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Reproducibility of first trimester three-dimensional placental measurements

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ABSTRACT

Objective: The aim of this study was to assess intra and interobserver reproducibility of placental volume and vascularization during the first trimester of pregnancy studied by three dimensional ultrasonography and angio power Doppler.

Study design: This is a prospective study in 69 singleton pregnancies.

Once the bi-dimensional protocol study was carried out, we performed a 3D-US (three-dimensional ultrasonography) of the placenta by abdominal ultrasonography. The Virtual Organ Computer-Aided Analysis program was used to evaluate the placental volume (PV), the placental quotient (PQ: placental volume/crown-rump length) and the vascular indices (vascularization index VI, flow index FI and vascularization-flow index VFI). The intraobserver and interobserver variability were respectively expressed as an intraclass correlation coefficient (Intra-CC) and interclass correlation coefficient (inter-CC).

Results: Intraobserver correlation for PV was excellent with an Intra-CC of 0.97 while an Inter-CC of 0.71 demonstrated less agreement between observers. In the same way, PQ showed better intraobserver than interobserver correlation, with an Intra-CC of 0.97 and an inter-CC of 0.67. The analyzed vascular indices had both excellent intraobserver and interobserver correlation coefficients, with values of 0.98 and 0.96 for VI, 0.93 and 0.89 for FI and 0.97 and 0.95 for VFI, respectively.

Conclusion: Our study demonstrate an excellent intra and inter-observer reproducibility for vascular indices and a good reproducibility of the evaluated Doppler indices with intra-CC higher than 0.90. PV and PQ were also reproducible most of all within the same observer. As a conclusion, first trimester tridimensional sonography is a reproducible tool for the systematic study of placental vascularization.

Introduction

The placenta plays a central role in the pathogenesis of most adverse pregnancy outcomes. Trophoblast invasion is closely related to maternal endothelial preconditions. Defective trophoblast invasion was shown to occur in the first trimester of pregnancy, nevertheless, its consequences could be identified and diagnosed only later. This is the reason why treatment interventions are usually delayed after the second trimester diagnosis study [1].

The combination of three-dimensional volume and three dimensional ultrasonography (3D-US) and angio power Doppler (APD) makes possible the morphological study of vascular tree and the quantification of total blood flow of the ovary [2], endometrium [3] and placenta [4–6].

Quantitative assessment of placental vascularization may be useful for predicting possible complications in pregnancy, and even to make an early diagnosis of adverse events [4]. Today, placental vasculature can be evaluated quantitatively using a combined method of three-dimensional ultrasound imaging and 3D-APD, that has the advantage of assessing and quantifying the power Doppler signal in the whole organ studied, whereas two-dimensional-power Doppler ultrasonography only allows analysis of vascularization in a restricted previously determined bidimensional plane [4]. De Paula et al. showed that the placental vascular indices (vascularization index VI, flow index FI and vascularization-flow index VFI) estimated by 3D-APD were constant throughout gestation in normal pregnancies despite the increase

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in placental volumes. This fact suggests that the placental vascularization (number of vessels and blood flow) may increase proportionally to the organ volume, contributing to maintain the placental vascular indices constant throughout pregnancy [4].

The aim of this study was to evaluate the reproducibility of placental volume (PV) and placental quotient (PQ) and 3D-APD of placental vascularization calculated from the rotational method with the use of VOCAL imaging program.

Methods

Patients

This prospective study included 69 singleton pregnancies, 38 primiparae (55%) and 31 multiparae (45%), aged 18–43 years (average age: 32 years). Ultrasound scans were performed between 11 weeks and 4 days and 13 weeks and 5 days, as part of a screening program for aneuploidy. All women were singleton pregnancies without fetal structural anomalies in the first trimester sonography; had no preexisting conditions (as diabetes mellitus, hypertension, or any other) and had no previous history of obstetric complications.

The study protocol was approved by the local Ethics Committee, and written informed consent was filled and obtained from all women.

