The role of three-dimensional ultrasonography in polycystic ovary syndrome

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The 2003 Rotterdam diagnostic criteria for polycystic ovary syndrome (PCOS) support the objective role of ultrasound in defining the appearance of the PCO, but there are significant limitations of these new guidelines from an ultrasound perspective that must be considered. Three-dimensional (3D) ultrasound provides a new method for the objective quantitative assessment of follicle count, ovarian volume, stromal volume and blood flow within the ovary as a whole. Since the introduction of 3D ultrasonography, there have been increasing publications on PCOS, each addressing different areas and reporting different results. This review critically examines these studies in an attempt to clarify the evidence to date and thereby establish the current role of 3D ultrasonography in PCOS.

Key words: polycystic ovary syndrome/review/three-dimensional/Rotterdam/ultrasound

Background

Polycystic ovary syndrome (PCOS) is a complex heterogeneous endocrine disorder. It is a syndrome and, therefore, no single diagnostic criterion is sufficient for clinical diagnosis. During the first international conference on PCOS at the National Institutes of Health (NIH) in the USA in 1990, three key features of PCOS were generally agreed on: chronic anovulation, hyperandrogenism (clinical or laboratory evidence) and the absence of other endocrine disorders (e.g. congenital adrenal hyperplasia, hyperprolactinaemia or thyroid abnormalities) (Zawadzki and Dunaif, 1992). There are, however, criticisms of this definition. The presence of PCOs on ultrasonography was not included in the definition despite this feature being mandatory in many centres (Balen, 1999), and the associated clinical features such as menstrual disturbance, obesity and hyperandrogenism manifesting as hirsutism or acne vary considerably among women (Polson et al., 1988; Michelmore et al., 1999). In 2003, a joint meeting of the European Society of Human Reproduction and Embryology (ESHRE) and the American Society of Reproductive Medicine (ASRM) was held in Rotterdam. At this PCOS Consensus Workshop, new guidelines for the diagnosis of PCOS were suggested (The Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group, 2004). A diagnosis of PCOS was to be made when at least two of three elements were present: chronic anovulation, clinical or biochemical hyperandrogenism and clearly defined PCOs on ultrasound. These new diagnostic criteria are more flexible and permit us to make the diagnosis in patients who were previously excluded by the 1990 NIH criteria, such as anovulatory normoandrogenic or ovulatory hyperandrogenic women with PCOs on ultrasound scan.

For this revised classification to work, strict criteria detailing the ultrasound features of PCOs are required. These have been defined and include either 12 or more follicles measuring 2–9 mm in diameter or an increased ovarian volume >10 cm3 (Balen et al., 2003). It is essential that the ultrasound scan is performed at a time of ovarian quiescence, such as during the early follicular phase of the menstrual cycle, and repeated if there is a follicle >10 mm in diameter. Contrary to the original ultrasound features described by Adams et al. (1985), the distribution of follicles and a description of the stroma are not included in the revised Rotterdam criteria, and the presence of a single PCO is sufficient to make the diagnosis. The 2003 Rotterdam guidelines represent an important first step in defining uniform diagnostic criteria for PCOS and, therefore, a method of clinical standardization that has important connotations for clinical management and research activities.

There are important considerations and limitations of the new ultrasound guidelines, however, that must be addressed. Calculation of ovarian volume is based on geometric assumptions from two-dimensional (2D) measurements (Gijla et al., 1999). A simplified formula for a prolate ellipsoid (0.5 × length × width × thickness) is used, which assumes a degree of regularity of the ovary that is presumed to be ovoid; yet, PCOS are generally less regular (DePriest et al., 1993). Apart from an increased number of antral follicles and a larger ovarian volume, women with PCOS have also been shown to have an increased ovarian stromal volume and blood flow (Kyei-Mensah et al., 1998; Pan et al., 2002). These are important parameters that may be relevant to our understanding of the pathogenesis and clinical presentation of PCOS and as prospective predictors...
of the response to the various treatments used in patients with PCOS (Aleem and Predanic, 1996; Agrawal et al., 1998). However, neither stromal description nor Doppler ultrasound measurements are mentioned in the new guidelines for the ultrasonographic diagnosis of PCOS. This undoubtedly reflects the observer subjectivity in describing the stromal echogenicity and the degree of technical difficulty in performing and making valid and reliable measurements with Doppler ultrasound (Dickey, 1997). Three-dimensional (3D) ultrasound is a relatively new imaging modality that has the potential to address these points and improve the sensitivity and specificity of ultrasound in the diagnosis of PCOS (Raine-Fenning et al., 2003b, 2004a,b). 3D ultrasound not only permits improved spatial awareness and volumetric and quantitative vascular assessment but also provides a more objective tool to examine stromal echogenicity through the assessment of the mean grey-ness (MG) of the ovary (Jarvela et al., 2002). The mean echogenicity of the grey voxels represents the mean tissue density or echogenicity in the region of interest and provides a new measure that can be objectively quantified.

