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Comparison between Uterine Artery Doppler Indices and Placental Volume During Early Pregnancy as Prediction of IUGR and Preeclampsia in Third Trimester

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ORIGINAL ARTICLE

Comparison between Uterine Artery Doppler Indices and Placental Volume During Early Pregnancy as Prediction of IUGR and Preeclampsia in Third Trimester

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Abstract

Background: ***Intrauterine growth restriction and preeclampsia are significant pregnancy-related outcomes. Noninvasive and early ultrasound diagnosis could aid in the early prevention and management of such cases.***

Aim: ***To determine the role of 3D Power Doppler ultrasonography in uteroplacental circulation in early pregnancy.***

Patients and Methods: ***This prospective clinical research involved 400 pregnant women who were admitted to the antenatal care clinic at El Maadi Military Hospital during the 24-month period from December 2020 to December 2022. All cases underwent ultrasonographic monitoring of the fetus.***

Results: ***The cut-off level was detected depending on the vascular indices and placental volume. The best cut-off point of Placental volume to detect IUGR and PET group was = 55 * with 91.2% sensitivity, 86.7% specificity, 73.2% PPV, 96.1% NPV, and total accuracy of 95.0%. The best cut-off point of F. I to detect IUGR and PET group was found = 50 * with 93.0% sensitivity, 91.6% specificity, 81.5% PPV, 97.0% NPV, and total accuracy of 98.0%.***

Conclusion: ***In the first trimester, the quantitative evaluation of placental volume and Uterine Artery Doppler can be valuable for early detection of IUGR and PET.***

Keywords: First Trimester; Placental Volume; Preeclampsia; Intrauterine Growth Restriction

1. Introduction

Hypertensive disorders are a common occurrence during pregnancy and are regarded as one of three deadly risks, along with infection and hemorrhage. These factors account for the majority of fatalities and maternal complications, such as preeclampsia.[1]

Preeclampsia frequently affects young, nulliparous women, and its prevalence is strongly impacted by genetic predisposition, ethnicity, and race.[2]

According to prior studies, at 11 - 14 weeks of pregnancy, an abnormal Doppler can efficiently detect preeclampsia patients at high risk.[3]

The abnormalities of the Doppler ultrasonography involve a high pulsatility index (PI), a high vascular resistance index (RI), or a bilateral or unilateral notch in the diastolic notch.[4]

Internal placental vascular features, such as tortuosity, branching, density, and caliber changes, can be observed by 3D power Doppler US (3D PDUS).[5]

When 3D PDUS was performed on all patients involving 3D power Doppler parameters of the placental bed (as placental vascularization index, flow index, vascularization flow index), the mean vascular parameters were decreased in pregnant women with preeclampsia compared to normal pregnancy.[6]

Uterine artery Doppler investigations show that in IUGR, the uterine artery's impedance to blood flow is higher, and this higher impedance precedes the emergence of clinical signs of IUGR.[7]

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In a typical pregnancy, the placental volume (PV) doubles between 11 - 14 weeks of gestation, coinciding with the doubling of gestational sac volume and fetal size.[5]

Antenatal surveillance and umbilical artery Doppler investigations are excellent predictors of pregnancy outcome in both kinds of IUGR.[8]

The work aimed to investigate the role of 3D PDUS in uteroplacental circulation in early pregnancy (PV and Uterine Artery Doppler) and compare the predictive value of PV and uterine artery Doppler as monitoring measures for preeclampsia and IUGR.

2. Patients and methods

This prospective clinical research involved 400 pregnant women admitted to the antenatal care clinic at a Local Military Hospital for 24 months from December 2020 to December 2022. All patients underwent fetal monitoring by ultrasonography. We included pregnant women aged between 21 and 39 years, at 11 – 13 + 6 weeks of gestation, with a satisfactory Doppler recording from uterine arteries and satisfactory ultrasound recording of PV. Additionally, women with a single viable pregnancy, normal fetal morphology, and no other medical conditions associated with pregnancy, as diabetes mellitus and hypertension, were included.

The exclusion criteria were patients with multiple pregnancies, pregnant women with any systemic disease, history of hypertension, any congenital fetal anomalies and oligohydramnios, any congenital umbilical artery or placental abnormalities, and with gestational age 11 weeks or >14 weeks.

Methodology in details:

First Ante-natal Visit:

After an explanation of the whole procedure, each woman was recruited for the following:

Written consent was obtained from the patient. A full history was recorded, including personal history involving age, occupation, marital status, address, parity, and special habits of medical importance. Family, past, menstrual, and obstetric history were also taken. A history of the current pregnancy was taken, with an emphasis on risk factors related to pregnancy and acknowledgment of inclusion and exclusion criteria.

