FIRST-TRIMESTER 3-DIMENSIONAL POWER DOPPLER OF THE UTEROPLACENTAL CIRCULATION AND PLACENTAL VOLUME IN PREDICTING ADVERSE PREGNANCY OUTCOMES

Thesis

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Mohamed Mahmoud Abd El Hamid

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List of Abbreviations

Abbr.	Full-term
ACTH	Adrenocorticotropic Hormone
AUCs	Area Under the Curves
BPD	Bi Parietal Diameter
BPP	Biophysical Profile
BMI	Body Mass Index
CRH	Corticotropin Releasing Hormone
CRL	Crown Rump Length
CT	Computed Tomography
CW	Continuous Wave
2D	2Dimensional
3DPD	3Dimensional Power Doppler
EDD	Expected Date of Delivery
EDV	End Diastolic Volume
FGR	Fetal Growth Restriction
FI	Flow Index
FL	Femoral Length
FMH	FetoMaternal Hemorrhage
GH	Gestational Hypertension
GPA	Gravid Para Abortus
HCG	Human Chorionic Gonadotropin
HCS	Human Chorionic Somatotropin
HELLP	Hemolysis, Elevated Liver enzymes, Low Platelets
HIV	Human Immunodeficiency Virus
HPA	Hypothalamic Pituitary Adrenal
IUGR	Intrauterine Growth Restriction
Kg	Kilogram
lgG	Immunoglobulin G
IVF	InVitro Fertilization
LBW	Low Birth weight

LH	Luteinizing Hormone
LMP	Last Menstrual Period
MCA	Middle Cerebral Artery
mmHg	Millimeter of Mercury
MRI	Magnetic Resonance Imaging
NHBPEP	National High Blood Pressure Education Program
PE	Preeclampsia
PI	Pulsatile Index
PIH	Pregnancy-Induced Hypertension
PPROM	Premature Preterm Rupture of Membranes
PSV	Peak Systolic Velocity
PTL	Preterm Labor
PV	Placental Volume
PW	Pulsed Wave
RI	Resistance Index
ROC	Receiver Operator Characteristics
SD	Standard Deviation
SGA	Small for Gestational Age
SLE	Systemic Lupus Erythromatosis
SPSS	Statistical Program for Social Science
TAMV	Time-Average Maximum Velocity
US	Ultrasound
VFI	Vascularization Flow Index
VI	Vascularization Index
VOCAL	Virtual Organ Computer-aided Analysis
WHO	World Health Organization
Wks	Weeks
UA	Umbilical Artery
µmol	Micromole

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Introduction

The placenta is named for its appearance after the Greek" *plakuos"*, meaning "flat cake" and is responsible for the nutritive, respiratory, and excretory functions of the fetus. The placenta is often overlooked in the routine evaluation of a normal gestation, receiving attention only when an abnormality is detected ***(Hill, 2008).***

Development of the placenta is a highly regulated process that is essential for normal fetal growth and development, and for maintenance of a healthy pregnancy. The placenta fulfills several critical roles as the interface between mother and fetus: it prevents rejection of the fetal allograft, enables respiratory gas exchange, transports nutrients, eliminates fetal waste products, and secretes peptide and steroid hormones ***(Aplin, 2000).***

The human placenta is a highly invasive and proliferative structure during the first half of pregnancy. While the growth rate of the human placenta decreases, its maturation continues throughout gestation ***(Arroyo and Winn, 2008).***

Abnormal placental development is associated with a few obstetrical adverse outcomes, such as fetal growth restriction, preterm labor, preeclampsia, fetal hypoxia and death ***(Cnossen et al., 2008).***

Adverse pregnancy outcomes, including Preeclampsia (PE), preterm birth (PTB), low birth weight (LBW), intrauterine growth restriction (IUGR), and stillbirth, are important events determining neonatal morbidity and mortality. Newborn infants from pregnancies affected by one of these events can develop severe long-term disabilities as well as problems due to neonatal intensive care ***(Kramer, 1987)***.

Three-dimensional (3D) ultrasound can provide improved imaging of fetal anatomy compared with conventional 2D ultrasound. Specifically, novel assessment of the placenta by 3D ultrasound is more available than 2D ultrasound, including surface-rendering imaging and volume measurement. With the recent advances in 3D power Doppler ultrasound, as well as quantitative 3D Power Doppler histogram analysis, quantitative and qualitative assessments of the vascularization and blood flow of the placenta have become feasible ***(Hata et al., 2004).***

Uteroplacental and fetoplacental perfusion have been extensively studied throughout gestation and after delivery, in order to understand the pathogenetic mechanisms underlying adverse pregnancy outcomes including preeclampsia, intrauterine growth restriction (IUGR) and other adverse pregnancy outcomes. Direct investigation of the perfusion of *in-vivo* placentae has become possible using three-dimensional (3D) power Doppler sonography ***(Matijevic and Kurjak, 2002).***

Thanks to great technological progress over the last few years, it is now possible to quantitatively evaluate intraplacental blood circulation and placental volume by

means of 3D Power Doppler and Virtual Organ Computer-aided Analysis (VOCAL) technique ***(Yu et al., 2003).***

Even very small blood movements within the investigated volume can be detected by a combination of power and color Doppler sonography, and their impact in the given volume, representing the overall perfusion, is evaluated by indices computed by built-in algorithms. In the placenta, these indices potentially reflect both uteroplacental and fetoplacental blood flow. These two vasculatures can be indirectly and separately evaluated by conventional Doppler velocimetry ***(Papageorphiou et al., 2004).***

Intraplacental blood circulation is described by three vascular indices: vascularization index (VI), flow index (FI), and vascularization flow index (VFI). Vascularization index is the ratio of the number of color voxels (volumetric pixel) to the total number of voxels in the sampled tissue, thus it represents the percentage of vascularized tissue. Flow index is the average color value of all color voxels and it describes the mean velocity of flow in the sampled tissue. The vascularization-flow index is the average color value of all color and gray voxels and describes both: the vascularization and the blood flow ***(Merce' et al., 2004).***

So far, only a small number of studies evaluating placental vasculature with the use of 3D Power Doppler technique have been conducted. They differed from one another in respect of the applied methodologies of measuring the placental vasculature and placental volume (***Merce' et al., 2005).***