



Application of three-dimensional ultrasound in the assessment of PCOS

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Introduction

Polycystic Ovary Syndrome (PCOS) is a complicated and heterogenous endocrine disorder affecting more than 10% of women worldwide, with clinical manifestations such as hyperandrogenemia, acne, hirsutism, obesity, infertility etc. Diagnosis of PCOS is based on the Rotterdam criteria, which require ≥ 2 of the following: chronic anovulation, hyperandrogenism and PCO ultrasonographic morphology (≥ 12 follicles, diameter 2-9mm, ovarian volume ≥ 10 cm³ at least in one ovary). However, there are limitations with the current methodology, such as measurement subjectivity, lack of adequate and objective stroma perfusion assessment etc, with the advent of 3D-US and 3D Doppler being a promising solution to these problems, offering many diagnostic parameters to facilitate PCOS assessment.

3D-US parameters

Ovarian Volume (OV)

OV can be measured by 3D-US, similarly to 2D-US, however the former has been proven more reliable as 2D-US measurements require geometrical formulas and thus certain mathematical assumptions to calculate OV [1].

Follicle Count (FC)

FC by 3D-US can be more easily performed compared to 2D-US, as inversion mode can be applied and seamlessly differentiate between liquid-filled cystic components and the surrounding stroma. Additionally, automated software offers a diagnostic alternative (**Figure 1 and 2**), that despite not unanimously proven more accurate, is certainly less time-consuming. Studies propose higher diagnostic thresholds in 3D-US examination with one concluding that 20 was optimal (AUC=0.987) [2].

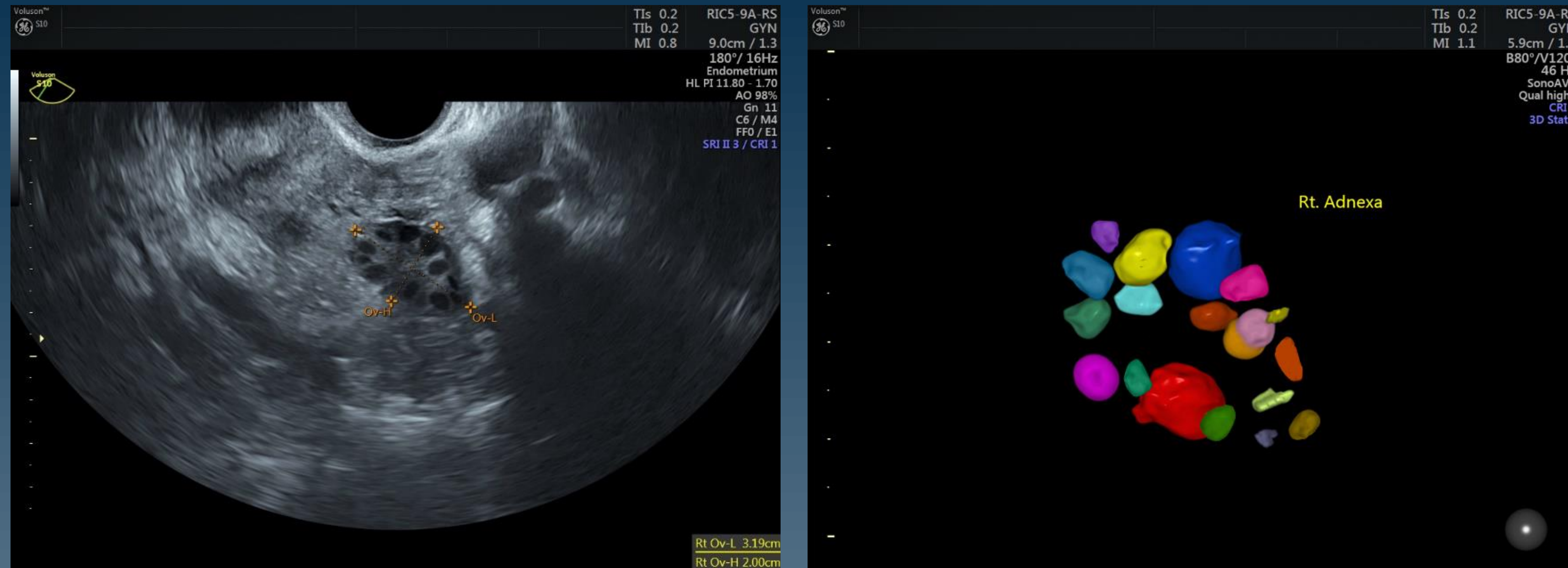
Ovarian Stromal Volume (OSV)

