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Mini Review

Diagnostic Accuracy of Ultrasound Criteria in Polycystic Ovarian Disease

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ABSTRACT

Polycystic Ovarian Disease (PCOS) is a common endocrine disorder affecting reproductive-aged women and is characterized by ovulatory dysfunction, hyperandrogenism, and polycystic ovarian morphology. Transvaginal ultrasound (TVUS) is a cornerstone in the diagnostic evaluation of PCOS, providing direct visualization of ovarian morphology and follicle distribution. Over the past decade, significant refinement in ultrasound criteria, including follicle count, ovarian volume, and stromal metrics, has enhanced diagnostic performance. However, variability in ultrasound equipment, operator expertise, and patient characteristics continue to influence accuracy. This mini-review synthesizes evidence on the diagnostic accuracy of ultrasound criteria in PCOS, including sensitivity, specificity, and comparative analyses with clinical and biochemical parameters. We highlight strengths, limitations, and future directions in ultrasound-based diagnosis, emphasizing evidence-based application in clinical practice.

Keywords: Polycystic Ovarian Disease; Ultrasound Diagnosis; Follicle Number per Ovary; Ovarian Volume; Diagnostic Accuracy

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INTRODUCTION

Polycystic Ovarian Disease, commonly known as Polycystic Ovary Syndrome (PCOS), is one of the most common hormonal disorders affecting women of reproductive age. It is estimated to affect nearly one in ten women worldwide, although the true prevalence may be even higher due to underdiagnosis and variation in diagnostic criteria. [1,2] PCOS is not a single disease but a spectrum of disorders that can present differently from one woman to another. Some women experience irregular menstrual cycles or difficulty in conceiving, while others struggle with acne, excessive hair growth, weight gain, or metabolic problems such as insulin resistance and type 2 diabetes. [3,4] Because of this wide range of symptoms, diagnosing PCOS remains a clinical challenge. To bring uniformity to diagnosis, international expert groups have proposed standardized criteria. Among these, the Rotterdam criteria are the most widely used and accepted. According to these criteria, a diagnosis of PCOS can be made when any two of the following three features are present: ovulatory dysfunction, clinical or biochemical signs of excess androgens, and polycystic ovarian morphology on ultrasound. [5] This framework highlights the important role of imaging, particularly ultrasound, in the diagnostic pathway of PCOS. Ultrasound has become an essential tool in the evaluation of women suspected of having PCOS because it allows direct visualization of the ovaries. Unlike blood tests or clinical examination, ultrasound provides real-time information about ovarian size, follicle number, and internal structure. The typical ultrasound appearance of a polycystic ovary includes multiple small follicles arranged

around the periphery of the ovary, often described as a "string of pearls," along with an increased ovarian volume. [6] These features reflect the underlying hormonal imbalance in PCOS, where follicle development is arrested, leading to accumulation of immature follicles. Despite its widespread use, the interpretation of ultrasound findings in PCOS is not always simple. One of the main challenges is that polycystic ovarian morphology is not exclusive to PCOS. Many healthy women, particularly adolescents and young adults, may show ovaries with multiple follicles without having any symptoms of PCOS. [7] Similarly, women using hormonal contraception or those in different phases of the menstrual cycle may exhibit changes in ovarian appearance that can mimic polycystic morphology. [8] On the other hand, some women with clear clinical signs of PCOS may have normal-looking ovaries on ultrasound, especially as ovarian morphology can change with age. [9] This overlap between normal and pathological findings raises concerns about the diagnostic accuracy of ultrasound criteria.

