-ultrasonic and histomorphological changes of the ovaries in PCOS, their relationship with hormonal

and clinical phenotypes, technical-methodical factors, and clinical significance. The aim is to highlight the limitations and opportunities in diagnostics, in accordance with IMRAD requirements, while providing a consistent description of morphology.

Materials and methods

This work was organized as a conceptual-orderly literature review. International English-language guidelines, consensus documents, and comprehensive reviews published between 1995 and 2024 were searched in the PubMed, Scopus, and Web of Science databases. The main search terms were: "polycystic ovary syndrome", "ovarian morphology", "antral follicle count", "ovarian volume", "stromal hyperplasia", "Doppler", "anti-Müllerian hormone (AMH)". The selection criteria were: a) a consensus or guideline that provides clear defining criteria for the diagnosis of PCOS and/or polycystic ovarian morphology; b) reviews in high-impact journals covering ultrasonography and histomorphology related to ovarian morphology; c) classic essays explaining pathogenesis. Limitations: isolated clinical series with small samples and general recommendations without clear morphological indicators. In assessing the quality of sources, their citation rate and sectoral significance were taken into account. In some cases, the authors' positions on morphological definitions were critically compared. Hypothetical empirical data were not presented; the results are based on a synthesis of existing literature.

Results

Ultrasound morphology and anatomical indicators: The most widely used criteria for PCOM are increased ovarian volume and increased antral follicle count (AFC). According to the Rotterdam definition, an ovarian volume of >10 ml confirms PCOM [1]. These indicators, especially when using high-frequency transvaginal transducers of 6–9 MHz, required an increase in the AFC limit due to increased follicle resolution; the 2018 international guideline noted that at least 20 antral follicles is an acceptable criterion in modern equipment (individualization is recommended in accordance with the clinical context) [2]. In PCOS, the stromal part of the ovarian parenchyma occupies a relatively

large proportion, with hyperechogenic stroma, increased echogenicity in the central part, and a ring-shaped (peripheral) arrangement of follicles being common on ultrasound. However, follicles do not have to be located only in the periphery; diffuse distribution is observed in some phenotypes. In addition, indicators such as the stroma-ovary area ratio and increased stromal vascularization (Doppler Vascularization Index) serve as an additional signal associated with obesity and hyperandrogenism [3].

Histomorphological features: In PCOS, focal fibrosis in the tunica albuginea and cortical layer, accumulation of small antral follicles in the subcapsular part, sparseness of the granulosa layer and a tendency to constant atresia, hyperplasia and hyperthecosis of the theca-stroma cells are observed. These changes are considered to be associated with changes in autocrine-paracrine interactions in androgen-sensitive tissues [4]. Insulin resistance and hyperinsulinemia enhance androgen synthesis in theca cells, thereby affecting stromal mass and vascularization [5]. Although the term "polycystic" is used in a histological sense, it should be emphasized that the main finding is a large number of small antral follicles and a state of "arrest" of development.

Hormonal-morphological connections: Anti-Müllerian hormone (AMH) is considered a close indicator of the mass of small antral follicles and is elevated in PCOS; the correlation between AMH and AFC has been confirmed by numerous studies [6]. Nevertheless, it is not recommended to directly replace AMH with PCOM; because there are differences in laboratory methods and populations. In phenotypes with a high level of hyperandrogenism, stromal echogenicity and vascularization may be higher, and ovarian volume may be larger, but this pattern is not strict in all patients [3,4].

Age, BMI and phenotype influence: Physiological AFC decreases with age; therefore, morphological boundaries may differ slightly according to age groups. At the beginning of reproductive age, PCOM may be mild and the ovulatory cycle may be preserved; it is important to differentiate this condition from PCOS. In obesity (high BMI), technical ultrasound limitations, as well as a paroxysmal increase in the stromal signal, make morphological assessment difficult. Hormonal contraceptives can

temporarily suppress AFC, so a "wash-out" window from therapy is taken into account in the differential diagnostic process [2]. While PCOM expressions are more pronounced in classic (A phenotype) PCOS, PCOS without PCOM (e.g., B phenotype) also occurs among ESHRE/ASRM phenotypes, indicating that the use of morphology as a single measure is limited [1–3].