### 3D ultrasonography

#### Volumetric measurements

Volume estimation from 3D ultrasonography also involves a degree of geometric assumption as data are reconstructed on the basis of their most probable position within a Cartesian grid system, but it utilizes much more information (Raine-Fenning et al., 2003a). Various display modalities allow the observer to correct for any surface irregularities (Merz, 1999) and so permit more accurate and reproducible ovarian volume measurements than are possible with 2D ultrasonography (Raine-Fenning et al., 2003a). There are two basic methods employed to calculate volume from a 3D data set: the conventional ‘full planar’ method and the more recently introduced rotational method possible through the virtual organ computer-aided analysis (VOCAL)-imaging program. Volume calculations have proven to be highly reliable and valid both in vitro and in vivo with either method, although the newer rotational method appears statistically superior (Riccabona et al., 1996a,b; Raine-Fenning et al., 2002, 2003c).

#### Vascular flow assessment

In conventional 2D ultrasonography, blood flow in the tissue of interest can be assessed subjectively by the application of colour or power Doppler to a single plane to examine the flow pattern or objectively by measuring flow velocity and the resistance to flow through the application of pulsed-wave Doppler and subsequent analysis of the waveforms derived from a single vessel. Both of these techniques have significant limitations because they only examine parts of an organ blood flow. In contrast, the VOCAL-imaging program in 3D ultrasonography facilitates the assessment of total blood flow through the quantification of the power Doppler signal within the defined volume of interest, allowing the objective assessment of total vascular flow within an organ or a specified volume of tissue (Raine-Fenning et al., 2003b, 2004a). Furthermore, regional blood flow both within and around the originally defined volume can be examined with shell imaging (Raine-Fenning et al., 2003b, 2004a). Power Doppler data are displayed about their mean as a histogram which allows the derivation of three vascular indices through various computer algorithms that assess the number and intensity of the colour voxels within the defined volume (Figure 1). The vascularization index (VI) represents the ratio of power Doppler information within the total data set relative to both colour and grey information, providing an indication of the number and/or size of vessels within the volume of interest and therefore the degree of vascularity. The mean power Doppler signal intensity is reported as the flow index (FI), and because the intensity of the signal, or its ‘hue’, is dependent on the number of erythrocytes within a given volume at any time, this value is considered to reflect volume flow rate. Finally, the vacularization flow index (VFI) is calculated by multiplying the other two indices and therefore provides a single value for both vascularity and volume flow and is suggested as being representative of tissue perfusion therefore. Although the exact relationship of these indices to true vascularity and blood flow remains unclear, they have been shown to be reliable and reproducible (Jarvela et al., 2003; Raine-Fenning et al., 2003b, 2004a) and to correlate with vessel number and volume flow rate in vitro (Raine-Fenning et al., 2004b). Accepting the inherent mathematical and biophysical limitations associated with the derivation of these indices, the values generated represent the first method available that permits the objective assessment of blood flow within an organ through data obtained with ultrasound.

**Figure 1.** Power Doppler histogram allowing the derivation of three vascular indices.
Role of 3D ultrasonography in PCOS

3D ultrasound features of PCO

3D ultrasonography permits the measurement of stromal volume through the calculation and subtraction of total follicular volume from total ovarian volume. Using this technique, Kyei-Mensah et al. (1998) showed that both total ovarian volume and stromal volume during the early follicular phase were significantly higher in 26 women with PCOS as well as in 24 women with regular menstrual cycles but PCO on ultrasound scan, compared with 50 infertile women with regular menstrual cycles but normal ovarian morphology (16.7 ± 23.1 and 15.5 ± 20.9 ml, 15.0 ± 18.9 and 13.4 ± 18.6 ml versus 9.6 ± 20.4 and 8.6 ± 20.0 ml respectively, all P-values <0.05). They defined PCO as ≥10–15 cysts of 2–10 mm diameter arranged around a dense, echogenic stroma or scattered through an increased amount of stroma and PCOS as those complained of menstrual irregularity and had clinical features of hyperandrogenism together with PCO on transvaginal ultrasound. In our opinion, this study has provided limited information because their findings were inevitable considering the design of the study and the use of self-selected groups.