Another important factor influencing ultrasound accuracy is technological advancement. Early diagnostic criteria were developed using ultrasound machines with lower resolution. Modern high-frequency transvaginal probes can detect a much larger number of small follicles, leading to higher follicle counts even in women without PCOS. [10] As a result, the original cut-off of 12 follicles per ovary is now considered outdated, and recent guidelines suggest higher thresholds, such as 20 or more follicles per ovary, when using high-resolution equipment. [11] While these updates aim to improve specificity, they also highlight the evolving nature of ultrasound-based diagnosis. Operator experience and scanning technique further affect diagnostic reliability. Accurate follicle counting requires proper image acquisition, optimal gain settings, and careful scanning of the entire ovary. Variations in technique between sonographers and radiologists can lead to inconsistent measurements, reducing reproducibility across centers. [12] Additionally, factors such as obesity, pelvic anatomy, and patient discomfort can limit image quality and influence diagnostic confidence. Given these challenges, it is important to critically evaluate how well ultrasound criteria perform in diagnosing PCOS. Diagnostic accuracy is commonly assessed using measures such as sensitivity, specificity, and predictive values. High sensitivity ensures that most women with PCOS are correctly identified, while high specificity reduces the risk of falsely labeling healthy women as having the condition. Understanding the strengths and limitations of individual ultrasound parameters, such as follicle number, ovarian volume, and stromal characteristics, is essential for appropriate clinical use [13-15]

AIM AND OBJECTIVES OF THE REVIEW

Aim: The primary aim of this review is to evaluate the diagnostic accuracy of ultrasound criteria used in the identification of Polycystic Ovarian Disease (PCOS) and to assess the reliability of various sonographic parameters in distinguishing PCOS from normal ovarian morphology.

Objectives

1. To review and summarize the commonly used ultrasound criteria for diagnosing PCOS, including follicle number per ovary, ovarian volume, and stromal characteristics.
2. To assess the diagnostic performance of individual ultrasound parameters by analyzing reported sensitivity, specificity, and predictive values from published studies.
3. To compare the accuracy of traditional ultrasound criteria with updated thresholds recommended in recent international guidelines.
4. To examine the influence of technological advances, such as high-resolution transvaginal ultrasound and three-dimensional imaging, on the diagnostic reliability of PCOS.
5. To discuss the limitations and challenges associated with ultrasound-based diagnosis, including operator variability, physiological variations, and overlap with normal ovarian morphology.

METHODS AND METHODOLOGY

This mini-review was designed to systematically evaluate the diagnostic accuracy of ultrasound criteria used in Polycystic Ovarian Disease (PCOS), with specific focus on follicle number, ovarian volume, stromal features, and the impact of technological advances. A narrative mini-review methodology was adopted, integrating evidence from observational studies, diagnostic accuracy studies, systematic reviews, and international consensus guidelines. This approach was chosen to allow a comprehensive yet clinically relevant synthesis of available evidence related to ultrasound-based diagnosis of PCOS.

Literature Search Strategy: A structured literature search was conducted across major biomedical databases including PubMed, Scopus, Web of Science, and Google Scholar. The search covered articles published from January 2000 to December 2024, reflecting the period during which ultrasound criteria for PCOS evolved significantly. The following keywords and Medical Subject Headings (MeSH) terms were used in various combinations:

- *Polycystic Ovary Syndrome*
- *Polycystic Ovarian Disease*
- *Ultrasound diagnosis*

- *Polycystic ovarian morphology*
- *Follicle number per ovary*
- *Ovarian volume*
- *Stromal echogenicity*
- *Diagnostic accuracy*
- *Sensitivity and specificity*
- *Transvaginal ultrasound*
- *Three-dimensional ultrasound*

Inclusion Criteria: Articles were included in the final review if they met the following criteria:

- Original research articles, systematic reviews, or consensus guidelines evaluating ultrasound criteria for PCOS diagnosis.
- Studies involving reproductive-aged women (adolescents included only if clearly defined).
- Articles reporting at least one diagnostic accuracy parameter such as sensitivity, specificity, predictive values, or diagnostic odds ratio.
- Studies comparing ultrasound findings with clinical or biochemical diagnostic standards, including Rotterdam or Androgen Excess Society criteria.
- Articles published in English.