Examination:

General examination; temperature, blood pressure, pulse; BMI calculation (weight/height2); Abdominal examination; fetal heart rate, inspection, palpation; Using three-dimensional ultra-sonographic examination to determine PV and uterine artery PI considering sufficient uteroplacental circulation at early pregnancy, which accompanied with an assessment of fetal biometry for gestational age that confirmed by the length of fetal crown-rump and the latest menstrual period; Assessment of fetal weight estimation; Measurement of amniotic fluid index; Determining the cases which develop preeclampsia, IUGR, or both and compare the result of the uterine artery PI, PV with average pregnant women using these results as a predictive diagnostic power at early pregnancy for the possibility of preeclampsia and IUGR in late pregnancy; and throughout pregnancy, monitoring for preeclampsia is advised by checking a woman's blood pressure.

Some definitions:

High-risk participants with an increase in DBP > 90 and SBP > 140 gave a 24-hour urine sample.

IUGR is described as fetal weight that falls under the 10th percentile for GA. [9]

Preeclampsia is diagnosed when a woman has a blood pressure of at least 140/90 mmHg measured at least twice and six hours apart, a UPCI of at least 0.3, a urine dipstick result of at least 1+, or proteinuria of at least 300 mg/24 hours. After 20 weeks of gestation, the earliest signs of elevated blood pressure and proteinuria often appear. [10]

Early onset preeclampsia is the incidence of preeclampsia prior to 34 weeks of pregnancy [10], whereas preeclampsia occurring after 34 weeks of gestation is the definition of preeclampsia of late-onset. [11]

Using (GE LOGIQ P5) with pulsed-wave Doppler and real-time color flow localization, ultrasonographic and Doppler flow velocity waveforms (FVW) studies of uterine arteries were done [12]: A transabdominal ultrasound equipment with a 5.0-7.0 MHz probe was utilized, in addition to power/color Doppler and 3D US advancements (Voluson Pro 700 General Electric, New York City, USA). An obstetrician and a radiologist were selected to operate this advanced ultrasound device. The identification of the uterine artery was facilitated by its distinctive flow velocity waveform. From the supine position, the patient was seated in a semi-recumbent position with her head and chest supported at an angle of roughly 45°. In order to get recordings from the left and right uterine arteries, the transducer was longitudinally positioned in the left and right lower quadrants of the abdomen (iliac fossa immediately superior to the inguinal ligament).

For the 3DUS placental examination, real-time 4–8 MHz transducer scanning was applied. Angiomode, cent; smooth, 4/5; FRQ, low; density, 6; filter, 2; quality, 16; real power, 2dB; enhance, 16; balance, GO150; and pulse repetition frequency, 0.9 were utilized to standardize 3D placental vascular parameter acquisition techniques.

We collected images with the lowest feasible

gain, which allowed us to avoid artifacts and capture a good image of the placental vascular network. 2D ultrasound was utilized to obtain an entire placental image.

A little lateral tilt was applied to the transducer to facilitate the evaluation of the posterior and lateral placental segments. To eliminate interference from beam shadowing caused by the fetus's position and obtain the majority of the placental longitudinal axis, the transducer was rotated carefully, and a larger sweep angle (900) was utilized.

The PV was determined utilizing the VOCAL software (3D Sono View, GE Medical Systems, Milwaukee, WI, USA) and the VOCAL rotating method after visualizing the zone of clinical significance. This method involves continually defining the form of the placenta after six rotations of its picture by 30 degree increments. VOCALt Software is used to automatically estimate PV, flow index (FI), vascularization index (VI), and vascularization flow index (VFI) after a rotation.

FI is the mean value of all color-coded voxels within the vasculature of the examined volume. VI (%) shows the percentage of color-coded voxels and the total number of voxels inside a given volume of interest. This estimates the portion of the volume containing measurable blood flow. The ultrasound device displays the value of each color-coded voxel on a scale from 0 to 100 in arbitrary units. It is multiplying VI by FI results in VFI. [13]

Statistical Analysis:

The information was collected, reviewed, and coded before being imported into IBM SPSS v.20. When the data distribution was parametric, we represented the qualitative data numerically and in percentages and the quantitative data using mean ± SD and range. When appropriate, quantitative data was evaluated using the Chi-square test or Fisher exact test. Quantitative data having a parametric distribution were compared across more than two groups using one-way ANOVA. The p-value used to determine significance was ≤0.05.

