Automated Folliculometry Using Five-Dimensional Ultrasound in Women With Unexplained Infertility (pilot study)

Thesis

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بسم الله الرحمن الرحيم

قالوا

سبحانك لا علم لنا
إلا ما علمتنا إنك أنت
العليم الحكيم

صدق الله العظيم

سورة البقرة الآية: ٣٢

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Ahmed Hesham Fahmy Ragab

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List of Abbreviations

Abb.	Full term
2D	Two-dimensional
3D	Three-dimensional
4D	Four-dimensional
5D	Five-dimensional
ACOG	American College of Obstetricians and Gynecologists
AIUM	American Institute of Ultrasound in Medicine
COS	Controlled ovarian stimulation
dV	Volume-based diameter
FSH	Follicle stimulating hormone
GnRH	Gonadotrophin-releasing hormone
LH	Luteinizing hormone
MFD	Mean follicular diameter
PASS	Power Analysis and Sample Size
PCO	Polycystic ovaries
SOFs	Stimulated ovarian follicle
STIC	Spatio-Temporal Image Correlation Technique
TUI	Tomographic Ultrasound Imaging
VCI	Volume Contrast Imaging
VOCAL	Virtual organ computer-aided analysis
WHO	World Health Organization

Abstract

The limits of agreement between the two methods ranged from a lower limit of -1.32 mm (95% CI, -1.3 mm to -1.96 mm) to an upper limit of 1.04 mm (9%% CI, 1.04 to 1.96).

There was no statistically significant difference found between size of follicles when measured by 2D or by 5D with p-value > 0.05 meaning that 5D result are highly comparable to the gold standard 2D U/S.

The maximum limit of difference between 5d rather than 2d was 1.04 mm in 95 % of visualized follicles and the minimum difference between 5d and 2d was -1.32mm.

The rather narrow limits of agreement denote that both methods may be used interchangeably.

2D US could estimate the follicle diameter with an accuracy of ±0.93 mm of that estimated by 5D US.

Key words: American Institute of Ultrasound in Medicine- Polycystic ovaries- Stimulated ovarian follicle- Tomographic Ultrasound Imaging

INTRODUCTION

Two-dimensional ultrasound [2D] is in routine use in nearly most hospitals and many physician clinics as it offers a lot of benefits compared to other medical imaging techniques. Ultrasonography offers unique qualities including real-time imaging, physiologic measurement, use of non-ionizing radiation, no known bio-effects in the diagnostic range while being non-invasive. Sonographic image quality has benefited from increasingly sophisticated computer technology ***(Schaapas, 1999).***

2D Ultrasound is basically an axial image and 3D Ultrasound is a volume and 4D Ultrasound is a volume with time and the fifth dimension is how do you bring a level of workflow into ultrasound, and it is basically bordering on the sense of automation. 5D technology is a form of automation where you go through and do a scan and you get the results autopopulated for you. Five-Dimensional Ultrasound included features like 5D-LB (fetal long-bone) and 5D-NT (nuchal translucency),5D (fetal echo-cardiography),5D-CNS(central nervous system) and 5D follicle monitor ***(Liza, 2015).***

Serial ultrasound (US) examinations are performed to assess the number and size of follicles during controlled ovarian stimulation (COS) for IVF. The likelihood of a follicle containing a mature oocyte is related to its size ***(Rosen et al., 2008).***

Traditionally, two-dimensional ultrasound is used to monitor follicular development during ovulation induction or IVF cycles. Follicular assessment is performed to assess follicular size and growth, the follicle is imaged and the largest x and y or x, y, and z diameters are obtained, these diameters are then averaged to obtain the mean follicular diameter (MFD). The MFD is a surrogate for the size of the ovarian follicle. This method of follicular assessment is often inaccurate, because the follicular borders are irregular ***(O'Shea et al., 2008).***

Accordingly, oocyte collection is done when as many follicles as possible in the growing cohort are large enough to suggest the presence of mature oocytes. Traditionally, the size of a follicle is assessed by measuring its diameter with two-dimensional (2D) US. However, a follicle is a three- dimensional (3D) structure and its volume is the most accurate measure of its size. Using the diameter as a surrogate for volume assumes the follicles are spheres. However, in the case of multifollicular growth, follicles rarely attain a spherical conformation and most are ellipsoids or have irregular shapes. Therefore, the diameter of follicle is an imperfect surrogate for its true size ***(Penzias et al., 1994; Raine-Fenning et al., 2008a,b).***

5D Follicle in three-dimensional(3D) volume data provides three planes with colored tracings of hypoechoic follicle margins and multiple volumetric parameters for each selected follicle with a 3D computer-reconstructed view. Utilizing a slice reviewing function analyzes the individual follicles and improve its accuracy with additional editing by users. 5D Follicle is expected to contribute in monitoring ovulation for infertility patients and predicting the success of IVF cycles with its availability automatic detection and evaluation of follicle volume. In addition, this method has potential to improve clinical workflow and broaden the areas of interest ***(5DFollicle / Issue Date 29 Aug, 2014).***

AIM OF THE WORK

To evaluate trans-vaginal Five-Dimensional Ultrasound in automated measurement of ovarian follicles with controlled ovarian stimulation in contrast to the conventional trans-vaginal 2D ultrasound.

Chapter (1)

INTRODUCTION TO ULTRASOUND

The development of ultrasound in medicine:

The term "ultrasound" refers to sound waves of a frequency greater than that which the human ear can appreciate, namely frequencies greater than 20,000 cycles per second. For diagnostic ultrasound imaging in obstetrics and gynecology, frequencies of 2 to 12 million cycles per second are used. Ultrasound imaging has been used for medical purposes for several decades and is safe when properly performed ***(Phillips et al., 2010).***

In 1912, the passenger ship Titanic hit an iceberg on its maiden trip crossing the Atlantic from Southampton to New York. In the time that followed, physicists took an interest in using sound to detect large objects submerged in water. Initially their research for that purpose was unsuccessful. During World War I, the French physicist Paul Langevin was responsible for developing the hydrophones needed to detect submarines; this underwater sonar technology resulted in the first sinking of a German submarine in 1916. In 1917, Langevin invented the quartz sandwich transducer which served as the basis for the modern ultrasonic era. Between World War I and World War II Physics and instrumentation, the development of sonar (Sound Navigation and Ranging System) and radar (Radio Detection and Ranging) took place. The latter technique used electromagnetic waves rather than ultrasound. The next important step was the use of ultrasound to detect flaws in metal using high- frequency ultrasound. The metal flaw detectors became increasingly important as World War II was approaching, but were reported after the war ***(Kremkau, 2006).***

After World War II, Howry and Bliss, in Denver, started to experiment with sonar equipment and amplifiers from the navy. They developed a pulse-echo technique in 1948–49, and later produced cross-sectional images of a human partly submerged in water. At the same time, Wild in Minneapolis developed a breast scanner and actually made a diagnosis of breast lesions with his device ***(American Institute of Ultrasound in Medicine, 2008).***

The Swedish physician Inge Edler and physicist Helmut Hertz, at the University of Lund, borrowed a metal flaw detector from Kockum's Shipyard in Malmö, Sweden. In 1953, they managed to trace the movements of the human cardiac valves by means of the sound waves emitted and received by their modified instrument. This was the start of a new era in cardiology relying on sound technology ***(Chervenak et al., 2009)***.

The next breakthrough was by the Scottish physician Ian Donald, in Glasgow, who conducted the basic research for the development of a machine for clinical use employing ultrasound to make two-dimensional images of human tissue. Donald had served in the Air Force during World War II and his past