The Value of 3D Power Doppler Study of Placental Vasculature Versus Doppler Indices in Patients with Placental Insufficiency

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Abstract

Objectives: The aim of this study is to show the value of 3D power doppler in assessment of placental vasculature in patients with placental insufficiency in relation to Doppler indices.

Study Design: Cohort prospective study.

Methodology: This study included 100 pregnant women at risk of placental insufficiency. Those patients were recruited from the Obstetric Outpatient Clinic and Obstetric Department at Kasr Al-Ainy Hospital, Faculty of Medicine, Cairo University during the period between February 2013 to August 2014. The patients were examined by 3D power doppler for placental vasculature and fetal doppler indices to detect which will be affected first.

Results: Placental blood perfusion in patients with affection of fetal doppler had a lower VI, FI, VFI (affected 7 weeks before fetal doppler) compared to patients with normal fetal doppler. This difference was statistically highly significant (p<0.001).

Conclusion: 3DPD indices of placental bed vasularity revealed a significant change of placental vasculature before refrection on fetal doppler. 3DPD ultrasound may be an important modality in future for the evaluation of feto-placental insufficiency in clinical practice.

Key Words: Three dimensional power Doppler (3DPD) – Placental insufficiency – Doppler indices.

Introduction

PLACENTA is the most important endocrine organ with intimate relation to fetus. It is the functional center of the maternal-fetal system and is responsible for respiratory, nutritional, excretory, endocrine, and immunological functions. Placenta is actually a window providing insight vision for understanding maternal dysfunction and its impacts on fetal well being [1].

Placental insufficiency, whether primary or secondary to maternal factors such as hypertension, poor nutrition is the most common cause of Intrauterine Growth Retardation (IUGR), which is an important obstetric problem on account of the high associated perinatal mortality and morbidity [2].

Doppler examinations of intraplacental blood circulation appear to be an efficient method for diagnosing and managing pregnancies complicated by fetal Intrauterine Growth Restriction (IUGR), especially because the changes in maternal Doppler findings (i.e., uterine artery) and in fetal Doppler (i.e., umbilical artery) are secondary to the changes in the placental vascular tree [3].

The umbilical artery was the first fetal vessel to be evaluated by Doppler velocimetry, and since then became the most widely investigated component of the fetal circulation as it is readily accessible to Doppler interrogation and also it is a vital component of fetal circulation acting as a lifeline between fetus and the placenta [4].

The cerebral umbilical (C/U) ratio [also known as the Cerebral/Placental Ratio (CPR)] changes are indicators of peripheral fetal flow distribution. These parameters, based on the comparison of the brain (cerebral to umbilical index, CRI) and the placental (umbilical to cerebral index, URI). By measuring the flow redistribution between the placenta and brain, these C/U ratios (in cases of pathologic pregnancies) take into account the placental vascular disease, and the cerebral response (vasodilation) to the hypoxia induced by placental dysfunction [5].

In normal pregnancies the diastolic component in the cerebral arteries is lower than in the umbilical arteries at any gestational age. Therefore the cerebral vascular resistance remains higher than the
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placental resistance and the CPR >1.1. The CPR becomes <1.1 if any flow redistribution in favor of the brain occurs. In such cases the cerebral diastolic flow amplitude is higher than normal, and the umbilical one is lower than normal [6].

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 VOCAL technique. 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 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 [7].

Three-dimensional power Doppler sonography can provide new insights into placental pathophysiology [8].

**Aim of the work:**

The aim of this study is to show the value of 3D power doppler in assessment of placental vasculature in patients with placental insufficiency in relation to fetal doppler indices.

**Patients and Methods**

This study is a prospective cohort study which included 100 pregnant women. Those patients were recruited from the Obstetric Outpatient Clinic and Obstetric Department at Kasr Al-Ainy Hospital, Faculty of Medicine, Cairo University during the period between February 2013 to August 2014.

**Inclusion criteria:**

Age (18-45) years, Singleton viable pregnancy, gestational from 22 to 42 weeks, normal fetal anatomy, visualized totally anterior wall placenta, patients at risk of placental insufficiency (hypertensive disorders with pregnancy, antiphospholipid syndrome. Preeclampsia, past history of placental insufficiency).

**Exclusion criteria:**

Multifetal pregnancy, fetal anomalies, gestational age below 22 weeks, non totally visualized placenta.

