Is Three-dimensional/Four-Dimensional Ultrasonography Necessary in Obstetric Practice?

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Introduction

Standard two-dimensional ultrasonography (2DUS) has been the cornerstone of prenatal diagnosis of foetal abnormalities. In the last 10 years, we saw an advance in the technology of three-dimensional/four-dimensional ultrasonography (3D/4DUS), an increase in the availability of 3D/4D ultrasound machine and a decrease in its price. More expectant mothers requested a 3D/4D ultrasound examination with an impression that the latter is better than a conventional 2D ultrasound examination. Rendered 3D/4D images of their foetus can be very impressive. However, the fundamental question is whether 3D/4DUS can help.

Basic Techniques of 3D/4D Ultrasonography

A basic 3D/4DUS includes two steps: automatic volume acquisition and imaging display. 3D/4D volumes can be acquired when the scanning mode is black and white alone or together with colour, power Doppler, or B-flow. Once a 3D or 4D volume is acquired and stored, the volume can be displayed in three orthogonal planes (planes that are at right angles to each other) which are parallel (plane A), perpendicular (plane B) and coronal (plane C) to the original plane of volume acquisition. More recently, the display can be in a multi-slice format which allows the simultaneous display of multiple sequential parallel views of a reference (sagittal, transverse or coronal) plane of an object. The images can also be displayed in a rendered format which is unique to 3DUS. Surface rendering allows curved structures or organs to be viewed in a single image. Maximum or x-ray mode can be used to emphasise bones while minimal mode or inversion mode can be used to study blood vessels or fluid. 3D power Doppler enables the visualisation of the foetal vascular system.

4DUS displays a continuously updated and newly acquired volume in the planar and/or rendered images, creating the impression of a moving structure. Spatiotemporal image correlation (STIC) allows the automatic acquisition of a volume of data from the foetal heart that is displayed as a cine loop of a single cardiac cycle.

Detection and Assessment of Foetal Abnormalities

At present, 3DUS has been used mostly as an adjunct to traditional 2D foetal imaging rather than for primary investigation of foetal anatomy. When foetal abnormalities are suspected or confirmed on a 2DUS, a 3DUS examination is useful to confirm or exclude an abnormality and assess the severity of the abnormalities including facial cleft, spina bifida, and skeletal abnormalities. However, its impact on the management is small, in about 5% of cases. The use of a properly shown 3D/4D rendered image may help counselling women on certain types of foetal abnormalities including cleft lip or club feet.

Subtle facial features that are hallmarks of other diseases are not so easily appreciated with 2DUS. 3DUS plus 2DUS can correctly identify more cleft palate than 2DUS alone. Using 3D multiplanar and/or multi-slice technique, cleft palate can be diagnosed or excluded more confidently than 2DUS alone. Besides, the use of 3DUS also assists the diagnosis of micrognathia, nasal hypoplasia and small ear. On the other hand, the use of 2DUS is good enough to detect cleft lip, and 3DUS does not offer additional benefits.

In the assessment of spina bifida, 3DUS with multiplanar views can facilitate the localisation of bony defects of the foetal spine. The site of spina bifida is the most significant outcome predictor, as high spinal dysraphisms were associated with abnormal postnatal neurological outcome.

3DUS with rendered images in maximum mode and/or rotation of volume data set is helpful in depicting abnormal spatial relationships such as short ribs, splayed digits, and absent bones, the diagnosis of scapular aplasia or hypoplasia, and the visualisation of cranial sutures and fontanelles.

Overall, STIC offers a new look into the foetal heart and provides additional information over 2DUS. Some studies found that 3D/4DUS is advantageous over 2DUS in visualisation of congenital heart diseases, while other studies did not. Whether 3D/4DUS can improve the detection rate of congenital heart disease is yet to be determined.

When women are at high risk of having foetal abnormalities, the use of 3DUS can provide more convincing evidence of a normal foetus than a conventional 2DUS. The use of 3D ultrasound may allow the assessment of the planes that are difficult or impossible to obtain with 2D ultrasound. When foetal echocardiography is performed for pregnancies at risk of congenital heart diseases, nine standard planes across the heart and the connecting vessels should be examined according to the standard in the U.S.

Sometimes, an examination of these nine planes is incomplete because of unfavourable foetal position or foetal movements. The use of static 3DUS or STIC facilitates the examination of different planes across the foetal heart, and a segmental approach to the diagnosis of congenital heart disease.

For low risk women, currently, there is no evidence showing a clear benefit of adding a 3DUS over 2DUS. A review of 525 articles comparing 2D and 3DUS for the diagnosis of congenital anomalies has not demonstrated a difference in the detection rates. A randomised controlled trial did not show that the addition of 3D/4D ultrasound to 2D ultrasound could reduce the maternal anxiety. Although the use of 3DUS in a routine anomaly scan may reduce scanning time, the anatomic survey is less satisfactory than a 2DUS. A recent study has shown that the standard foetal cardiac anatomy survey can be performed in the routine second-trimester scan by STIC. Further study is required to show whether this approach can reduce an operator's dependency in the prenatal diagnosis of congenial heart disease.

Other Uses

It is generally accepted that 3DUS volumetry gives more precise results than 2DUS measurements, in particular, of irregularly shaped objects. 3D volumetry can be performed using multiplanar techniques, Virtual Organ Computer aided Analysis (VOCAL) or more recently eXtended Imaging VOCAL. In cases of congenital diaphragmatic hernia, lung volumes can be predictive of pulmonary hypoplasia and the neonatal outcomes. The use of a new formula using 3D volumetry of foetal abdomen and thigh plus 2D measurements is superior to weight estimation by traditional formulae using 2D measurements alone in foetuses weighing <or= 1600 g at birth.

Digital storage capabilities of 3D/4D imaging allow offline analysis in one centre or review by experts in another centre connected by internet link. Sending a STIC volume though the Internet to a centre with paediatric cardiologists can improve the prenatal diagnosis of congenital heart disease and counselling. Besides, if 3DUS volume data of various foetal structures are collected and stored, they can be reviewed in the future to assess findings which have initially been overlooked or forgotten.

4DUS can be used to guide precise needle placement during intervention procedures but this offers no advantages to an experienced operator who can perform a procedure well with a 2DUS.

Limitations of 3D/4DUS

Diagnostic accuracy can be affected by the quality and artifacts of 3D/4DUS images. The quality of the reconstructed multi-planar images not derived from the original plane of acquisition is generally not as good as 2DUS images. Besides, the quality of 3D images can be adversely affected by several factors including foetal or maternal movements, unfavourable foetal position, advanced gestational age, multiple pregnancies, oligohydramnios, and anterior placenta. In addition, there are artifacts unique to 3D volume acquisition and visualisation. To overcome artifacts, acquiring optimal 2DUS images, several volumes through an area of interest, additional 3D volumes from different angles, using different scanning parameters and at a later time are useful measurements. Education and training are required.

Ultrasound Safety

Ultrasound has a demonstrated record of safety for more than 50 years of clinical use. However, ultrasound power levels have gone up, and there is increasing use of more powerful colour and spectral Doppler in the first trimester, so safety cannot be presumed. The U.S. Food and Drug Administration recommends against the use of medically unindicated or commercial prenatal ultrasonography.

Conclusions

2DUS remains the method of choice for detection of foetal abnormalities. 3D/4DUS is useful in the evaluation of a foetal abnormality, and provides more convincing evidence of a normal foetus than 2DUS in at risk pregnancies.

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Erratum

With reference to the article in Feb Issue: Retrospective Study on the Outcome of Patients Attending Psychogeriatric Day Hospital (PGDH)

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