3. Results

The finding of ultrasound Doppler showed that there were 14 Cases were IUGR, 34 cases were PET, 9 cases were IUGR and PET and 343 cases were Normal, their ages ranged from 21 to 39 years (mean 28.35 years), mean BMI (kg/m2) was 24.61 ± 2.86 and the Fetal Weight ranged from 1500 to 3500 (mean 2705.01). The Gestational age (day) ranged from 35 to 83 (mean 65.58 ± 11.57), and the mean Birth weight (gm) was 9.96 ± 2.78. Table 1

Table 1. Finding of ultrasound Doppler of the studied cases

FINDING OF ULTRASOUND DOPPLER	NO	%
IUGR	14	3.5%
PET	34	8.5%
IUGR AND PET	9	2.2%
NORMAL	343	85.8%

Our study showed that the PV ranged from 40 - 60 (mean 53.01 ± 3.71), the V.I ranged from 2 - 7 (mean 5.59 ± 1.10), the F. I ranged from 1.3 - 2.5 (mean 1.83 ± 0.33), the mean V.F.I were 275.55 - 8.65 and the mean UAPI was 3424.34 ± 447.68.

Gestational age (day) and Birth weight (gm), V.I, F.I, V.F.I, UAPI and PV, were significantly different between IUGR group, PET group, IUGR and PET group and Normal group.

Age, BMI (kg/m2), Parity, Mode of delivery, and Fetal Weight were insignificantly different between IUGR group, PET group, IUGR and PET group and Normal group.

Table 2 and Figure 1 shows that the best cut off point of PV to detect IUGR and PET group was found <=55 * with 91.2% sensitivity, 86.7% specificity, 73.2% PPV, 96.1% NPV and total accuracy of 95.0%, the best cut off point of V.I to detect IUGR and PET group was found <=10 * with 100.0% sensitivity, 54.6% specificity, 46.7% PPV, 100.0% NPV and total accuracy of 70.0%, the best cut off point of F.I to detect IUGR and PET group was found <=50 * with 93.0% sensitivity, 91.6% specificity, 81.5% PPV, 97.0% NPV and total accuracy of 98.0%, the best cut off point of V.F.I to detect IUGR and PET group was found <=4.99 * with 82.3% sensitivity, 85.3% specificity, 69.1% PPV, 92.4% NPV and total accuracy of 92.0% and the best cut off point of UAPI to detect IUGR and PET group was found >1.9 * with 84.2% sensitivity, 75.5% specificity, 57.8% PPV, 92.3% NPV and total accuracy of 79.0%.

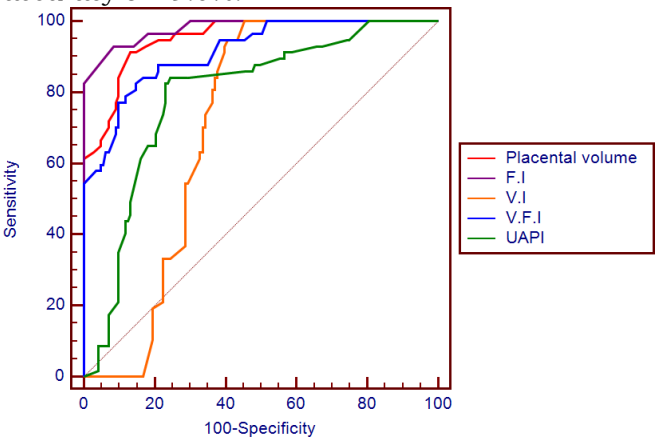

Figure 1. ROC curve to Predict IUGR and PET regarding PV, V.I, F.I, V.F.I and UAPI

Table 2. ROC curve to Predict IUGR and PET regarding PV, V.I, F.I, V.F.I and UAPI.

	CUT OFF POINT	AUC	SENSITIVITY	SPECIFICITY	+PV	-PV
PLACENTAL VOLUME	<=55 *	0.95	91.2	86.7	73.2	96.1
V.I	<=10 *	0.70	100.0	54.6	46.7	100.0
F.I	<=50 *	0.98	93.0	91.6	81.5	97.0
V.F.I	<=4.99 *	0.92	82.3	85.3	69.1	92.4
UAPI	>1.9 *	0.79	84.2	75.5	57.8	92.3

4. Discussion

Significant drawbacks are associated with 2D Doppler: It is impossible to observe blood flowing perpendicular to the ultrasonic beam's axis, and the sensitivity needs to be improved to detect sluggish flows. Moreover, in the case of small vessels and sluggish flows, movement (including adhering tissue and organ movement) diminishes the reproducibility and accuracy of 2D Doppler acquisition. Compared to the uterine artery P.I. on 2D Doppler after the first trimester, the 3D placental indices appear more accurate in predicting PE. [14]

The patients included in this study were subjected to fetal monitoring by ultrasonography. The present revealed that the ultrasound Doppler results showed 14 Cases of IUGR, 34 cases of P.E.T., 9 (92.2%) cases of IUGR and P.E.T., and 343 cases of Normal.