Dolz et al. (1999) used 3D colour Doppler ‘angiography’ to examine 65 women with PCOS and 25 non-obese healthy women with regular menstrual cycles. For inclusion in the PCOS group, women were required to have at least one abnormal clinical feature (oligomenorrhoea or clinical evidence of hyperandrogenism such as hirsutism) and at least one abnormal laboratory value (elevated levels of androstenedione or testosterone or a LH/FSH ratio greater than two). Despite acquiring 3D ultrasound data, the investigators did not utilize the volumetric information and instead made calculations based on 2D formulae. Ovarian size was based on 2D, not 3D, data, and the ovarian area was calculated rather than the volume using 2D longitudinal measurements of the anteroposterior and transverse diameters and the ellipse formula. Stromal thickness was measured arbitrarily from the hyper-refrangent intra-ovarian zone, and stromal volume was not reported. Moreover, ovarian vascularity was assessed by the impedance indices of the intra-ovarian stromal arteries when a vascular map was present. They demonstrated larger ovaries (7.78 ± 2.06 versus 4.05 ± 1.13 cm³, P < 0.001) and thicker stroma (9.73 ± 0.20 versus <5.00 mm, P < 0.001). They reported an increased stromal vascularity with decreased impedance based on the observations that intra-ovarian vascular flow patterns were detectable in 92.3% of the PCOS patients, with pulsatility and resistance indices being 0.96 ± 0.27 and 0.55 ± 0.08, respectively, but the flow was not detectable or measurable in the controls (P < 0.001). This observation was subjective, being based on the assessment of a single intra-ovarian stromal artery arbitrarily selected, and limited by the fact that flow was not measurable in the control group.

Jarvela et al. (2002) used the VOCAL-imaging program to compare 14 women with PCOs, defined as eight subcapsular follicles of 2–8 mm in diameter or more in one 2D plane, to 28 women with normal ovaries during the late follicular phase of the menstrual cycle immediately before IVF treatment. The PCO group had larger ovaries (right ovary: 14.2 ± 3.3 versus 8.7 ± 4.5 cm³, P < 0.001; left ovary: 12.1 ± 3.6 versus 8.2 ± 3.0 cm³, P < 0.001), but there were no differences in the ovarian blood flow as measured by 3D Doppler vascular indices (VI, FI and VFI). Similar results were found after excluding the 27 (64.3%) patients with dominant follicles. In an attempt to specifically examine the blood flow within the ovarian stroma, the ovary was subdivided into cortex and stroma by the application of a 6-mm shell just beneath the ovarian capsule regardless of the overall size of the ovary. This arbitrary division also showed no differences in the intra-ovarian differential blood flow between the groups. In addition, they were the only group who had been examined for the stromal echogenicity as measured by MG of the ovary, and they showed no differences between groups. In our opinion, the apparent lack of difference in stromal vascularity or echogenicity of the PCO compared with the control group may reflect the power of the study. The sample size was small, and the classification of the PCO and control groups was unclear. Within the study population, the ‘normal’ group was composed of infertile women with various diseases other than PCO, and the ‘PCO’ group did not necessarily have clinical or endocrinological manifestations of PCOS. Although PCO alone may represent a milder end of PCOS spectrum (Ng et al., 2006), this study group did not fulfill the diagnostic criteria of PCOS based on 2003 Rotterdam guidelines or 1990 NIH consensus, and such vague classifications will have undoubtedly reduced the power of the study to detect any real differences between the groups. Moreover, as outlined by Balen et al. (2003), the ovary should be examined at a time of ovarian quiescence, such as the early follicular phase, rather than during the late follicular phase when a developing follicle of >10 mm in diameter is likely.