**Interventions:**

All these pregnant women were subjected to history, clinical examination, laboratory investigations and ultrasound examinations.

**Ultrasound examination:**

Ultrasound examinations were performed using Voluson E8 Expert (General Electric Medical Systems) with a volumetric abdominal probe RAB 4-8D (4-8 MHz). Ultrasound examinations were done every 2 to 3 weeks. Ultrasound examinations were performed by a single operator.

**Two dimensional ultrasound:** It was used for (gestational age, fetal weight, and placental site and doppler indices).

**Doppler indices:**

Resistance Index (RI) = (S-D) / (S).

Where (S) peak systolic flow and (D) peak diastolic flow.

This ratio is applicable only to the umbilical and the uterine arteries, as low diastolic values limit the usefulness in the fetal aorta or other central vessels [9].

**Cerebral-Umbilical (C/U) ratio:**

RI of middle cerebral artery/RI of umbilical artery.

**Three dimensional ultrasound and power doppler (3D U/S, 3D power doppler):**

It is done for evaluation placental vascular indices Vascularization Index (VI), Flow Index (FI) and Vascularization Flow Index (VFI) with the use of 3D Power Doppler and VOCAL technique.

**Statistical analysis:**

Results are expressed as mean ± standard deviation or number (%). Comparison between numerical data in three studied groups was performed using one way ANOVA followed by LSD test if significant results were recorded. Comparison between categorical data was performed using Chi square test. Correlation between different variable was performed using Pearson correlation coefficient test. SPSS computer program (version 16 windows) was used for data analysis, p-value less than or equal to 0.05 was considered significant and less than 0.01 was considered highly significant.

**Results**

The current study was a prospective cohort study, which included 100 pregnant women at risk...
of placental insufficiency. Those patients were recruited from the Obstetric Outpatient Clinic and Obstetric Department at Kasr Al-Ainy Hospital, Faculty of Medicine, Cairo University during the period between February 2013 to August 2014.

According to our results, we divided our patients into two groups as regards RI of the umbilical artery that measured just before termination.

- Group 1: RI umbilical <0.9 (55 patients).
- Group 2: RI umbilical 0.9 (45 patients).

Table (1): Demographic features of the two studied groups.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (N=55)</th>
<th>Group 2 (N=45)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs.)</td>
<td>26.02±5.81</td>
<td>25.64±5.46</td>
<td>0.750 (NS)</td>
</tr>
<tr>
<td>Parity</td>
<td>2.16±1.26</td>
<td>1.88±1.08</td>
<td>0.079 (NS)</td>
</tr>
<tr>
<td>Gestational age (GA) at termination</td>
<td>37.96±1.38</td>
<td>33.92±2.68*</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD.

NS = p > 0.05 = not significant.

* p < 0.01 highly significant.

There was no statistical significant difference (p>0.05) between the two groups as regard age, and parity but there was highly significant difference between them in relation to gestational age at termination.

Table (2): Comparison between mean values of placental vasculature indices (VI, VFI and FI) in the two groups.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (55 patients)</th>
<th>Group 2 (45 patients)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI</td>
<td>18.73±4.91</td>
<td>10.04±4.38</td>
<td>0.001</td>
</tr>
<tr>
<td>VFI</td>
<td>10.20±6.55</td>
<td>4.16±2.62</td>
<td>0.001</td>
</tr>
<tr>
<td>FI</td>
<td>33.96±5.54</td>
<td>20.56±4.78</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD.

* p < 0.01 highly significant.

Patients in group 2 showed low VI, VFI, FI in comparison to group 1 with statistically highly significant difference.

Table (3): Comparison between the mean gestational age at which the placental vascular indices and fetal doppler indices were affected in group 2 (patients with fetal doppler affection).

<table>
<thead>
<tr>
<th></th>
<th>Placental vascular indices (VI, VFI, and FI)</th>
<th>Fetal doppler indices (RI umbilical and RI MCA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean gestational age of doppler changes</td>
<td>p-value</td>
</tr>
<tr>
<td></td>
<td>26.8±2.3</td>
<td>33.92±2.60*</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD.

* p < 0.01 highly significant.

As shown above, there was statistically high significant difference between the two groups as regard fetal doppler indices.

Table (4): Correlation between RI umbilical and RI MCA and placental vascular indices (VI, VFI, FI) in the studied patients.

