Best Practice & Research Clinical Obstetrics and Gynaecology 37 (2016) 25–37

Contents lists available at ScienceDirect

Best Practice & Research Clinical Obstetrics and Gynaecology

journal homepage: www.elsevier.com/locate/bpobgyn

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Sonographic evaluation of polycystic ovaries

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Keywords:
polycystic ovaries
ultrasonography
polycystic ovary syndrome
diagnosis

The morphological features of the ovaries in women with polycystic ovary syndrome (PCOS) have been well described by ultrasound imaging technology. These include enlarged ovary size, multiple small follicles of similar size, increased ovarian stromal volume and echogenicity, peripheral distribution of the follicles, and higher stromal blood flow. Ultrasound identification of the presence of polycystic ovarian morphology (PCOM) has been recognized as a component of PCOS diagnosis. With the advance of ultrasound technology, new definition has been proposed recently. There is, however, a paucity of data for the ovarian morphology in normal and PCOS adolescents. Magnetic resonance imaging has the potential to be an alternative imaging modality for diagnosing PCOM in adolescence.

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Introduction

Polycystic ovary syndrome (PCOS) is a common endocrine disorder of unknown etiology, affecting 6–8% of reproductive-aged women [1–3]. PCOS is defined as a clinical syndrome characterized by oligoamenorrhea, obesity, infertility, and signs of excess androgen. It is also associated with long-term complications including endometrial carcinoma, metabolic syndrome, and cardiovascular disease. There is no single diagnostic test for this complex disorder. The identification of PCOS is based on clinical findings that are heterogeneous and highly variable, which makes it challenging to establish the diagnosis.

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http://dx.doi.org/10.1016/j.bpobgyn.2016.02.005
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In 1935, Stein and Leventhal reported a case series of seven women characterized by oligomenorrhea or amenorrhea, hirsutism, and enlarged bilateral cystic ovaries found at laparotomy [4]. It was the first report to link ovarian pathology with clinical hyperandrogenism and oligoamenorrhea. The clinical triad they described later became the basis for PCOS diagnosis [5]. The histopathological characteristics of Stein–Leventhal ovaries are as follows [6,7]:

1) Bilaterally enlarged ovaries (two to five times the normal size);
2) Multiple small follicles typically of similar size (<1 cm in diameter) densely packed and lined within the superficial cortex;
3) Increased stroma, occasionally with luteinized cells (hyperthecosis);
4) Morphological signs of an absence of ovulation (thick smooth capsule and absence of corpora lutea and corpora albicans);
5) Hyperplasia and luteinization of the inner theca cell layer.

Ultrasound by the transvaginal route has provided a noninvasive technique for assessing the ovarian morphology and is the most commonly used method for the identification of the polycystic ovary. The 2003 Rotterdam consensus ultrasound criteria of polycystic ovarian morphology (PCOM) proposed the presence of $\geq$12 follicles measuring 2–9 mm in diameter and/or increased ovarian volume (>10 cm^3) in a single ovary or both ovaries [8].

However, the role of ultrasound finding of polycystic ovary in the diagnosis of PCOS is under considerable debate. Although the polycystic appearance of the ovaries was part of the original disease description, it is not considered as a specific pathological entity, which may also be seen in other endocrine disorders [9]. In addition, polycystic ovaries are common in young healthy women with a prevalence of 20–30% in women younger than 36 years [10–12]. The high prevalence of the polycystic ovary has further reduced the importance of the ultrasound criteria and raised doubts on its precision.

With the advance of imaging technology, numerous efforts have been made to define the ovarian appearance in women with PCOS and the ultrasound criteria of PCOM have been refined over time. The aim of this article is to review the updated guidelines and current opinions on the sonographic features of ovarian morphology for clinical practice and further research.

Ultrasound features of the polycystic ovary

The features of a typical polycystic ovary appearance that can be identified by ultrasound show a high concordance with these histopathological characteristics [13–15]:

1) enlarged ovaries that are usually more spherical in shape;
2) multiple small follicles of similar size arranged around the periphery, giving the appearance of a "string-of-pearls";
3) the increased and hyperechoic stroma occupying the center of the ovaries; and
4) higher intraovarian stromal blood flow.

Among these features, follicle number and ovarian volume are the sonographic parameters chosen to establish the diagnostic criteria for polycystic ovary. In 2014, the Androgen Excess Society and Polycystic Ovary Syndrome Society (AEPS) guidelines recommended using FNPO (follicle number per ovary) $\geq$25 for the definition of PCOM when using the newer technology that affords maximal resolution of ovarian follicles (i.e., transducer frequency >8 MHz). If such technology is not available, the ovarian volume is recommended for the diagnosis of PCOM.

Antral follicle number

Antral follicles measure 2–9 mm in average diameter and increased antral follicle number per ovary (FNPO) is a key and consistent morphological feature of polycystic ovary. In the physiological state, antral follicles are recruited during each menstrual cycle, and growth is followed by the selection of the

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