Correlations of fetal-maternal outcomes and first trimester 3-D placental volume/3-D power Doppler calculations

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Summary

Objective: To investigate correlations between first trimester placental volume, placental vascularization indexes and the outcome of those pregnancies. The possible prediction of macrosomia and intrauterine growth restriction in the first trimester are studied. *Methods:* We prospectively examined 145 pregnant patients at 11-14 weeks of gestation using transvaginal 3D gray-scale and power Doppler ultrasound. The acquired volumes were analyzed using the VOCAL imaging program, for assessing placental volume, vascularization index (VI), flow index (FI) and vascularization flow index (VFI). The results were correlated with the pregnancy outcome. *Results:* Correlations between placental volume and the intrauterine growth restriction group of infants classified according to their anthropometric measurements were significant. As the placental volume decreases, percentage of intrauterine growth restriction increases. In the aspect of placental vascularisation indexes, VI showed a positive lineer correlation with newborn weight. *Conclusion:* The 3D placental volume and blood flow calculations could be important in the prediction and easy, rapid diagnostic evaluation of fetal growth restriction presenting with placental volume and vascular tree alterations even beginning at the first trimester.

Key words: 3-D ultrasound; VOCAL; Placental volume; IUGR; Pregnancy outcome.

Introduction

Three-dimensional (3-D) ultrasound (US) has been used as a tool in many placenta-based researches to evaluate the volume and power Doppler features [1]. 3-D US and virtual organ computer-aided analysis (VOCAL) software have superior ability of configuring anatomy and abnormality when compared to 2-D US [2]. Usage of 3-D power Doppler helps in diagnosing fetal and placental abnormalities and their vascularity [1]. In our study we focused on outcomes of pregnancy as IUGR and LGA. As for placental vascularization, our study revealed results of indexes of a global view of the placenta, not only a particular part of it.

3-D volumetric calculations of the placenta were made through all trimesters. The first focus of investigations was to show correlations of placental volume and fetal growth [2, 3]. The second was to predict fetal growth disproportion and pregnancy-related complications such as preeclampsia [4, 5]. The correlation of placental volume and fetal growth disproportion – especially growth restriction – was the major aim in these investigations [3-5]. Placental 3-D power Doppler indexes (vascularization index (VI), flow index (FI) and vascularization-flow index (VFI)) were used to correlate with fetal growth. Those parameters have been shown to have a positive linear correlation with first trimester fetal anthropometric calculations and the feasibility of using them in fetal delivery weight and prediction of fetal growth restriction has been noted [1-5].

The purpose of our study was to investigate the correlation between first trimester placental volume, placental VI and infant outcomes such as weight of infants, infants classified according to their gestational week at birth, and birth weight. We also investigated the prediction of IUGR by help of placental volume and placental VI calculations as early as the first trimester.

Materials and Methods

One hundred and forty-five pregnant volunteers in their first trimester in the period of 11-13 weeks and six days were examined after informed consent was obtained. The study had the approval of the university ethical committee. None of the patients had any gynecologic or obstetric complications in their medical history and they all had a normal course of pregnancy. Systemic and obstetric examinations were performed on the women and gestational age was confirmed by crown-rump length (CRL) with a transabdominal 3.5 mHz probe (Voluson 730 GE Expert Diamond Kretztechnik, Zipf, Austria).

After determining the placental site 3-D power Doppler volume of the placenta was obtained. Then placental volume was calculated automatically by VOCAL analysis of 3-D US. The volume acquisition lasted from 5-10 sec. To minimize errors in measurements all patients were investigated with the same setup of the system.

The placental contours were drawn manually. After defining volume of the placenta the software automatically calculated the vascular indexes: VI, FI and VFI. VI represents the percentage of the color-coded volume units (voxels) within the investigated volume. FI is the average color value of all the color voxels, and it shows the average blood flow intensity. VFI value is formed from the percentage of the color coded voxels weighted by average relative intensity of the power Doppler signal. Statistical analysis was undertaken using SPSS (Statistical Package for Social Science) for Windows 15.0; $p < 0.05$ level was considered statistically significant.

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Results

Demographic features of the 145 pregnant volunteers in the first trimester and newborns are listed in Table 1.

Our results show that placental volumes of the study group were significantly different when infant weights were classified according to their week of delivery as AGA, SGA, LGA, and IUGR. This significance was found when placental volume of the IUGR (37.0 ± 18.4) cm³ group was compared with placental volume of the AGA (63.7 ± 28.0) cm³, SGA (73.1 ± 30.4) cm³, LGA (72.0 ± 38.1) cm³ groups one by one (t: 2.88, $p < 0.05$). Quantity of placental volume was also different when groups were classified as IUGR (37.0 ± 18.4) cm³ and non-IUGR (64.8 ± 28.8) cm³ (t: 4.001 $p < 0.005$). As placental volume range was 16-166 cm³, none of placental volume of the IUGR group was higher than 70 cm³. While placental volume had a correlation with birth weight, no correlation was found with birth height (t: 0.181 $p < 0.05$ vs t: 0.021 $p = 0.802$). Sex of the fetuses did not show any statistical difference in placental volumes of male and female newborn groups.