<table>
<thead>
<tr>
<th></th>
<th>r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI umbilical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>-0.660</td>
<td>0.001**</td>
</tr>
<tr>
<td>VFI</td>
<td>-0.652</td>
<td>0.001**</td>
</tr>
<tr>
<td>FI</td>
<td>-0.752</td>
<td>0.001**</td>
</tr>
<tr>
<td>RI MCA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>0.197</td>
<td>0.050*</td>
</tr>
<tr>
<td>VFI</td>
<td>-0.064</td>
<td>0.529</td>
</tr>
<tr>
<td>FI</td>
<td>0.228</td>
<td>0.022*</td>
</tr>
</tbody>
</table>

r=Pearson Correlation.

* p<0.05=Correlation is significant at the 0.05 level (2-tailed).
** p<0.01=Correlation is highly significant at the 0.01 level (2-tailed).

There was statistical significant (p<0.05) inverse correlation between RI of umbilical artery versus placental vascular indices (VI, VFI, FI). While RI of middle cerebral artery showed statistical significant (p<0.05) direct correlation with VI, and FI, but there was no significant correlation (p>0.05) between it and VFI.

Discussion

The present study showed that no statistical significant difference (p>0.05) between patients as regard age, and parity but there was significant difference (p<0.05) between patients with fetal doppler affection (group 2) and those without affection (group 1), as regards gestational age at termination, this indicates that vascularity affection was reflected on fetal wellbeing ending by termination of pregnancy.

Our study showed that patients in group 2 (patients with abnormal fetal doppler) showed low VI, FI, VFI (statistically high significant difference)
Changes of fetal doppler occurred at about gestational age 34 weeks, while changes of placental vascular indices occurred at gestational age 27 weeks with a period in between about 7 weeks. This means that patients with abnormal fetal doppler indices showed affection of placental vascularity, the changes of placental vascularity was detected by placental vascular indices (VI, VFI, FI) earlier than reflection on fetal doppler indices.

This may give us a chance to use drugs that improve placental circulation, delay the onset of the disease and prevent the progression of the disease.

Zhonghua et al., published a study on 80 cases of normal and pre-eclamptic pregnant women. Comparison between normal group and mild pre-eclampsia group VI, FI, VFI had no significant difference (p>0.05), while placental VI, FI, VFI of severe pre-eclampsia group and chronic hypertension with severe pre-eclampsia group were significantly lower than the normal group (p<0.01) and than mild pre-eclampsia group (p<0.05) [10].

Mihu et al., published a prospective study on two groups of pregnant women (normal pregnancy and patients with preeclampsia), this study assessed the value of intraplacental vascularization indices, determined by three-dimensional (3D) power Doppler ultrasound, in the evaluation of placental circulation, they found that the values of the three intraplacental vascularization indices were lower in the group of pregnancies with preeclampsia compared with the group with normal pregnancies [11].

Guiot et al., performed a study on a group of 45 pregnant women between 23 and 37 weeks of gestation, including 30 IUGR and 15 normal pregnancies. Placental vascular indices were calculated for five different regions of the placenta. The authors stated that VI, FI, and VFI values were significantly lower in the IUGR pregnancies [12].

Michal Pomorski et al., published a prospective study included 120 pregnant patients, the normal pregnancy group included 100 patients and the IUGR pregnancy group included 20 patients, placental vasculature in normal and IUGR pregnancies were compared, the values of VI, FI, and VFI are statistically significantly lower in the IUGR group compared to those in the normal group [13].

In the present study there was high statistical significant (p<0.001) inverse correlation between RI of umbilical artery versus placental vascular indices (VI, VFI, FI), r was 0.660, 0.650, and 0.752 respectively. While RI of middle cerebral artery showed statistical significant (p<0.05) direct correlation with VI, and FI (r was 0.187, 0.228 respectively) but there was no significant correlation (p>0.05) with VFI.

Accordingly, an equation between placental vascular indices and fetal doppler indices (RI umbilical) can detect the value of (VI, VFI, or FI) at which the value of RI umbilical will need immediate termination of pregnancy, taking into consideration the average period between start of affectation of both indices (in our study that period was 7 weeks).

Conclusion:
Placental vascular indices (VI, FI, and VFI) are early predictors of placental hypoperfusion and ischemia.
Fetal doppler indices are affected lately in relation to placental vascular indices.

References


