ORIGINAL ARTICLE

3D power Doppler ultrasound characteristics of the corpus luteum and early pregnancy outcome

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Abstract   *Objective:* to assess the relationship of corpus luteum morphology and vascularity by 3 dimensional power Doppler ultrasound and the pregnancy outcome in early pregnancy. *Design:* prospective observational cohort study. *Setting:* Zagazig University Hospital. *Materials and methods:* this is a prospective observational cohort study of thirty six pregnant patients examined by two dimensional and three dimensional transvaginal sonography for corpus luteum volume, echostructure and corpus luteum vascularization index in the period after documentation of fetal heart activity and nine weeks. *Results:* there were 36 study women, ultrasound morphologic features of corpus luteum: volume ranged from 0.91 to 42.8 ml with median of 6.85, vascularization index ranged from 0.05 to 23.8 with a median of 6.85, echostructure was cystic in 12 women (33.3%), hemorrhagic in 18 (50%) and solid in 6 women (16.7%). The relation between CL volume and pregnancy outcome was significant (*p*-value was 0.02), being smaller in group of missed abortion. The relation between CL VI and pregnancy outcome was non significant (*p*-value was 0.229). The relation between CL echostructure and pregnancy outcome was highly significant (*p*-value was 0.009). The prognosis was worst in group of solid echostructure. *Conclusion:* the corpus luteum volume and echostructure assessed by 3D power Doppler ultrasound have statistical relationship with the early pregnancy outcome.

1. Introduction

Corpus luteum (CL) is a powerful little gland producing progesterone that is essential for regulating menses as well as for initiating and maintaining early pregnancy [1].

Angiogenesis is an essential factor with a major impact on the growth and regression of follicles and corpus luteum [2,3].

Doppler flow study with its indices such as pulsatility index and resistance index gives important information about uterine perfusion and angiogenesis in the ovarian follicles [4].

Three dimensional (3D) power Doppler imaging (PDI) gives the combined advantages of the improved sensitivity of two dimensional (2D) PDI to small vessels and of 3D ultrasound, so it is useful for non-invasively visualizing tissue structure and vasculature [5,6].

The histogram facility of the vocal imaging program automatically obtains 3 vascularity indices vascularization index (VI), flow index (FI) and vascularization flow index (VFI)

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which potentially can reflect the vascular density, blood flow and tissue perfusion respectively so the quantification of complete blood flow of the region of interest from the analysis of power Doppler signals can be fully studied [7].

Many authors study vascularity of the ovary using 3D power Doppler and quantify vascularity in the ovary in the late follicular phase [8], study changes in blood flow in the ovarian stroma with age [9], and compare intraovarian vascularization in polycystic ovaries with that in normal ovaries [10].

To the best of our knowledge, there are no published studies where 3D power Doppler ultrasound has been used to study the CL vascularity and its relationship with the pregnancy outcome in early first trimester till nine weeks where placental function starts.

The objective of this study is to assess the CL morphology and vascularity by 3D power Doppler and its relationship with the early pregnancy outcome.

2. Material and methods

2.1. Patients

2.1.1. Study design
This is a prospective observational cohort study.

Our study included thirty-six women recruited from the antenatal outpatient clinic at Zagazig University Hospital between October 2012 and April 2013. The inclusion criteria were maternal age ranged from 18 to 27 years, singleton spontaneous viable pregnancy and gestational age after documentation of fetal heart activity (usually after 6 weeks gestation calculated by reliable last menstrual period, regular and no hormonal contraception at least three months before pregnancy, and/or crown rump length measurement) and nine weeks, all patients with history of ovulation induction, multiple pregnancy or with known cause of pregnancy loss were excluded.

2.1.2. Equipment
All the patients were evaluated in first trimester after documentation of fetal heart activity (usually after 6 weeks gestation), and followed up to 10 weeks gestation, by two-dimensional and three-dimensional ultrasound using a MyLap 60 (Esaote, Italy) ultrasound machine, equipped with endocavitary high frequency convex 3D/4D transducer (BE1123). Power Doppler ultrasound settings were used in all women: frequency 3–9 MHz, pulse repetition frequency 1 kHz, gain −4.0 and wall motion filter 'low 1' (40 Hz at pulse repetition frequency 1 kHz).

The women were examined in the lithotomy position with an empty bladder. 2D ultrasound was applied first to obtain confirmation of pregnancy, its location, number of gestational sacs; gestational age and fetal heart activity then the CL morphology and its power Doppler flow were examined. After this, the 3D ultrasound mode was switched on. The woman was asked to remain as still as possible, and a 3D power Doppler data set of the CL was acquired. The power Doppler box was placed on the maximum longitudinal plane of the CL, covering completely its whole surface. When an adapted device free color sign was obtained, we placed the 3D box to obtain the volume on region of interest.

All the analyses of stored ultrasound volumes were done off-line by one author. The volumes were processed by the VOCAL imaging program (Virtual Organ Computer-Aided Analysis). The contours of the CL were drawn manually following the outer contour of the thick color ring surrounding it.

The analyzed parameters were: the corpus luteum volume (CLV), corpus luteum echostructure and corpus luteum vascularization index (VI). Vascularization index (VI) measures the number of color voxels in the ovarian volume, representing the number of ovarian vessels expressed as a percentage [11].

3. Results

In this study of the 36 selected pregnant women, it was possible to visualize the CL in 36 of them (100%). The age of the women in whom it was possible to distinguish the CL was in the range of 18–27 years. The average age was 22.2 years with a standard deviation of ±2.8 years.

The study included 32 pregnant women with no history of prior abortion, two cases gives history of abortion once and two cases aborted twice before.

Pregnancy outcome was good in 72.2% ($n = 26$) (26/36) and missed abortion occurred in 27.8% ($n = 10$) (10/36).

The most common morphologic type was the hemorrhagic CL in 50% ($n = 18$) (18/36), followed by CL with cystic echostructure in 33.3% ($n = 12$) (12/36) and solid in 16.7% ($n = 6$) (6/36).

Regarding CL morphology by 3D US, the relation between CL echostructure and pregnancy outcome was highly significant (p-value was 0.009). The prognosis was worst in group of solid echostructure, Table 1.

The CL had an average volume ranged from 0.91 to 42.8 ml with median of 6.85 ml.

It was observed that pregnant women with smaller size CL had more incidence of abortion than those with larger one this difference was statistically significant.

Regarding the Doppler study of CL blood flow the average vascularization index (VI) ranged from 0.05 to 23.8 with a median of 6.85. By comparing the vascular characteristic (VI) between those who aborted and those with good outcome no significant difference was found (p-value was 0.229), Table 2.

Table 1 The relationship between CL echostructure and pregnancy outcome.

Prognosis/echostructure	Cystic	Hemorrhagic	Solid	P value
Good: 72.2% (26/36)	12	12	2	0.009
Poor: 27.8% (10/36).	0	6	4	

Table 2 The relation between corpus luteum volume and vascularization index and pregnancy outcome.

Prognosis	Volume (ml) Range (median)	Vascularization index Range (median)
Good: 72.2% (26/36)	0.91–42.8 (3.4)	0.05–23.8 (6.4)
Poor: 27.8% (10/36).	0.9–3.5 (1.9)	1.5–21.8 (10.2)
P value	0.02	0.229