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ARTICLE

Intra- and inter-observer variability of uterine measurements with three-dimensional ultrasound and implications for clinical practice

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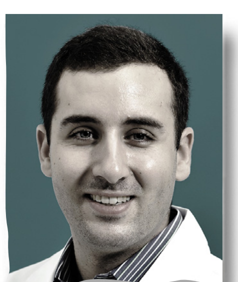

Dr Sotirios Saravelos graduated from the University of Sheffield, UK, where he later completed an Academic Research Foundation Programme in the field of recurrent miscarriage and uterine anomalies. He subsequently undertook his specialty training in the London Deanery, where he was also awarded an honorary clinical research fellowship by Imperial College London, UK. He is currently a Visiting Scholar at the Chinese University of Hong Kong, where he is completing a thesis on 'the use of three-dimensional ultrasound in reproductive medicine' under the supervision of Professor Tin-Chiu Li.

Abstract Despite the emergence of new classifications, the best way to measure and differentiate between the most common congenital uterine anomalies remains debatable. The aim of this study was to test the intra- and inter-observer variability of the different three-dimensional ultrasound (3DUS) uterine measurements described to date. Twenty consecutive women underwent 3DUS in a standardized manner. Two observers analysed each volume three times to assess the interostial distance, indentation distance, indentation angle, percentage of indentation, fundal wall thickness, and lateral wall thickness. Intra- and inter-class correlation coefficients (intra- and inter-CC), limits of agreement (LOA) and repeatability coefficients were estimated. For observers 1 and 2, the intra-observer reproducibility was the lowest for the left lateral wall thickness (intra-CC 0.91 [LOA –6.54 to 7.10] and 0.58 [LOA –6.58 to 6.94], respectively) and right lateral wall thickness (intra-CC 0.92 [LOA –5.68 to 4.74] and 0.56 [LOA –6.79 to 5.59], respectively). The inter-observer reproducibility was also the lowest for both these measurements (inter-CC 0.74 [LOA –4.01 to 6.09] and 0.72 [LOA –3.33 to 5.83], respectively). The remaining measurements showed high levels of intra- and inter-observer reproducibility (intra- and inter-CC ≥0.95). It is evident that not all uterine measurements are equally reproducible on 3DUS. RBMOnline

KEYWORDS: reproducibility, three-dimensional ultrasound, uterus

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Introduction

Congenital uterine anomalies are relatively common in women with reproductive failure (Chan et al., 2011; Saravelos et al., 2008), and have long been associated with adverse reproductive outcomes (Grimbizis et al., 2001; Venetis et al., 2014). Some studies have shown that correction of even the most subtle of septate anomalies may result in improved reproductive outcomes (Gergolet et al., 2012; Ozgur et al., 2007), highlighting the need for accurate and reproducible diagnoses.

Three-dimensional ultrasound combines the benefit of a precise depiction of the uterus in the coronal plane with low cost and high patient tolerability (Bermejo et al., 2010; Faivre et al., 2012). Despite the availability of this methodology, however, a consensus has yet to be reached on which uterine measurements to use to make a diagnosis. This is of most relevance in the differentiation between the normal, septate and bicorporal uteri. As an example, for the diagnosis of the septate uterus, four different propositions have been presented by Salim et al. (2003), Troiano and McCarthy (2004), Bermejo et al. (2010) and the new European Society of Human Reproduction and Embryology–European Society for Gynaecological Endoscopy (ESHRE–ESGE) classification (2013). In the first, it is proposed that a septate uterus must have an indentation, with a central point angle of less than 90°; in the second, it is proposed that the ratio between the cavity indentation and the interostial distance must be over 10%; in the third, it is proposed that the cavity indentation must be 1.5 cm or over; and, finally, in the classification jointly published by ESHRE–ESGE, it is proposed that the cavity indentation should be more than 50% of the uterine wall thickness, although it is not described whether lateral or fundal wall thickness should be used to determine the uterine wall thickness.