Eltolemy et al.[12] used 3DPD to study whether the P.V. and vasculature may accurately differentiate between pre-eclampsia and/or IUGR and normal pregnancies. They reported 12 patients with P.E.T. alone, 5 with IUGR alone, and 3 with both P.E.T. and IUGR. This was in disagreement with González-González et al.[15] who reported a greater prevalence of P.E.T. with IUGR, but with the prevalence of 30 instances of P.E.T. with IUGR out of 193 (15This studies of IUGR.

This differences were insignificant, as the mean age in the ent, as the mean age in IUGR group was 29.43 ± 5.85, in P.E.T. the IUGR and PET groups89, in IUGR and P, and in the Normal group ± 4.17 while in the Normal group was 28.34 ± 6.32.

Hashish et al.[16] found insignificant differences between the mean ages of the standard and high-risk groups of women who gave birth to a single child in their prospective case-control study (26.8 ± 6.4 vs. 28.7 ± 5.4).

In line with our results, Hashish et al.[16] reported an insignificant difference between groups regarding the B.M.I.

This was also in agreement with Ali et al.[17], who revealed an insignificant difference in B.M.I. between pregnant women who developed preeclampsia and those who did not. Our research contradicts the results of Ali et al.[17] who reported an insignificant difference in gestational age between pregnant females who developed preeclampsia and those who did not.

The P.V. was 64.58 ± 11.34, according to Eltolemy et al.[12] In this research, the mean of the placental vasculature indices were as follows: V.I. (9.78 ± 1.7), F. I (51.48 ± 2.5), and V.F.I. (5.19 ± 1.19). The uterine artery has a mean P.I. of 1.92 ± 0.25.

Guyomard et al.[18] assessed the reproducibility, distribution, and applicability of P.V. parameters related to crown-rump length at 11 weeks, 13 weeks, and 6 days, where the mean P.V. was 62.3 ± 14.8 cm3.

For monitoring IUGR, González-González et al.[15] evaluated the P.V. and perfusion parameter in combination with PAPP-A biochemical markers. According to their data, the mean F.I. was 48.8 ± 4.56, the mean V.I. was 9.49 ± 4.57, and the mean V.F.I. was 4.73 ± 2.53.

Abdallah et al.[19] investigated placental vasculature in pregnancies with and without pregestational diabetes. The placental vasculature parameters were much greater than those of their study group, who had previously had IUGR.

Alves et al.[20] estimated the uterine artery P.I. reference parameter to have a mean value of 1.5 ± 0.5 and a range of 11-14 weeks.

Our results aligned with those of Yuan et al.[21] who performed 3D PD on pregnant women and achieved VI, F.I., and V.F.I. The hypertensive group showed considerably lower VI and V.F.I. than the normotensive group, although placental F.I. was comparable in both groups.

Mallikarjunappa et al.[22] reported an association between pre-eclampsia and abnormal Doppler velocity waveforms in the middle cerebral, umbilical, and uterine arteries, which was also supported by Adekanmi et al.[23].

Neto et al. [24] revealed that when placentas with preeclampsia were evaluated between 16 and 20 weeks, all three placental vascular indices were considerably lower than in normal pregnancies.

In studies involving normal pregnancies, it was observed that intraplacental parameters (VI, F.I., and V.F.I.) tend to elevate with the development of the gestational age [25].

The lower F.I. values can be explained as decreased placental blood flow due to increased placental resistance. Low levels of VI are explained as a reduction in the number of placental blood vessels. Low V.F.I. values imply a decrease in the number of placental blood vessels and a reduction in blood flow at this level. [24]

Harrington et al.[26] studied 191 pregnant women

followed up at 24 weeks of gestation utilizing Doppler US assessment of uterine artery waveforms (notching). 110 (57.6 %) patients observed aberrant Doppler signals in the uterus, including unilateral and bilateral notching. They observed that high-resistance uterine waveforms (R.I.) are associated with an increase in preeclampsia and other adverse pregnancy outcomes.