3-D power Doppler results and statistical analysis of patient FIs were not significantly different when infant weights were classified according to the week of delivery as AGA, SGA, LGA, and IUGR. Similar non-significant results were seen when VI and VFI were compared with infant weights classified according to their week of delivery (t: 3 $p < 0.05$ vs t: 3 p: 0.088). Statistical comparison of 3-D power Doppler indexes of the placenta with birth weight revealed a significant difference just in VI (t: 0.279 $p < 0.001$). No significant difference was found between birth weight and 3-D power Doppler indexes of FI and VFI of the placenta (t: 0.027 p: 0.744 vs t: 0.147 $p < 0.05$).

Table 1. — *Characteristics of the 145 volunteers in the study.*

Parameter	*p* value
Age (years, mean ± SD)	30.0 ± 4.3
Gravidy (number, mean ± SD)	1.7 ± 0.8
Parity (number, mean ± SD)	1.4 ± 0.7
Maternal weight (kg, mean ± SD)	59.8 ± 9.5
Placental volume (cm³; mean ± SD)	63.1 ± 28.9
Vascularization index (mean ± SD)	6.7 ± 6.9
Flow index (mean ± SD)	43.0 ± 8.6
Vascularization flow index (mean ± SD)	2.9 ± 2.9
Male newborn (number, percentage)	88; 60.7%
Female newborn (number, percentage)	57; 39%
AGA (appropriate for gestational age) (number, percentage)	120; 82.8%
LGA (large for gestational age) (number, percentage)	9; 6.2%
SGA (small for gestational age) (number, percentage)	8; 5.5%
IUGR (intrauterine growth restricted) (number, percentage)	8; 5.5%
Newborn weight (g, mean ± SD)	3381 ± 524.8
Newborn height (cm, mean ± SD)	49,9 ± 2.2
Gestational age at delivery (week, mean ± SD)	37,8 ± 1.3

Discussion

Introduction of 3-D US and feasibility of its usage in perinatal medicine appear to have opened a new domain to investigate structures that can not be evaluated by conventional 2-D US as much as 3-D ultrasonography. In respect to volumetric calculations with 3-D US in obstetrics, numerous fetal and placental volume studies have been designed to correlate with fetal and pregnancy related outcomes [1, 2, 4, 6]. Merce *et al*. demonstrated a good reproducibility of the 3-D power Doppler parameters when applied to the study of the placental vascular tree in normal pregnancies [6]. In another study Merce *et al*. showed that 3-D Doppler indices change as pregnancy progresses and are significantly related with fetal biometry and umbilical artery Doppler velocimetry [7].

Zalud *et al*. defined normal placental and spiral artery volume in the second trimester of normal pregnancies using 3D sonography in 2007 [1]. In another study they also defined normal 3-D power Doppler vascular indexes in pregnancies between 14 and 25 weeks of singleton gestation. They found that placental and spiral artery volume blood flow increased with the advancement of gestational age [8].

Clapp *et al*. showed a correlation of placental volume calculated at 14 and 26 weeks of gestation with newborn weight in 40 patients [2]. Thame *et al*. also reported a correlation of placental volume calculated at 14, 17 and 21 weeks of gestation with newborn weight in 561 patients [3]. In our study we measured the placental volume only in the first trimester. Our results can allow us the capability and simplicity to predict newborn weight as early as the first trimester.

Hafner *et al*. have attracted attention to the connection of placental volume calculated serially at 12, 16 and 22 weeks of gestation by revealing relatively smaller placental volume in the 12th week of gestation in SGA [4]. Moreover they stated that placental growth between week 12 and 22 is too heterogeneous to justify using this method as a clinical tool, but that it could provide new information on placental physiology underlying unfavorable obstetric outcomes.

In the present study we demonstrated that placental volumes of IUGR fetuses in the period of 11-13 weeks and six days were significantly different and lower compared with placental volumes of AGA, SGA, and LGA babies. In classification of all infants in groups of IUGR and non-IUGR, statistical analysis of placental volumes in both groups consolidated these differences. In the IUGR group, placental volume value did not reach beyond 70 cm³. While placental volume decreased, the percentage of IUGR infants increased. Lower bound placental volume of all IUGR infants has approximately a 6-fold higher risk of being IUGR than upper bound placental volume of all IUGR (28% vs 4.8%). By analyzing statistically one by one each infant's birthweight and placental volume with each other, placental volume had a positive linear correlation with birth weight.

Besides volumetric calculations in 3-D US, the feature of power Doppler was another way of obtaining data from tissues three dimensionally. Placental vascularization indexes obtained by 3-D power Doppler were other parameters used in our study. VI, FI and VFI did not show any significant difference when correlated with infant weights classified according to their week of delivery as AGA, SGA, LGA, and IUGR, thus results were not meaningful. When birth weight and placental vascularization indexes were compared, only VI revealed a positive linear correlation with birth weight. Our statistical analyses show parallelism with results of studies in the literature [1, 3, 7-9]. Although these studies show that 3-D Doppler indexes change as pregnancy progresses and are significantly related with fetal biometry, in our study placental FI and VFI showed no correlation with birth weight; VI had a linear and positive relation with birth weight, thus this index can be emphasized for its producibility and feasibility [7].

In conclusion, the 3-D placental volumetric calculation technique is an appropriate approach for routine evaluation of the human placenta during early gestation. 3-D power Doppler sonography will especially improve investigation of early placental vascularization and its connection with fetal growth.

These results could be of great importance for the predictive and diagnostic evaluation of fetal growth restriction presenting with placental volume and vascular tree alterations as early as the first trimester.

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