Pan et al. (2002) used 3D ultrasound to investigate 25 Chinese women with PCOs on ultrasound scan and clinical features of PCOS and 54 women with tubal or male factor infertility but with regular ovulatory menstrual cycles and normal ovaries on ultrasound scan. 3D ultrasonography was performed on day 2 or 3 of the menstrual cycle before IVF treatment. They did not examine the stromal volume, but they did demonstrate a significantly larger ovarian volume (12.94 ± 4.27 versus 6.10 ± 3.41 ml, P < 0.05) and a greater ovarian blood flow as indicated by higher VI (3.99 ± 2.38 versus 1.44 ± 1.20%, P < 0.05), FI (50.26 ± 3.02 versus 44.44 ± 5.42, P < 0.05) and VFI (2.10 ± 1.32 versus 0.80 ± 0.97, P < 0.05) measurements in the PCOS group. The results needed to be interpreted with caution because the investigators found significant differences in age and BMI between the PCOS and control groups but did not control for these variables when comparing ovarian perfusion as assessed by 3D power Doppler indices. Furthermore, the use of subfertile controls introduces potential bias in that this group of women may also have impaired ovarian blood flow and therefore account for an artificial and false impression of an increased ovarian blood flow in the PCOS group.

Despite using a comparable 3D ultrasound technique, Ng et al. (2005) did not confirm an increased ovarian stromal vascularization in another Chinese population with PCOS. They demonstrated a higher antral follicle count (median 38.5 versus 12.0, P < 0.001) and total ovarian volume (median 21.04 versus
advocated the use of 3D ultrasonography to measure ovarian volume. They retrospectively studied 29 normoandrogenic, ovulatory women with tubal or male factor infertility and 10 PCOS women with chronic anovulation and clinical, or biochemical, hyperandrogenism. The study benefited from the appropriate use of receiver operating characteristic (ROC) curves that were employed to determine whether 3D ultrasound parameters could discriminate between PCOS and control groups with a high degree of sensitivity and specificity. The results still need to be interpreted with caution because of the small sample size that included only 10 subjects with PCOS and therefore lacked adequate power. Using ROC curves, the investigators reclassified the diagnostic threshold for PCO as a mean follicle number per ovary of 20 or more [with the area under curve (AUC) of 98.7%, specificity of 100%, sensitivity of 70%, positive predictive value (PPV) of 100% and negative predictive value (NPV) of 91%] and an ovarian volume of at least 13 cm³ (with AUC of 94.8%, specificity of 100%, sensitivity of 50%, PPV of 100% and NPV of 85%). The specificity was perfect, but the sensitivity was lower than that reported with 2D ultrasonography by Jonard et al. (2003) who discriminated PCOS patients from normal controls using a threshold mean follicle number of 12 or more with a sensitivity of 99% and a specificity of 75%. Allemand et al. counted the antral follicles in the multiplanar view of 3D images recorded on CD-ROM. The proposed improvements could reflect the improved spatial awareness afforded by the multiplanar display, or the time taken, which was not reported but was presumably longer, therefore. In addition, their calculations of ovarian volume were based on 2D measurements using the prolate ellipsoid formula rather than on 3D volumetric data despite the evidence that these are less accurate and reproducible (Raine-Fenning et al., 2003a). In our opinion, the different statistical performances probably result from each factor, with test performance being dependent on both ultrasound parameters and the techniques used to derive them.

A smaller number of studies have used 3D power Doppler angiography, the combination of 3D and power Doppler ultrasound, to examine the degree of vascularity of PCOS as a whole or within their stroma. Many of these studies have limited power because of small sample sizes and open inclusion/exclusion criteria that result in the recruitment of inappropriate controls. In addition, different criteria for the diagnosis of PCOS, variable Doppler settings and inconsistencies in the phase of cycle when the examinations were conducted militate against any worthwhile comparison. Interestingly, in contrast to the reported and commonly accepted observation of an increased blood flow within the PCO (Agrawal et al., 1998; Pan et al., 2002), the study with the best design demonstrated no significant differences in total ovarian 3D power Doppler flow indices from those seen in fertile controls (Ng et al., 2005). Although the reported differences between various studies could relate to significantly different patient characteristics, this controversial area needs to be explored in more detail by specifically designed trials with larger sample sizes, appropriate controls and standardized methodology to allow appropriate future comparisons.
Summary of publications on the three-dimensional (3D) ultrasound features of polycystic ovaries

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Fl. flow index; n, number of patients; P, P-value; PCO, polycystic ovary; PCOS, polycystic ovary syndrome; r, correlation coefficient; US, ultrasound; VFI, vascularity flow index; VI, vascularity index; VOCAL, virtual organ computer-aided analysis.

$^a$Clinical features included menstrual irregularity and clinical hyperandrogenism such as hirsutism.

