Comparison between three-dimensional placental volume and uterine artery and umbilical artery Doppler in prediction of preeclampsia

Thesis

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بسم الله الرحمن الرحيم

قالوا

سبحانك لا علم لنا

إلا ما علمتنا إنك أنت

العليم الحكيم

صدق الله العظيم

سورة البقرة الآية: ٣٢

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Abstract

AIM OF WORK: To compare the value of first trimester three-dimensional placental volume and second trimester uterine artery in predicting pregnancy-induced hypertension.

Patients and methods:

Our study included 100 pregnant women (50 high risk & 50 control group). They were subjected to measurement of placental volume at their first trimester (11- 13 weeks) and blood flow indices assessment of the uterine artery at second trimester (20-22weeks).

Results:

Negative correlation between placental volume and uterine blood flow indices. Positive correlation between placental volume and VI, FI and VFI in prediction of preeclampsia.

Conclusion:

Placental volume measurement between 11-13 weeks is sensitive to predict preeclampsia as a first trimester screening test. So it has the advantage of early start of prophylactic treatment.

Keywords: Preeclampsia - Uterine artery Doppler - Placental volume

Contents

List of Abbreviations

Abb.	Meaning
2DUS	2-dimensional ultrasonography
3DUS	3-dimensional ultrasonography
AEDF	Absent end diastolic flow
AT1	Angiotensin II type 1 receptor
CRL	Crown – rump length
DIC	Disseminated intravascular coagulopathy
eNOS	Endothelial nitric oxide synthase
FHR	Fetal heart rate
FI	Flow index
GDM	Gestational diabetes mellitus
HELLP	Hemolysis, Elevated Liver enzymes and low platelet count
HLA	Human leukocyte antigen – C
IUFD	Intrauterine fetal death
IUGR	Intrauterine growth restriction
MMP2	matrix metalloproteinase 2
MMP9	matrix metalloproteinase 9
MVI	Deciduo-Myometrial vascularization index
NPV	Negative predictive value
PET	Preeclamptic toxaemia
PI	Pulsatility index
PIGF	Placental growth factor
PIH	Pregnancy – induced hypertension
PIR	Pulsitality index resistance
PPV	Positive predictive value
PQ	Placental quotient

Abb.	Meaning
PV	Placental volume
PVI	Placental vascularization index
REDF	Reversed end diastolic flow
RI	Resistance index
ROC curve	Receiver Opertating Characteristic
S/D	Systolic / Diastolic ratio
sEng	Soluble endoglin
SFlt-1	Soluble fms-like tyrosine kinase I receptor
SGA	Small for gestational age
TGF-beta	Transforming growth factor beta
UM	Umbilical artery
UPCS	Uteroplacental circulation space
VEGF	Vascular endothelial growth factor
VFI	Vascularization flow index
VI	Vascularization index
VOCAL	Virtual Organ Computer-aided Analysis

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Introduction

Preeclampsia and intrauterine growth restriction (IUGR) are major contributors to perinatal mortality and morbidity **(McIntire et al., 1999).**

The incidence of preeclampsia in the United States is estimated to range from 2% to 6% in healthy, nulliparous women. Among all cases of the preeclampsia, 10% occur in pregnancies of less than 34 weeks' gestation. The global incidence of preeclampsia has been estimated at 5-14% of all pregnancies (**Zavaleta et al., 2006).**

In developing nations, the incidence of the disease is reported to be 4-18%, with hypertensive disorders being the second most common obstetric cause of stillbirths and early neonatal deaths in these countries **(Vatten and Skjaerven, 2004).**

These pregnancy complications not only alter the immediate outcomes of pregnancy at the time of delivery but also the long-term cardiovascular health of the affected women and children. For example, a history of preeclampsia increases a female’s risk of myocardial infarction, stroke or diabetes mellitus by two to eight folds over the next two decades **(Ray et al., 2005).**

Moreover, newborns diagnosed with IUGR at birth have a two to eightfold increased risk for hypertension, cardiovascular disease, diabetes mellitus or renal disease as adults **(Gluckman et al., 2008).**

Normal development of the intervillous space during the first trimester is crucial to proper fetal-maternal interaction. Pivotal to this is the trophoblast-mediated modification of the small-caliber spiral arteries into wide-caliber utero-placental vessels that deliver blood to the intervillous space and ultimately to the placenta at low pressure.

Inadequate modification of the spiral arteries resulting in decreased blood flow to the placenta has been implicated in the pathophysiology of preeclampsia.

The vasoconstriction phenomena of the tertiary stem villi is considered responsible for the upriver modifications of the normal wave flow velocity of the umbilical artery (U.A) , with a decrease in the diastolic velocities reflected by an increase in the resistance and impedecance indices.

The fetus with abnormal U.A Doppler is markedly small for gestational age. Thus, Doppler of U.A is considered a risk - discriminator in the management of small for gestational age fetuses but Doppler studies show the best result many weeks afterwards at approximately 22-24 weeks. So, the prevention of preeclampsia remains a considerable challenge in obstetrics.

Although the symptoms of preeclampsia and IUGR generally manifest in the second to third trimester of pregnancy, their underlying pathology takes place in the first trimester **(Kaufmann et al., 2003).**

One possible reason why preventive strategies have proven very disappointing at present is that the proposed interventions have commenced in the mid to late second trimester, when the underlying placental dysfunction may already be established **(Yan Zhong et al., 2010).**

Earlier assessment before the establishment of placental dysfunction may have the potential to improve predictive value for clinical practice. While individual Doppler parameters and individual analytes on their own have poor predictive value, a combination of selected parameters appears promising. With the increased use of first-trimester screening for Down syndrome, there is the opportunity to 'piggy back' screening tests for preeclampsia and IUGR onto existing tests.

The introduction of 3-dimensional (3D) ultrasound technologies with the option of imaging vascular volumes has created an excellent opportunity to study early changes in the uteroplacental circulation space (UPCS), which includes the maternal spiral arteries and the intervillous space.

Vascular indices within the placenta are calculated from three dimensional data formed by the voxels (the basic information units of volume) for vascularization assessment of organs and structures. These indices represent the total and relative amounts of power Doppler information within the volume of interest. The vascularization index (VI) quantifies the number of color-coded voxels to all voxels within the volume expressed as a percentage, flow index (FI) represents the power Doppler signal intensity from all color-coded voxels and vascularization flow index (VFI) is the mathematical relationship derived from multiplying VI by FI **(Gaglioti et al., 2008).**

These indices are thought to reflect the number of blood vessels within the volume (VI), the intensity of flow at the time of the three-dimensional (3D) sweep (FI), and both blood flow and VFI. Using these indices, 3D power Doppler attempts to identify the different branches of the villous vessels, as well as the quantitative assessment of the number of vessels.

So, reduction in these indices has the potential of being an earlier marker of placental dysfunction than the increase in the uterine and umbilical artery resistance which occur later **(Guiot et al., 2008).**