As the debate continues, it is of utmost importance that the different parameters proposed are validated scientifically. Over 10 years ago, Salim et al. (2003) showed good intra- and inter-observer reproducibility using the three-dimensional ultrasound (3DUS) criteria that they had proposed. To our knowledge, no dedicated study has systematically tested all the different 3DUS uterine measurements described to date, such as the ones mentioned above. It seems prudent that, before any classification is adopted, the measurements proposed and described are assessed for reproducibility and validated scientifically.

Materials and methods

Twenty consecutive women were recruited at the Assisted Reproductive Technology (ART) unit of the Prince of Wales Hospital in Hong Kong. Inclusion criteria were all women aged between 25 and 45 years undergoing assessment for infertility. Exclusion criteria included women with pathology distorting or not allowing the visualization of the endometrial cavity, such as large fibroids, diffuse adenomyosis and Asherman's syndrome. In all women, the primary screening for uterine anomalies was conducted directly with 3DUS.

Ethical approval from the Institutional Review Board was not required for the present work, as all the ultrasound scans included in the study analysis were conducted as part of our routine clinical practice for all women attending our Assisted Reproductive Technology unit.

Three-dimensional ultrasound

Every attempt was made to reduce the examination variability and bias. All examinations were conducted using the same Voluson E8 Expert series ultrasound machine and RIC5-9-D 3D probe (GE Medical Systems Kretztechnik GmbH and Co, Austria), and using similar technique and settings for acquisition. The default rendering mode was used rather than advanced rendering settings (e.g. HDLive) to reduce measurement variability. Specifically, the patients were scanned with an empty bladder, the probe was inserted carefully into the vagina until the cervix and uterus was identified clearly. The depth was adjusted so the uterus could be seen in its entirety and the three-dimensional acquisition box was adjusted to include a clear margin around the uterus to allow delineation of the myometrium. The uterus was visualized in the sagittal plane so that the endocervical canal and endometrial outline could be seen in their entirety. An automated sweep was then carried out using the widest angle for angle for acquisition (120°) and the highest quality mode for image, with the patient lying completely still.

After acquisition, each volume was stored and examined independently three consecutive times by each observer, both of whom have experience of three-dimensional volume analysis. The analysis was carried out after the patient had left and without any time pressure or limitations. In addition, each analysis was carried out under the same light conditions on the same ultrasound machine as it was acquired, i.e. not on a desktop computer, to avoid bias from using different screens and software. Each observer adjusted the region-of-interest box and rotated the x–y–z axes according to their own technique and assessment. In addition, customized tabs were formulated through the measurement setup of the machine, so that each measurement could be stored on a single worksheet for recording and analysis. This allowed the observers to be blinded to both their own repeated measurements but also to the measurements of the each other.

The parameters measured by each observer were also defined in a standardized way. Interostial distance was measured as the distance between the two ostia, at the transition point between the endometrial cavity and the isthmic part of the fallopian tubes. The cavity indentation was measured as the perpendicular distance between the point of maximum cavity indentation and the mid-interostial line. If the uterine cavity outline was concave, then the cavity indentation represented a septum and was measured as a positive number; if the cavity outline was convex, then the cavity indentation was measured as a negative number. The angle of the cavity indentation was measured as the angle between two lines originating from the two ostia and intersecting at the point of maximum cavity indentation; when the uterine cavity outline was concave then the angle was less than 180°, whereas when it was convex, the angle was more than 180°. The fundal wall thickness was measured from the cavity indentation to the fundal wall outline in the coronal view, crossing the mid-point of the interostial line perpendicularly. The percentage of cavity indentation was calculated as cavity indentation over fundal wall thickness. Finally, the lateral wall thickness was measured as the distance between the mid-point of the right and left lateral cavity wall extending perpendicularly to the lateral uterine serosa. Both fundal and lateral wall thickness measurements were included in the