Conventional sonography provides two-dimensional (2D) views of three-dimensional (3D) structures that an experienced ultrasonographer has to dynamically examine in order to create their own 3D impression of the object of interest. In contrast, 3D sonography allows the simultaneous assessment of individual sectional planes, which dependent upon the particular field of interest may be examined in one of several different viewing modalities to maximize the information available and improve spatial awareness (1). Uniquely, 3D sonography allows demonstration of the coronal plane perpendicular to the transducer face facilitating the identification of surface irregularities which can then be accounted for during volume measurement. The digital technology central to its development also means that 3D imaging lends itself to telemedicine, as it allows the storage of large datasets without loss of information that may be subsequently analysed off-line and reappraised by experts in a 'virtual real-time consultation' (2). 2D color Doppler sonography provides a subjective estimation of uterine and ovarian vascularity. It is limited, however, by providing flow depiction in a single plane as opposed to the sample volume as obtained by 3D imaging. 3D sonography suggests that these features offer the user the following advantages in comparison to 2D sonography:

* accurate measurement of organ dimensions and volumes
* improved anatomic and blood flow information
* enhanced assessment of complex anatomic anomalies
* a better specificity in regard to the confirmation of normality
* standardization of the sonographic examination procedure
* reduced scanning times with increased cost-effectiveness
* telemedicine and tertiary consultation

Applications in Infertility

3D ultrasound has been used to diagnose uterine anomalies, assess tubal patency and to exclude intrauterine and ovarian pathology:

**Mullerian Anomalies**

Congenital uterine anomalies are associated with an increased risk of repeated first and second trimester miscarriage and preterm delivery. Accurate and reliable diagnosis is important therefore as it allows the identification of patients at risk of these complications and timely surgical intervention. This is undoubtedly the area where 3D sonography has contributed the most. This reflects its ability to demonstrate both the endometrial cavity and the myometrium simultaneously in the coronal plane as shown by Jurkovic et al. in their pioneering study of 61 patients with a history of recurrent miscarriage or infertility (3).

Women with a subseptate uterus have a significantly higher proportion of first-trimester loss and women with an arcuate uterus a significantly greater proportion of second-trimester loss (p < 0.01) and preterm labor (p < 0.01)
compared to women with a normal uterus. Another important finding derived from these 3D studies has been that outcome is related not only to the degree of defect but also to the remaining cavity length which is significantly shorter in both arcuate and subseptate uteri in women with recurrent miscarriage (4).

**Intrauterine Lesions**

La Torre et al. compared 3D sonography with conventional imaging with and without saline contrast in their study of twenty-three patients in whom subsequent hysteroscopy revealed the presence of 16 endometrial polyps (5). Standard two-dimensional sonography demonstrated a relatively poor specificity of only 69.5% suggesting the presence of polyps in 23 patients. This was improved to 94.1% when two-dimensional sonography was used in conjunction with saline infusion as only 17 patients were then thought to have polyps. A similar improvement in specificity with 3D sonography has been shown by Sylvestre et al. in their study of 209 subfertile patients thought to have an intrauterine lesion on transvaginal two-dimensional sonography or hysterosalpingography (6). Using saline infusion sonography with two-dimensional and then 3D sonography, 92 patients were subsequently identified as having a variety of intrauterine lesions suggesting a sensitivity and specificity of 97% and 11% for two-dimensional sonography, 87% and 45% for 3D sonography and 98% and 100% for two-dimensional saline infusion sonography.

**Tubal Patency**

The combination of contrast media and 3D sonography has also been used to assess tubal patency. Kiyokawa et al. found 3D saline sonohysterosalpingography was able to demonstrate the entire contour of the uterine cavity in 96% of cases compared to only 64% cases with conventional X-ray hysterosalpingography (p < 0.005) and was associated with a positive predictive value and specificity of predicting tubal patency of 100% in 25 unselected infertile patients (7). Sladkevicius et al. found 3D power Doppler imaging demonstrated free spill almost twice as often as conventional imaging (114 versus 58 tubes respectively) when used during hysterosalpingo-

contrast sonography (8). Sankpal et al. reported less promising results with the same technique when they reassessed tubal patency in 15 women who had normal X-ray HSG examinations within the previous year (9).

**Polycystic Ovaries**

Several groups have used 3D sonography to demonstrate ovarian volume and vascularity are increased in polycystic ovarian syndrome. 3D sonography also allows for 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 showed stromal volume was positively correlated with serum androstenedione concentrations (p < 0.01) in 26 women with clinical evidence of polycystic ovaries (10).

**Assisted Reproduction Techniques (ART)**

Transvaginal sonography is used on a daily basis to monitor the response to treatment and to guide the transvaginal collection of oocytes and subsequent transcervical transfer of embryos to the uterus. 3D sonography may be used in any of these areas but has largely been applied as a predictor of ovarian response and as a determinant of endometrial receptivity.