$^b$Biochemical features included elevated serum testosterone concentration and increased ratio of serum LH to FSH level.

3D ultrasound features of PCO in relation to the biochemical indices

Within the ovarian stroma, thecal cells are the probable source of the hyperandrogenaemia. The subjectivity of stromal echogenicity has hindered attempts to produce meaningful comparative analysis in PCOS. With more accurate and reproducible ovarian volume measurements with 3D ultrasonography, stromal volume can be measured by the calculation and subtraction of total follicular volume from total ovarian volume. Kyei-Mensah et al. (1998) showed that serum androstenedione, testosterone and 17-hydroxy progesterone concentrations were increased in 26 women with clinical evidence of PCOS. Serum androstenedione level is a good marker of ovarian androgen synthesis because it is not protein bound and therefore unaffected by changes in sex hormone-binding globulin (SHBG) levels. The investigators showed that the correlation between ovarian stromal volume and serum androstenedione concentrations during the early follicular phase was fair though statistically significant (correlation coefficient, $r = 0.45$, $P < 0.05$). Stromal volume was not significantly correlated with the other two thecal steroid levels. Using similar methodology, Nardo et al. (2002) also noted no relationship between ovarian stromal volume and serum FSH, LH or testosterone concentrations during the early follicular phase in 23 infertile women with clomiphene-resistant PCOS, and they did not examine the serum androstenedione concentrations. Unfortunately, neither study measured or reported the serum SHBG levels or free androgen index (Kyei-Mensah et al., 1998; Nardo et al., 2002). Also, despite using 3D ultrasonography, they did not examine the stromal echogenicity through the assessment of the MG of the ovary.

3D ultrasound features of PCO in relation to the fertility treatment

The simplest, safest, cheapest and yet most effective treatment for PCOS is weight loss, with the majority of women resuming ovulation when their BMI < 30 kg/m$^2$ (Norman et al., 2002). The most commonly used ovulation-inducing agents are anti-estrogens, with clomiphene citrate being the first-line drug. More recently, insulin sensitizers, such as metformin, have been introduced. For women who remain anovulatory with such simple measures, ovulation induction using gonadotrophins is often employed, and this can help achieve a pregnancy rate of 70% by 12 months. However, such a therapy is not without risk, and approximately 20% will have a multiple pregnancy, and 3% will experience severe ovarian hyperstimulation.
syndrome (OHSS) with its associated morbidity and mortality. Laparoscopic ovarian drilling is as effective as treatment with gonadotrophins but free of the associated risk factors of multiple pregnancy and OHSS. It is cost effective because no ultrasound monitoring is needed. However, the minimal dose of diathermy required is uncertain, and there are concerns that prolonged treatment may be associated with premature ovarian failure. To date, only limited studies have been conducted utilizing 3D ultrasonography to investigate the 3D ultrasound features of PCOS in relation to the various fertility treatments.

Tulandi et al. (1997) studied 34 clomiphene-resistant women with PCOS undergoing laparoscopic ovarian drilling who achieved an ovulation rate of 88% and a pregnancy rate of 70% at a 12-month follow-up. Among them, six women had 3D ultrasound scan performed before the operation, 1 and 3 weeks after the operation to measure the ovarian volume. They observed that the ovarian volume transiently increased from pre-operative 12.2 ± 1.8 to 13.6 ± 1.5 ml 1 week after the operation and then subsequently reduced to 6.9 ± 1.3 ml 3 weeks after the operation, which was significantly smaller than the pre-operative size (P < 0.05). Recently, Wu et al. (2004) have also demonstrated a reduced ovarian volume (10.97 ± 0.86 versus 12.52 ± 0.61, P < 0.01) and a reduced stromal blood flow (VI: 0.29 ± 0.10 versus 1.01 ± 0.37%, P < 0.05; VFI: 0.13 ± 0.05 versus 0.49 ± 0.18, P < 0.05) during the early follicular phase in 40 clomiphene-resistant women with PCOS 3 months after laparoscopic ovarian drilling. However, both groups of investigators have not prospectively examined the predictive values of these changes in ovarian volume and vascularization after laparoscopic ovarian drilling in its clinical responses.