Patients with increased mean P.I., as determined by Papageorghiou and Leslie [27], are six times more likely to encounter catastrophic pregnancy outcomes.

Our results contradict those of de Almeida Pimenta et al. [28], who used 3D sonographic, 3D power Doppler hectographic imaging, and 2D color Doppler imaging to evaluate P.V.s and vascularity. During pregnancy, P.V.s did not decrease in hypertensive/disordered women. In contrast, pregnancies complicated by hypertension conditions were associated with lower placental vascularization indices (VI and V.F.I.).

P.V.s tend to be lower in cases with superimposed preeclampsia; this may be demonstrated by calculating the P.V. to estimated fetal weight ratio. Hypertensive pregnant women had significantly poorer vascularization indices compared to normotensive cases. This was especially obvious in patients with diagnosed preeclampsia.

Farid et al.[29] also found that P.V. was comparable between the studied groups. Of their patients, 8 % had S.G.A., 9.0 % had G.H., and 7.7 % had P.E., with insignificant variation in P.V. between cases with unfavorable outcomes and those without.

Additionally, Farid et al.[29] reported that group A had a significant high value of R.I. and abnormalities, whereas the P.I. of the umbilical artery was comparable between the two groups; the P.V.s were found to be comparable between the studied groups, as reported by de Almeida Pimenta et al.[28] Compared to normotensive pregnant women, patients with superimposed preeclampsia had a considerably decreased.

De Almeida Pimenta et al.[28] evaluated the P.V.s and vascularity utilizing 3D sonography, 3D power Doppler histography, and 2D color Doppler investigations. Based on the nature of their hypertension concerns, pregnant women were categorized as hypertensive or normotensive. The P.I. in the umbilical arteries was comparable between the two groups. In hypertensive individuals, the right and left uterine arteries had an elevated P.I.

Adekanmi et al.[23] performed uterine and umbilical artery Doppler sonography to high-risk singleton pregnant women between 22 to 24 weeks and 32 to 34 weeks gestation.

Hashish et al.[16] revealed that the study group had considerably greater uterine artery R.I. and P.I. There was a significant negative correlation between the uterine artery P.I. and P.V. and vascularization measures.

Lopez-Mendez et al.[30] reported that the general US examination revealed 50.8% sensitivity and a 46.7% N.P.V., whereas the general Doppler result had the most representative results, with 75.7% specificity and 78.6% PPV.

Odibo et al.[6] revealed that the R.O.C. curve for predicting PE was 0.69 for F.I., 0.71 for VI, and 0.70 for V.F.I. Dhakar and Naz[31] revealed that the Doppler sensitivity of the umbilical artery was the same for all indices. Doppler RI showed 93.68 % specificity and 25 % PPV in the umbilical artery, whereas the combination of parameters had 91.58 % specificity and 20 % PPV. The N.P.V. of all indices was determined to be between 96 and 97 %. Thus, among the characteristics of the umbilical artery, the Doppler S/D ratio is regarded as the most accurate indicator.

Soongsatitanon et al.[32] examined P.V. and vasculature in the 1sttrimester to predict IUGR and P.E.T. During the first-trimester aneuploidy monitoring; the P.V. was assessed using transabdominal 3D ultrasonography. This examination's predictive values were measured by Eltolemy et al.[12]. Eltolemy et al.[12] collected and evaluated information from 360 pregnant women. The accuracy of P.V. in predicting IUGR and preeclampsia, with a 90.7% specificity, 23.5% sensitivity, 11.1% PPV, and 96.7% N.P.V., was established. For the prediction of early-onset preeclampsia, a 90.7% specificity, 50% sensitivity, 3.0% PPV, and 99.7% N.P.V. were also determined. The decline in P.V. and vascularity was associated with an increase in the incidence of P.E.T. in IUGR, which can be attributable to the exact mechanism of insufficient deep placentation that happens in both preeclampsia and IUGR as demonstrated by Eltolemy et al. [12].

4. Conclusion

During the first trimester, the quantitative assessment of P.V. and Uterine Artery Doppler is considered a valuable approach for the early determination of IUGR and/or P.E.T. Pregnancies complicated by hypertension illnesses are related to a reduced P.V.

All indices (F.I., VI, V.F.I.) were considerably reduced; thus, we showed that the decline of 3D parameters of flow intensity and vascularization may be displayed in preeclampsia prior to the clinical image, and this may be a useful monitoring tool for preeclampsia.

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