Exclusion Criteria: The following studies were excluded:

- Case reports, editorials, letters to the editor, and conference abstracts.
- Studies focusing exclusively on treatment outcomes rather than diagnostic evaluation.
- Articles involving animal models.
- Studies lacking clear ultrasound methodology or diagnostic outcome measures.
- Duplicate publications or overlapping datasets.

Study Selection Process: The initial search yielded a large pool of articles. Titles and abstracts were screened for relevance to the review objectives. Full-text articles were then assessed for eligibility based on inclusion and exclusion criteria. From this process, 30 articles were selected for the final review. These studies collectively represented diverse geographic regions, ultrasound technologies, and patient populations, enhancing the generalizability of findings.

Data Extraction: From each selected article, the following data were extracted:

- Study design and sample size
- Ultrasound modality used (2D, 3D, Doppler)
- Diagnostic criteria applied for PCOS
- Ultrasound parameters assessed (follicle count, ovarian volume, stromal features)
- Cut-off values used
- Reported diagnostic accuracy metrics

Data Synthesis: A qualitative synthesis approach was used. Findings were grouped according to ultrasound parameters, allowing comparison of diagnostic performance across studies. Special emphasis was placed on evaluating changes in diagnostic accuracy related to updated follicle count thresholds and advances in ultrasound technology. Methodological heterogeneity among studies was acknowledged and discussed rather than statistically pooled, in keeping with the scope of a mini-review.

RESULTS

A total of 30 peer-reviewed articles were included in the final analysis of this review. These studies comprised diagnostic accuracy studies, observational cohort studies, systematic reviews, and international consensus guidelines. Collectively, they evaluated the performance of ultrasound criteria in diagnosing Polycystic Ovarian Disease (PCOS) across diverse populations, age groups, and ultrasound technologies. Across the reviewed literature, ultrasound was consistently shown to be a valuable diagnostic tool for identifying polycystic ovarian morphology. However, its diagnostic accuracy varied depending on the specific ultrasound parameter used, the cut-off values applied, and the imaging technology employed. Most studies emphasized that ultrasound performed best when used as part of a combined diagnostic approach rather than as a standalone test.

Table: Diagnostic Accuracy of Ultrasound Criteria for Polycystic Ovarian Disease

Ultrasound Parameter	Common Cut-off Value	Sensitivity (%)	Specificity (%)	Key Observations
Follicle Number per Ovary (FNPO)	≥20 follicles (2–9 mm)	80–90	88–95	Most accurate ultrasound criterion; performance improves with high-resolution transvaginal probes
Follicle Number per Ovary (Older Criteria)	≥12 follicles	85–95	60–75	High sensitivity but poor specificity; risk of overdiagnosis with modern ultrasound
Ovarian Volume	>10 mL	65–80	70–85	Useful supportive marker; limited accuracy when used alone
Ovarian Volume (Higher Threshold)	>12 mL	55–70	85–90	Improves specificity but reduces sensitivity
Stromal Echogenicity / Stromal Area Ratio	>0.34 (ratio-based)	75–85	70–80	Reflects androgen excess; lacks

				standardized measurement
Combined Criteria (FNPO + Volume)	≥20 follicles + >10 mL	70–80	90–95	Higher diagnostic confidence when parameters are combined
3D Ultrasound Follicle Count	≥20 follicles	85–95	90–96	More precise follicle assessment; limited availability
Doppler Stromal Vascularity Indices	Variable cut-offs	70–85	65–80	Increased flow in PCOS; not recommended for routine diagnosis

Follicle Number Per Ovary (FNPO): Follicle number per ovary emerged as the most reliable and accurate ultrasound parameter for diagnosing PCOS. Studies using modern high-resolution transvaginal ultrasound probes reported significantly higher diagnostic accuracy compared to older equipment. An FNPO threshold of ≥20 follicles per ovary demonstrated high sensitivity (80–90%) and specificity (88–95%) in most studies. Several articles showed that increasing the follicle count threshold improved specificity and reduced false-positive diagnoses, particularly in young and asymptomatic women. FNPO also showed a strong correlation with biochemical hyperandrogenism and anti-Müllerian hormone (AMH) levels, reinforcing its biological relevance. In comparison, the older threshold of ≥12 follicles were associated with over-diagnosis, especially when high-frequency probes were used.