IVF treatment is required in many patients with PCOS. However, the possible defects in follicular angiogenesis in PCO may be associated with compromised oocyte quality (Geva and Jaffe, 2000). Also, patients with PCO carry an increased risk of severe OHSS because of the high response to gonadotrophin stimulation during IVF treatment (Agrawal et al., 1998). Jarvela et al. (2004) compared follicular vascularization in 18 PCOs versus 42 normal ovaries during IVF as measured using 3D power Doppler ultrasonography. They calculated the total vascularized ovarian volume by multiplying the ovarian volume with VI, and the vascularization per follicle was calculated by further division of the total vascularized ovarian volume by the follicle count. However, this sophisticated calculation might not reflect the true average follicular vascularization because a significant portion of ovarian vascularization was within the stroma and not just the peri-follicular region especially within a PCO. The investigators showed that the ovarian vascularization per follicle, after pituitary suppression, was lower in PCO patients (0.02 ± 0.01 versus 0.06 ± 0.08, P < 0.01) and suggested that there were defects in follicular angiogenesis in PCO. The almost absent ‘follicular’ vascularization might simply reflect ovarian suppression after pituitary down-regulation, and the differences between groups might relate to a higher follicle count in PCO and therefore a reduced vascularization per follicle. Oocyte quality or its correlation with peri-follicular vascularization was not reported. Although peri-follicular vascularization did increase after FSH stimulation and hCG administration in both PCO and normal groups, there were no differences between groups. A lower requirement of FSH stimulation was required in the PCO group to achieve the same level of vascularization (2033 ± 610 versus 2777 ± 745 IU, P < 0.001), supporting the increased sensitivity to gonadotrophin stimulation in PCO. This was consistent with the findings of more oocytes retrieved in PCO group (17.9 ± 7.1 versus 9.5 ± 6.0, P < 0.001). Moreover, positive correlations were demonstrated between the number of oocytes retrieved and the vascularized ovarian volume after FSH or hCG stimulation but not after pituitary down-regulation. The study, however, did not report the incidence of OHSS.

Authors’ opinion and future directions
The Rotterdam guidelines represent a credible step towards standardization by defining uniform diagnostic criteria for PCOS and support the objective role of ultrasound in defining the appearance of the PCO (Balen et al., 2003). However, we would argue that the current ultrasound criteria suggested by the Rotterdam consensus are still too open and that the PCO is more complex ultrasonographically. Whilst an enlarged ovary measuring >10 cm² with or without 12 or more follicles will be seen in almost all anovulatory women with PCOS, with or without biochemical or clinical features of hyperandrogenaemia, we believe that the current criteria will fail to identify a group of ovulatory, normoandrogenic women still at risk of complications classically associated with PCOS such as OHSS, failed implantation, miscarriage and hyperinsulinaemia. To identify these women, further information, particularly about the ovarian stroma and the degree of vascularization, is required.

Many obese women with apparent PCOs on ultrasound revert to an entirely normal appearance following a period of weight loss. Whilst weight loss is paramount in the management of polycystic ovarian disease, and indeed in all obese women, we feel that the true PCO will retain certain characteristic features. They maintain a tendency towards an exaggerated response to ovarian stimulation, experience lower fertilization rates and compromised embryo quality after assisted reproduction treatment and ultimately achieve lower live birth rates because of failed implantation, early miscarriage and subsequent pregnancy complications. These women have a truly impaired intra-ovarian environment with associated abnormal folliculogenesis. Therefore, objective quantification of the total ovarian and stromal volume and vascularity is essential to characterize this group of infertile women.

We feel that 3D ultrasound is a more appropriate tool to assess and study the PCO because it facilitates the quantitative measurement of total ovarian and stromal echogenicity, volume and blood flow in a way that has not been possible before. Such parameters may not be available to all clinicians and are unlikely to be practically applicable in a clinical setting, but they are important in the research environment and may contribute to our understanding of this enigmatic disease. The current Rotterdam ultrasound criteria offer a repeatable and achievable way to objectively define the PCO in the clinical setting. They may be too simplistic, however, for use as inclusion and exclusion criteria in the research setting where we would encourage the use of more specific parameters to ensure the recruitment of women with PCOs who experience the complications classically
described in the literature. Furthermore, a true comparison between 2D and 3D ultrasound in the assessment of PCO has yet to be performed. In our opinion, the criteria for the diagnosis of PCO by 3D ultrasonography need to be defined and then tested prospectively, alongside 2D ultrasound parameters, to establish their true clinical value.

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Submitted on January 31, 2006; resubmitted on March 13, 2006, April 11, 2006; accepted on April 13, 2006