Equipment and volume adquisition

A single observer (C.M.P.) performed all B-mode and 3D-mode ultrasound and Doppler scans and volume acquisitions using a Voluson 730 Expert ultrasound (GE Medical Systems, Kretz Ultrasound). All women were examined with an abdominal multifrequency volume transducer, which had an 85° field of view. An initial 2D study provided data to confirm viability, to establish gestational age accurately through crown-rump length measurement, to assess fetal anatomy and to detect gross fetal abnormalities. Nuchal translucency, aneuploidy screening, morphology of the uterus and the ovaries, and uterine artery medium pulsatility index were also studied. Once the bi-dimensional study was finished, we performed capturing the placenta by abdominal ultrasonography. Three-dimensional sweeps of the entire placenta were done by power Doppler angiography. The same pre-established instrument power settings were used in all cases (angio mode, cent; quality, 16; pulse repetition frequency, 0.9 kHz; wall motion filter, "low1"; gain, −0.5; angle of the grey-scale picture was 85-degree; zoom, 1.6; focus zone, 1; X-beam CRI1; SRI3; OTI normal; harmonic frequency, high) [4,5,7]. The entire view of the placenta was identified by 2-dimensional sonography, and the volume box was adjusted to scan the entire placenta. The volume acquisition interval was 20 s. All women were required to remain as still as possible and probe movements were avoided during the acquisition time. In case of artefact during volume recording due to fetal or maternal movements, the recording process was repeated until a sufficient volume quality could be achieved. Placental volumes were stored and later analyzed offline by two observers.

Volume and APD-3D indexes calculation

The Virtual Organ Computer-Aided Analysis program (VOCAL), included in the GE 4D View computer software, was used to evaluate the placental volume as well as the vascular indexes (Fig. 1). In the manual mode the placental contour rotation planes were traced with the use of plane A (longitudinal). The rotation steps were set at 30-degree, and six contours of the placenta were drawn manually. Once all contours had been drawn, the program automatically calculated the volume of the placenta. PV was reported in cm^3. With PV, the PQ was calculated. Later, a 3D-APD histogram was achieved to determine vascular indices from computer algorithms (Fig. 2). The vascular indexes analyzed were the VI: measures the number of color voxels in the studied volume, representing the number of blood vessels within the tissues and expressing it as a percentage; FI: average color value of all the color voxels, thus representing the average blood flow intensity; it is expressed as an entire number ranged 0–100; and VFI: average color value of all the grey and color voxels of the sphere above mentioned, which represents both blood flow and vascularization; expressed as an entire number ranged 0–100. Placental volumes and vascularization indices were performed using VOCAL program twice by the first evaluator (E.C.L.) while the second observer (C.M.P.) only calculated the further-mentioned volume and APD-3D indexes once from the stored volumes. All the measurementes

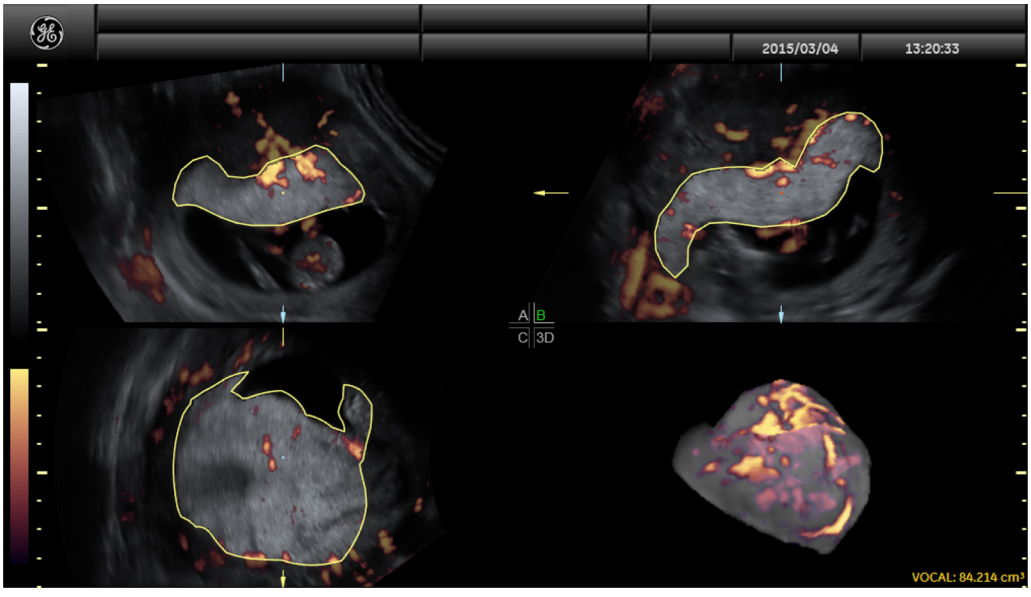

Fig. 1. Three-dimensional power Doppler image of the placenta.