Ovarian Volume: Ovarian volume was found to be a moderately accurate but less specific diagnostic parameter. Most studies used a cut-off value of >10 mL, which showed sensitivity ranging from 65–80% and specificity between 70–85%. While enlarged ovarian volume was commonly observed in women with PCOS, it was also present in some healthy women, reducing its diagnostic reliability when used alone. Several studies noted that ovarian volume declined with increasing age, even in women with PCOS, leading to reduced sensitivity in older patients. When ovarian volume was combined with follicle count, diagnostic specificity improved significantly, suggesting its value as a supportive rather than primary criterion.

Stromal Features: Assessment of ovarian stromal echogenicity and stromal area showed variable diagnostic performance across studies. Increased stromal echogenicity and stromal-to-ovarian area ratios were more frequently observed in women with PCOS and were associated with androgen excess. Reported sensitivity ranged from 75–85%, while specificity was generally lower (70–80%). Despite these findings, stromal measurements lacked standardized assessment methods, and interobserver variability was commonly reported. As a result, most studies concluded that stromal features should be considered adjunctive markers rather than core diagnostic criteria.

Advanced Ultrasound Techniques: Studies evaluating three-dimensional (3D) ultrasound demonstrated improved accuracy in follicle counting and ovarian volume estimation compared to conventional two-dimensional imaging. 3D-derived follicle counts showed sensitivity and specificity exceeding 90% in some studies. Doppler-based assessment of stromal blood flow also revealed increased vascularity in PCOS; however, diagnostic thresholds varied widely, limiting routine clinical application.

Impact of Technology and Operator Experience: The results highlighted a strong influence of ultrasound resolution and operator expertise on diagnostic outcomes. High-frequency probes and experienced operators consistently produced more accurate and reproducible results. Variability in scanning technique and image interpretation remained a major source of inconsistency across studies.

Summary of Key Findings: Overall, the review found that follicle number per ovary is the most accurate ultrasound criterion for PCOS diagnosis, particularly when updated thresholds are applied. Ovarian volume and stromal features improve diagnostic confidence when used in combination but are insufficient on their own. Advanced ultrasound techniques enhance accuracy but require further standardization. These findings support the use of ultrasound as a powerful diagnostic tool when interpreted alongside clinical and biochemical features.

DISCUSSION

This review examined the diagnostic accuracy of ultrasound criteria used in Polycystic Ovarian Disease (PCOS), focusing on follicle number per ovary, ovarian volume, stromal characteristics, and the influence of advancing ultrasound technology. Overall, the findings reaffirm that ultrasound is a valuable diagnostic tool, but its accuracy depends strongly on how specific parameters are applied and interpreted in clinical practice [16,17] Among all ultrasound parameters, follicle number per ovary (FNPO) consistently demonstrated the highest diagnostic accuracy. Several studies have shown that FNPO correlates closely with the underlying pathophysiology of PCOS, particularly follicular arrest and excess androgen exposure. [18] The traditional diagnostic threshold of ≥12 follicles per ovary was developed using older ultrasound systems with limited resolution. With modern high-frequency transvaginal probes, this cut-off has been shown to lack specificity and frequently identifies polycystic ovarian morphology in women without PCOS (19). Recent evidence supports increasing the threshold to ≥20 follicles per ovary, which

significantly improves specificity while maintaining acceptable sensitivity. [20,21] This adjustment reduces the risk of overdiagnosis, especially in younger women and those without clinical symptoms of PCOS.

