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Ultrasound automated volume calculation in reproduction and in pregnancy

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Objective: To review studies assessing the application of ultrasound automated volume calculation in reproductive medicine.
Design: We performed a literature search using the keywords "SonoAVC, sonography-based automated volume calculation, automated ultrasound, 3D ultrasound, antral follicle, follicle volume, follicle monitoring, follicle tracking, in vitro fertilization, controlled ovarian hyperstimulation, embryo volume, embryonic volume, gestational sac, and fetal volume" and conducted the search in PubMed, Medline, EMBASE, and the Cochrane Database of Systematic Reviews. Reference lists of identified reports were manually searched for other relevant publications.
Result(s): Automated volume measurements are in very good agreement with actual volumes of the assessed structures or with other validated measurement methods. The technique seems to provide reliable and highly reproducible results under a variety of conditions. Automated measurements take less time than manual measurements.
Conclusion(s): Ultrasound automated volume calculation is a promising new technology which is already used in daily practice especially for assisted reproduction. Improvements to the technology will undoubtedly render it more effective and increase its use. (Fertil Steril® 2011;95:2163–70. ©2011 by American Society for Reproductive Medicine.)

Key Words: Automated ultrasonography, sonoAVC, in vitro fertilization, assisted reproduction, antral follicle count, pregnancy ultrasound

Ultrasound technology is rapidly evolving. The development of three-dimensional (3D) ultrasound in late 1980s enabled acquisition and analysis of volume data. This has important implications for clinical practice because assessment of 3D structures with a two-dimensional (2D) imaging modality requires either making assumptions about the shape of the structure or simply ignoring its 3D conformation. The former leads to using certain mathematical formulas for volume calculations for size assessment, whereas the latter relies on 2D measurements as surrogates for true size of an object. However, with 3D ultrasound equipment and software, it becomes possible to delineate a particular structure in three dimensions and to evaluate with high accuracy.

A recent development in ultrasound technology is automatic identification and measurement of certain structures within an acquired 3D dataset. Algorithms for identification for ovarian follicles or details of fetal heart within acquired 3D ultrasound datasets have been developed. These applications aim to facilitate and increase accuracy and reproducibility of ultrasound examinations.

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One of the new automated applications is ultrasound automated volume calculation. The software is called Sonography-based Automated Volume Calculation (SonoAVC, GE Medical Systems). SonoAVC was initially developed to be used for follicle monitoring during controlled ovarian hyperstimulation (COH) cycles. In addition, it has been used for other purposes including antral follicle count (AFC) and assessment of embryonic/fetal structures. We aimed to review studies evaluating the application of SonoAVC in reproductive medicine and obstetrics.

MATERIALS AND METHODS

We performed a literature search using the keywords "SonoAVC, sonography-based automated volume calculation, automated ultrasound, 3D ultrasound, antral follicle, follicle volume, follicle monitoring, follicle tracking, in vitro fertilization, controlled ovarian hyperstimulation, embryo volume, embryonic volume, gestational sac, and fetal volume" and conducted the search in PubMed, Medline, EMBASE, and the Cochrane Database of Systematic Reviews. Reference lists of identified reports were manually searched for other relevant publications.

SONOAVC: THE TECHNOLOGY

Fluid-filled ovarian follicles have a hypoechoic appearance within the relatively hyperechoic ovarian tissue. After the capturing of a 3D image of an ovary, SonoAVC automatically analyzes the volume dataset, identifies the boundaries of hypoechoic follicles, and provides estimates of their absolute dimensions. These

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measurements include the largest diameters in three orthogonal planes, the mean follicular diameter (MFD), the volume of the follicle, and the volume-based diameter (d(V)) of the follicle.

The volume calculation is based on the voxel count within the identified hypoechoic structure. Accordingly, it represents a true measure of follicular volume regardless of its shape. Although the MFD is the arithmetic mean of the longest three orthogonal diameters, d(V) is the diameter of a perfect sphere with the same volume of the follicle. After calculation of the actual volume of a follicle, SonoAVC calculates the diameter of a perfect sphere that has the same volume as the follicle by using the relaxed sphere diameter formula.

There are two user adjustable settings called Growth and Separation. While the Growth setting determines the extent of voxel count with reference to the distance from the interface of echogenic and hypoechogenic areas, the Separation setting affects the discrimination between two adjacent hypoechoic regions. Individual follicles and their corresponding measurements are color coded and presented in descending order for ease of interpretation. A screen shot of SonoAVC analysis of a stimulated ovary and the output report are shown in Figures 1 and 2. Based on the same principles, SonoAVC can be used to assess other structures that are hypoechoic compared with surrounding tissue.