Doppler indicators: Increased blood circulation in the ovarian stroma has been described in PCOS. A decrease in the resistive index and an increase in the vascularization index on Doppler may reflect stromal metabolic activity. However, there is no prohibition on turning Doppler parameters into a routine diagnostic criterion, but there is still no uniform standardization in terms of procedure and reproductive risks [2,3]. For this reason, Doppler data should be interpreted as supporting evidence, together with the clinical and hormonal background.

Pathogenetic explanations of anatomical remodeling: Insulin resistance enhances androgenogenesis through CYP17A1 in theca cells; a high androgen environment interferes with FSH signaling in granulosa cells, leading to delayed follicle development and increased atresia [5]. This morphologically forms a large number of small antral follicles, a larger stroma, and fibrosis tendencies in the tunica-capsule. A NEJM review noted that PCOS is a "multifactorial condition that occurs at the intersection of genetic and environmental factors" [4]. In our opinion, it is not correct to accept the "thickened capsule" in morphology as an absolutely pathognomonic sign; it can be subjectively assessed and manifested differently across phenotypes.

Diagnostic criteria and their revision: The components of the Rotterdam Consensus (ovulatory dysfunction, clinical/biochemical hyperandrogenism, PCOM) are still dominant in clinical practice [1]. However, the 2018 international guideline proposes to recalibrate ultrasound criteria relative to equipment resolution, especially to view the AFC limit with higher values [2]. While we support this proposal, we believe that since technical capabilities vary in some centers, AFC should be used not as a figurative "universal" norm, but in the context of equipment and population.

Discussion

The findings confirm that morphology is a central indicator in PCOS, but requires contextual interpretation. On the one hand, increased ovarian volume, increased AFC, and stromal hyperechogenicity provide reliable evidence for PCOS. On the other hand, heterogeneity depending on age, obesity, contraception, equipment resolution, and phenotype spectrum alters the sensitivity/specificity of these signs. The Rotterdam definition (12+ follicles or >10 ml volume) was acceptable for its time, but today, due to the fact that high-frequency transducers record more AFC, it shows the need to re-measure the boundaries, as in the 2018 recommendations [1,2]. Here we quote directly from the consensus documents: "PCOM can be defined by an increased follicle number per ovary and/or increased ovarian volume" [1]. We conceptually approve of this formulation, but in practice its limitation is seen in recalibrating "how much it has increased" relative to the equipment and population.

From a histomorphological point of view, the hyperplasia and hyperthecosis of the stroma-theca block, the tunica-cortical fibrosis, and the spectrum of small antral follicles are the "central link" of PCOS morphogenesis. The interaction of insulin resistance and hyperandrogenism drives morphological remodeling [4,5]. At the same time, the high correlation of AMH with AFC serves as a biomarker bridge between morphology and endocrinology, although it is not yet appropriate to turn AMH into an independent diagnostic criterion [6]. Doppler indicators have additional value, but standardization work on protocols should be sufficiently carried out before they are introduced into general rules [2,3].

The following pragmatic points are important for clinical practice: a) if PCOM is found on ultrasound, but there are no signs of ovulatory cycle and hyperandrogenism, PCOS is not diagnosed; b) conversely, if there is a PCOS phenotype and PCOM is not detected, clinical-laboratory criteria are prioritized; c) when interpreting morphology, it is necessary to take into account age, BMI, blood-sugar, and cycle phase. For scientific research, the most urgent direction remains the quantitative calculation of morphological

parameters - ovarian volume, AFC, stroma area ratio, Doppler indices - according to standardized protocols.

Limitations:

This article relies on a literature review; no new empirical data were presented. The stated limit values may vary depending on the type of equipment and population. Since consensus and high-impact reviews were preferentially selected among the sources, some morphometric details may not have been covered.

Conclusion

Ovarian morphology in PCOS is characterized by a large number of small antral follicles, increased ovarian volume, stromal hyperechogenicity, and cortical-capsular remodeling. These changes are functionally related to insulin resistance and hyperandrogenism, and are reflected at the biomarker level via AMH and AFC. Although ultrasound criteria are important in diagnostics, they should be reviewed in the context of equipment and population, and integrated with clinical and hormonal criteria. A complex approach that does not limit itself to the "clear at a glance" appearance of morphology, but takes into account the heterogeneity of phenotypes and technical-methodical factors, is the most reliable way to correctly identify and manage PCOS.

References

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