**Ovarian Reserve**

Of the sonographic markers suggested as predictive of ovarian response the three that have been specifically addressed by 3D sonographic studies are antral follicle counts, ovarian volume and ovarian blood flow. Pellicer et al. were amongst the first to use 3D sonography as an adjunct to conventional markers of ovarian reserve when they examined ovarian volume and the number of 'selectable follicles' measuring 2–5 mm in a small group of low responders on day three of the menstrual cycle (11). Both the number of selectable follicles and the total number of antral follicles were significantly decreased in the 'low responder' group who also demonstrated significantly higher serum FSH levels despite having values within the normal range. Ovarian volume measurements, however, were similar between the two groups.
Pohl et al. also used 3D sonography to quantify the number of follicles of varying diameter in 113 patients following 'down-regulation' but prior to ovarian stimulation (12).

Jarvela et al. used 3D power Doppler angiography after pituitary 'down-regulation' and during gonadotrophin stimulation to compare ovarian vascularity in 33 women with normal ovarian reserve, as judged by antral follicle counts, to 12 women who had demonstrated a previous poor response (13). The number of oocytes retrieved correlated with the antral follicle count (R = 0.458, p < 0.01) and ovarian volume (R = 0.388, p < 0.05) but not with ovarian vascularity. All three indices of vascularity were shown to increase significantly during gonadotrophin stimulation in the group with normal ovarian reserve only but this was related to the antral follicle count reiterating the importance of this marker as an independent variable.

**Endometrial receptivity**

Schild et al. measured endometrial thickness and volume in a total of 47 IVF cycles on the day of oocyte retrieval (14). There were no significant differences between the group of fifteen patients that conceived (31.9%) and the remaining 32 non-pregnant women in terms of the mean endometrial thickness (10.8 ± 2.3 mm versus 11.8 ± 3.4 mm) or volume (4.9 ± 2.2 cm³ versus 5.8 ± 3.4 cm³) respectively. However, whilst there was no absolute endometrial thickness required for pregnancy a minimal endometrial volume above 2.5 cm³ favoured pregnancy. Raga et al. also described a cut-off point in endometrial volume in their study of 72 patients on the day of embryo transfer (15). Implantation rates were significantly lower (p < 0.05) in those women with endometria measuring less than 2 cm³ and no pregnancies were observed at volumes below 1 cm³.

Kupesic et al. reported more predictive information could be derived at the time of embryo transfer when 3D power Doppler was used to quantify endometrial vascularity (16). Of 89 patients studied successful conception cycles were associated with a significantly higher endometrial flow index (13.2 ± 2.2 versus 11.9 ± 2.4, p < 0.05). Wu et al. also found 3D power Doppler angiography to be an important determinant of 'endometrial receptivity' but on the day of hCG administration in 54 patients undergoing their first IVF cycle (17). The subendometrial vascularity flow index (VFI) proved the best predictor of conception being superior to the vascularity index (VI), flow index (FI) and endometrial volume in the receiver operating characteristics curve analysis.

**CONCLUSION**

There is sufficient evidence to support the notion that the theoretical advantages of 3D sonography are indeed translated into clinical practice in the field of reproductive medicine. The spatial orientation and additional information derivable from individual sectional planes has greatly enhanced our knowledge of uterine anomalies and contributed to our understanding of how these affect pregnancy outcome and may offer insight into the location of pregnancies of unknown location. Quantitative 3D analysis of volume and vascularity has proven less powerful and whilst individual studies suggest a potential role for such measurements these do not appear to out perform current assessments.

**REFERENCES**

Ultrasound examination of any patient performing an infertility workup is an integral part of the management. This is always done by 2D transvaginal ultrasound. It allows proper examination of pelvic organs; uterus, ovaries and possibly tubes. In the last decade 3D ultrasound has been extensively developed and applied and the field of it’s use has broadened. There is a strong prediction among workers in the field of ultrasound that in the near future every gynecology clinic will have a 3D ultrasound machine available.

Is there a real need to examine every infertility case using 3D ultrasound?

What are the definite advantages of 3D imaging over 2DUS?

* Probably the most important is the ability to obtain the 3 orthogonal planes of the structure examined, of which the coronal view is the most important to obtain, especially when examining the uterus. This view is essential for assessing the external uterine contour (of the fundus), to diagnose uterine anomalies. In addition determine exact site of lesions such as fibroids and polyps (in relation to endometrium).

* 3D Volume calculations are possible to be made and have been shown to be reproducible (1). This has been proven to be of value in prediction of IVF outcome by measuring endometrial volume prior to ET as compared to endometrial thickness (2). However was found of no predictive value by other authors (3). Similarly 3D Endometrial volume measurement has been proven to be reproducible (4). Endometrial volume calculation as compared to endometrial thickness has been found superior in detection of endometrial carcinoma (5).

* The ability to store images obtained (3D volumes and cine loops) and manipulate them later going through lesions thoroughly and confirming the diagnosis (as polyps or submucous fibroids), without keeping the patient.

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