In comparison, ovarian volume was found to have moderate diagnostic value. Although increased ovarian volume reflects follicular accumulation and stromal expansion, it is influenced by several physiological and demographic factors, including age, body mass index, and menstrual cycle phase. [22] Multiple studies reported that ovarian volume tends to decrease with age, even in women with established PCOS, which reduces its sensitivity in older reproductive-age groups. [23] Furthermore, enlarged ovarian volume is not unique to PCOS and may be seen in other benign ovarian conditions. These findings suggest that ovarian volume should be regarded as a supportive criterion, enhancing diagnostic confidence when used alongside follicle count rather than as a standalone parameter. [24] The assessment of stromal features, such as increased stromal echogenicity and stromal-to-ovarian area ratio, has generated interest due to their association with androgen excess. Several studies included in this review demonstrated that stromal hypertrophy is more prominent in women with PCOS and may reflect increased thecal cell activity. [25] However, the diagnostic accuracy of stromal measurements varied widely across studies. The absence of standardized measurement techniques, combined with subjective interpretation and interobserver variability, limits their routine clinical use. [26] Consequently, stromal features are best considered adjunctive markers rather than core diagnostic criteria.

Technological advances have played a critical role in improving the diagnostic performance of ultrasound. Three-dimensional (3D) ultrasound allows more accurate follicle counting and ovarian volume estimation compared to two-dimensional imaging, leading to improved reproducibility. [27] Doppler ultrasound studies have also demonstrated increased stromal blood flow in women with PCOS, reflecting heightened metabolic and hormonal activity within the ovary [28]. However, wide variation in Doppler indices and the lack of validated cut-off values restrict their application in everyday clinical practice. At present, these advanced techniques are more useful in research settings or complex diagnostic cases rather than routine screening [29]. An important observation from this review is that ultrasound findings should not be interpreted in isolation. Polycystic ovarian morphology is relatively common in adolescents and young women and may represent a normal physiological variant rather than disease [30] Conversely, some women with clear clinical and biochemical features of PCOS may not exhibit classical ultrasound findings, particularly with increasing age or prior hormonal treatment. This overlap underscores the importance of integrating ultrasound results with clinical history, physical examination, and biochemical evaluation to achieve accurate diagnosis.

Operator expertise and scanning technique were also shown to significantly influence diagnostic outcomes. Accurate follicle counting requires careful scanning of the entire ovary, appropriate machine settings, and familiarity with updated diagnostic thresholds [16,21] Variations in training and equipment quality remain major contributors to interobserver variability, highlighting the need for standardized protocols and continuous professional training. Taken together, the evidence supports current international ecommendations that prioritize follicle number per ovary as the most reliable ultrasound marker for PCOS, with ovarian volume and stromal features providing additional supportive information [20,24] Importantly, applying updated criteria tailored to modern ultrasound technology helps reduce misdiagnosis and unnecessary labeling of healthy women with a chronic endocrine condition.

CONCLUSION

Ultrasound remains a fundamental component in the diagnostic evaluation of Polycystic Ovarian Disease (PCOS), offering direct visualization of ovarian morphology and providing valuable insight into the underlying pathophysiology of the condition. This review highlights that among all sonographic parameters, follicle number per ovary (FNPO) demonstrates the highest diagnostic accuracy, particularly when updated thresholds compatible with modern high-resolution ultrasound technology are applied. The revised cut-off of ≥20 follicles per ovary significantly improves specificity and reduces the risk of overdiagnosis compared with older criteria. Ovarian volume and stromal characteristics contribute supportive diagnostic information but show moderate accuracy and considerable variability. These parameters should therefore be interpreted cautiously and used in combination with follicle count rather than as independent diagnostic markers. Advanced techniques such as three-dimensional ultrasound and Doppler imaging enhance morphological assessment; however, their routine clinical use remains limited by lack of standardization and accessibility. Importantly, this review reinforces that ultrasound alone is insufficient for definitive diagnosis of PCOS. Polycystic ovarian morphology may be present in healthy women, while some patients with clear clinical and biochemical features of PCOS may not exhibit classical ultrasound findings. Consequently, optimal diagnostic accuracy is

achieved through an integrated approach that combines ultrasound imaging with clinical evaluation and hormonal assessment.

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