OSV can be measured by 3D-US either manually via the activation of inversion mode or automatically via thresholding, with the latter being less time-consuming and more importantly with greater objectivity than 2D, thus rendering it more reliable in clinical practice compared to OSV estimation based on 2D-US.

Ovarian stromal volume to total ovarian volume ratio (OSV/OV)

OSV/OV is a proposed diagnostic parameter that has been shown to be an accurate predictor (AUC=0.915) of PCOS with OSV/OV>0.84 being the optimal diagnostic cutoff when measured using 3D-US [3].

Overall, 3D-US parameters were almost always significantly increased in PCOS patients compared to controls (**Table 1**) with highly reproducible measurements.



Study	Day	OV	FC	VI	FI	VFI	MG
Jarvela 2002 [4]	8-16	↑	N/A	ND	ND	ND	ND
Pan 2002 [5]	2-3	↑	N/A	↑	↑	↑	N/A
Lam 2007 [6]	3-5	↑	↑	↑	ND	↑	ND
Lam 2009 [7]	3-5	↑	↑	ND	ND	ND	ND
Mala 2009 [8]	2-5	↑	↑	↑	ND	↑	N/A
Battaglia 2012 [3]	3-5	↑	↑	↑	↑	↑	↑
Nylander 2016 [1]	N/A	↑	↑	ND	ND	ND	N/A
Garg 2018 [9]	2	↑	↑	↑	↑	↑	N/A

Figures 1 and 2: Application of the 3D-US automatic follicle detection and count modality.

Table 1: Several parameters of the PCOS group and their difference in comparison to control group measurements (↑: significant increase in PCOS group, ↓: significant decrease in PCOS group, ND: no significant difference between the two groups, N/A: not assessed)

3D Doppler parameters

Vascularization Index (VI)

VI is the proportion of the scanned volume that emits flow signal compared to the rest of the organ, thus reflects blood vessel density in the scanned volume and could help detect alterations in ovarian vasculature.

Flow Index (FI)

FI is an average of the signal intensity of the blood flow detected in the scanned volume, thus providing perfusion information.

Vascularization-Flow Index (VFI)

VFI is the combination of the information provided by the other two indices, reflecting both changes in vasculature, as well as in perfusion

Mean Grayness (MG)

Mean grayness assesses tissue echogeneity, similarly to 2D-US, however more objectively as a numerical value based on histogram analysis is provided and not a subjective evaluation by the examiner.

Research is still inconclusive on these indices' applicability in PCOS diagnosis, however VI and VFI appear to be the most reliable, as they are significantly elevated in PCOS patients in most studies, compared to the control group (**Table 1**).

Discussion - Conclusions

PCOS is a common endocrine disorder affecting many women worldwide, the diagnosis of which could be facilitated by the newer 3D ultrasonographic modalities. These offer quick and tolerable examination and provide vastly more information compared to 2D real time assessment. The stored data can be evaluated and shared among examiners and the calculated parameters more objectively represent the underlying pathology. However, data on actual diagnostic performance in comparison to the currently available technology is still lacking and inconclusive, with some studies proposing that 3D modalities are superior, whereas others showing no statistically significant difference between the two, with generally accepted diagnostic thresholds lacking as well.

Despite some limitations, mainly increased cost, need for additional training and the production of artifacts, it is made apparent that 3D ultrasound techniques are promising, and more research is required to further assess their accuracy and applicability, as well as to establish cut-off and potentially lead to the inclusion of more objective diagnostic criteria in the guidelines if sufficient evidence is found.

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