Role of Umbilical Artery and Middle Cerebral Artery Doppler in Clinically Suspected Intrauterine Growth Restricted Pregnancies

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Abstract: Background: Antepartum foetal surveillance is the corner stone of management aimed at reducing maternal and perinatal mortality and morbidity. Doppler velocimetry of the uteroplacental and foetoplacental circulation can be used to further investigate such complications of pregnancy as foetal growth restriction and other forms of foetal distress that result from foetal hypoxemia or asphyxia.

Objectives: 1) To evaluate the usefulness of umbilical artery and middle cerebral artery Doppler indices as predictors of adverse perinatal outcome in clinically suspected IUGR Pregnancies.
2) To establish the Role of Doppler Ultrasound in the Management of IUGR Pregnancies.

Methods: This prospective study included 30 pregnant patients with clinically suspected IUGR in the III trimester between 31-40 weeks who got admitted to K.S.Hegde Medical Academy Hospital, from October 2014 to October 2016.

Results: Total numbers of 30 IUGR cases were studied. In cases of IUGR, the Cerebroplacental Ratio (MCA PI/ UAD PI) is less than 1.07 and hence this was taken as the Gold standard for my study. One of the major interpretations obtained while concluding the study is that if the Cerebroplacental Ratio < 0.95:

- If the Middle Cerebral Artery RI value is >0.65 in the third trimester, then the fetuses going for IUGR have a sensitivity of 70% and specificity of 45%.
- If the Umbilical Artery S/D Ratio is >2.95 in the third trimester, then the fetuses going for IUGR have a sensitivity of 50% and specificity of 80%.
- If the Umbilical Artery RI value >0.65 in the third trimester, then the fetuses going for IUGR have a sensitivity and specificity of 70%.

Conclusion: It is been proved that Doppler technology has a significant impact on our ability to assess the physiological status of the fetus. It can help in identifying the changes in the fetal circulation. This study suggests that, Doppler assessment of foetoplacental circulation including both umbilical and middle cerebral artery is a better prognostic indicator than individual vessels for the prediction of adverse fetal outcomes in Intrauterine Growth Restricted pregnancies. Also the umbilical artery and middle cerebral artery pulsatility indices is equally an important tool in predicting adverse fetal outcome.

Keywords: Doppler Velocimetry, Umbilical Artery, Middle Cerebral Artery, Systolic/ Diastolic ratio, Cerebroplacental Ratio

1. Introduction

Antepartum foetal surveillance is the corner stone of management aimed at reducing maternal and perinatal mortality and morbidity. Ultrasound has revolutionized the antepartum foetal assessment as a whole. The incorporation of Doppler derived haemodynamic information into the standard anatomic sonographic assessment allows the additional evaluation of a variety of physiologic parameters in obstetrics and gynaecology, previously out of reach to the sonographer and sonologist. In obstetrics, Doppler velocimetry of the uteroplacental and foetoplacental circulation can be used to further investigate such complications of pregnancy as foetal growth restriction and other forms of foetal distress that result from foetal hypoxemia or asphyxia. Thus Doppler studies are useful in making the critical distinction between fetus that is truly growth restricted and one who is small and healthy.

The present study is designed to evaluate the role of Doppler velocimetry of uteroplacental and foetoplacental circulation in the prediction of abnormal perinatal outcomes, in Intrauterine Growth Restricted pregnancies.

2. Methodology

2.1 Source of Data

The study is a prospective observational study conducted in 30 cases between October 2014 to October 2016, in the department of Radio diagnosis, Justice K. S. Hegde Hospital, Mangalore.

2.2 Method of study

A colour Doppler ultrasound apparatus (GE VOLUSON 730 EXPERT) equipped with 3.5 MHz transducer was used for the Doppler study.
All the examinations were made with the patient lying in semi recumbent position with a lateral tilt. Doppler transducer was placed on the abdominal wall over the uterus and carefully manipulated till Doppler signals appropriate for those particular vessels were identified. All the examinations were performed only during foetal apnoea and foetal inactivity.

The signal was recorded for a minimum of 5 to 8 cycles with blood flow velocity waveforms of equal shape and amplitude and satisfactory quality. Then the image was frozen and measurements were taken.

Doppler velocity waveforms of umbilical and middle cerebral were taken for both normal and high risk pregnancies.