ACCURACY OF SONOAVC

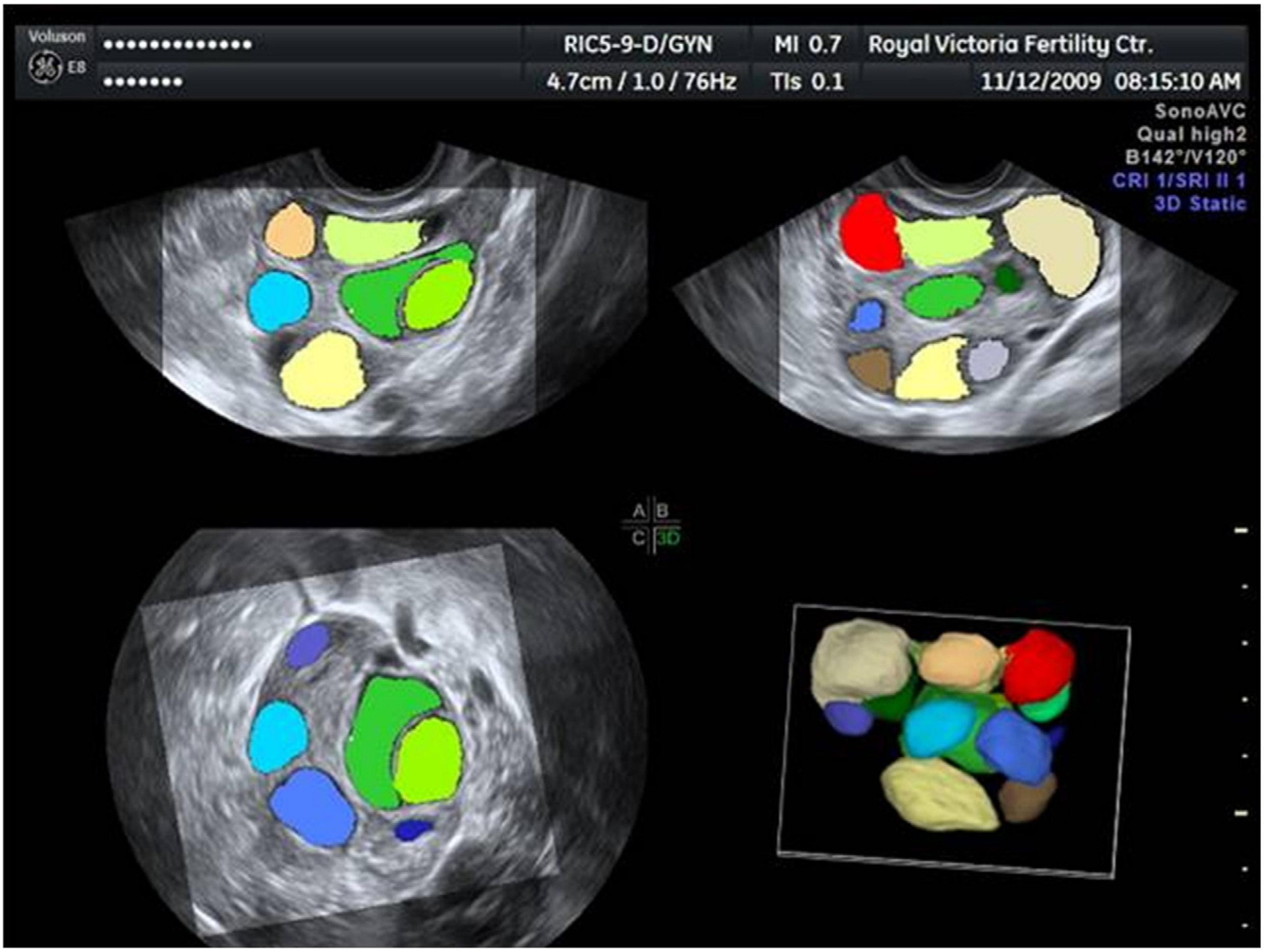
In Vitro Studies

Deutch et al. (1) used an ultrasound phantom (Computerized Imaging Reference Systems Inc.) that contained anechoic spheres of known volume within a hyperechoic matrix. A Voluson 730 (GE Medical Systems) with a 5- to 9-mHZ transvaginal probe was used for 3D volume acquisition. The maximum absolute error of volume calculations by SonoAVC was 0.00, 0.01, and 0.02 mL for spheres of 0.03, 0.12, and 0.53 mL, respectively (1).

Rousian et al. (2) examined 10 water-filled balloons with different volumes ranging between 1.0 and 3.0 mL placed in a ultrasound test reservoir. The test reservoir contained a fluid medium, comprised of a suspension of graphite particles in sterile water and glycerine. Volumes were acquired using a Voluson E8 (GE Medical Systems) and a 1.9- to 7.8-mHZ transabdominal probe. In contrast to the previous study (1), they concluded that SonoAVC systematically underestimated the volume, by a mean difference of −0.63 mL

FIGURE 1

Automatically identified and color-coded follicles in a stimulated ovary.



Ata. Ultrasound automated volume calculation. Fertil Steril 2011.