### 2.3 Inclusion Criteria

- Singleton pregnancy.
- Fetal gestational age of 31 to 40 weeks with clinically suspected intrauterine growth retardation. (Estimated fetal weight <10th percentile for gestation)

### 2.4 Exclusion Criteria

- Documented major congenital abnormality
- Multiple gestations

### 2.5 Statistical Analysis

Diagnostic comparison of Cerebroplacental Ratio ( MCA PI/UA PI ) with adverse fetal outcomes using Sensitivity, Specificity, p value, ROC curve diagrams (Area under the curve) were done.

### 3. Results

Among 30 patients in the study, comparisons of Cerebroplacental Ratio with certain parameters were performed. Table 1 shows comparison with Gestational age by LMP, where as Table 2 shows comparison with Gestational Age by Ultrasound. Table 3, 4 and 5 shows comparison of IUGR with Umbilical Artery S/D Ratio and Birth Weight.

#### Table 1: Comparison of IUGR v/s GA (LMP)

<table>
<thead>
<tr>
<th>IUGR</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>20</td>
<td>35.820</td>
<td>1.828</td>
<td>34.964</td>
<td>36.676</td>
<td>1.72</td>
</tr>
<tr>
<td>Absent</td>
<td>10</td>
<td>37.280</td>
<td>2.813</td>
<td>35.268</td>
<td>39.292</td>
<td>(Not significant)</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>36.307</td>
<td>2.266</td>
<td>35.461</td>
<td>37.153</td>
<td></td>
</tr>
</tbody>
</table>

Those having IUGR (Cerebroplacental Ratio <1.07), the mean GA(LMP) according to our study is 36wks ± 2wks and patients without IUGR, mean GA(LMP) is 37wks± 3wks.

However, test shows no significant difference in GA(LMP) between presence and absence of IUGR. (p value = 0.097)

#### Table 2: Comparison of IUGR v/s GA (USG)

<table>
<thead>
<tr>
<th>IUGR</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>20</td>
<td>31.455</td>
<td>2.446</td>
<td>30.310</td>
<td>32.600</td>
<td>2.09</td>
</tr>
<tr>
<td>Absent</td>
<td>10</td>
<td>33.350</td>
<td>2.107</td>
<td>31.843</td>
<td>34.857</td>
<td>(Significant)</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>32.087</td>
<td>2.474</td>
<td>31.163</td>
<td>33.011</td>
<td></td>
</tr>
</tbody>
</table>

Those having IUGR (Cerebroplacental Ratio <1.07), the mean GA(USG) according to our study is 31wks ± 2wks and patients without IUGR, mean GA(USG) is 33wks± 2wks.

Here, test shows significant difference in GA (USG) between presence and absence of IUGR. (p value = 0.046)

#### Table 3: Comparison of IUGR v/s UA S/D ratio

<table>
<thead>
<tr>
<th>IUGR</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>20</td>
<td>3.170</td>
<td>.718</td>
<td>2.834</td>
<td>3.506</td>
<td>1.41</td>
</tr>
<tr>
<td>Absent</td>
<td>10</td>
<td>2.790</td>
<td>.651</td>
<td>2.325</td>
<td>3.255</td>
<td>(Not significant)</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>3.043</td>
<td>.709</td>
<td>2.779</td>
<td>3.308</td>
<td></td>
</tr>
</tbody>
</table>

Those having IUGR (Cerebroplacental Ratio <1.07), the mean UA S/D ratio according to our study is 3.1 ± 0.7 and patients without IUGR, mean UA S/D ratio is 2.8 ± 0.6.

Here, test shows no significant difference in UA S/D between presence and absence of IUGR. (p value = 0.17).

This test is in keeping with increased UA S/D ratio (>3) in 3rd trimester UA Doppler studies.
Table 4: Comparison of IUGR v/s Birth Weight (Kg)

<table>
<thead>
<tr>
<th>IUGR</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>20</td>
<td>2.113</td>
<td>.543</td>
<td>1.858 to 2.367</td>
<td>1.49</td>
<td>.148</td>
</tr>
<tr>
<td>Absent</td>
<td>10</td>
<td>2.385</td>
<td>.269</td>
<td>2.193 to 2.577</td>
<td>(Not significant)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>2.203</td>
<td>.482</td>
<td>2.023 to 2.383</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Those having IUGR (Cerebroplacental Ratio <1.07), the mean birth weight according to our study is 2.1 ± 0.5 and patients without IUGR, mean birth weight is 2.3 ± 0.2. Here, test shows no significant difference in birth weight between presence and absence of IUGR. (p value = 0.14)

Table 5: Comparison of Birth Weight v/s Cerebroplacental Ratio (IUGR)

<table>
<thead>
<tr>
<th>Cerebroplacental Ratio (MCAP/PLR)</th>
<th>Present</th>
<th>Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth Weight &lt;2.5</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>75.0%</td>
<td>25.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>75.0%</td>
<td>50.0%</td>
<td>98.7%</td>
</tr>
<tr>
<td>Birth Weight &gt;= 2.5</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>50.0%</td>
<td>50.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>25.0%</td>
<td>50.0%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>66.7%</td>
<td>33.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

In cases of Intrauterine Growth Restriction (IUGR), 75% of cases had birth weight less than 2.5kg and 25% of cases without IUGR also had birth weight less than 2.5kg.

In cases of IUGR, 50% of cases had birth weight more than 2.5kg and 50% of cases without IUGR had birth weight more than 2.5kg.

4. ROC Curve Diagrams

1) IUGR v/s Birth Weight

Area under the curve is 0.6 which is good. The study shows that if the Cerebroplacental Ratio is less than 0.95, then the birth weight being <2.5kg has a sensitivity of 60% and specificity of 55%.

2) IUGR v/s Intrauterine Death

Area under the curve is 0.7 which is good. The study shows that if the Cerebroplacental Ratio is <0.95, then the sensitivity and specificity for fetuses going for Intrauterine death are 56% and 80% respectively.

3) IUGR v/s NICU Admissions
Area under the curve is 0.6 which is reasonably good. The study shows that if the Cerebroplacental Ratio is ≤ 0.95, then the sensitivity and specificity for fetuses going for NICU admission is 61% and 56% respectively.

4) Role of UA S/D Ratio and UA RI in IUGR

The area under the curve for UA S/D ratio and UA RI in IUGR is 0.7 and 0.6 respectively, which is good. The study shows that if the UA S/D ratio is ≥ 2.9 then sensitivity and specificity for IUGR is 70%. Similarly if the UA RI value is ≥ 0.65, then the sensitivity and specificity for IUGR is 50% and 80% respectively.

5. Discussion

a) Abnormal S/D Ratio of Umbilical Artery In IUGR

<table>
<thead>
<tr>
<th>Study</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schulman et al(1991)</td>
<td>65</td>
<td>91</td>
</tr>
<tr>
<td>Present study</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

According to the study conducted by Schulman et al (1991) in identifying IUGR, the S/D ratio of umbilical artery has got a sensitivity and specificity of 65% and 91% respectively.

In my study the sensitivity and specificity were 70%.

b) Abnormal RI of Umbilical artery and adverse fetal outcome in IUGR

<table>
<thead>
<tr>
<th>Study</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ebrashy A and co-workers (2005)</td>
<td>53.3%</td>
<td>86.4%</td>
</tr>
<tr>
<td>Present study</td>
<td>50%</td>
<td>80%</td>
</tr>
</tbody>
</table>

According to the study done by Ebrashy A and co-workers (2005) it was reported that UA RI was more accurate than each of its components in the diagnosis of fetal morbidity and compromise in IUGR. The umbilical artery RI had 53.3% sensitivity and 86.4% specificity.

In my study the sensitivity and specificity were 50% and 80% respectively.

e) Those having IUGR (Cerebroplacental Ratio <1.07), the mean GA(USG) according to our study is 31wks + 2wks and patients without IUGR, mean GA(USG) is 33wks + 2wks. Here, test shows significant difference in GA(USG) between presence and absence of IUGR. (p value = 0.046)

d) My study shows that if the Cerebroplacental Ratio is less than 0.95, then the birth weight being <2.5kg has a sensitivity of 60% and specificity of 55%.

e) The study shows that if the Cerebroplacental Ratio is < 0.95, then the sensitivity and specificity for fetuses going for Intrauterine death are 56% and 80% respectively.

f) The study also shows that if the Cerebroplacental Ratio is < 0.95, then the sensitivity and specificity for fetuses going for NICU admission is 61% and 56% respectively.

6. Conclusion

➢ One of the main goals of antepartum fetal monitoring is to identify the fetuses at increased risk for perinatal morbidity and mortality. Doppler technology has had a significant impact on our ability to assess the physiological status of the fetus. It can help in identifying the changes in the fetal circulation at a time when other tests are normal and in doing so, identify the truly hypoxic fetus.

➢ This study was conducted in Justice K. S. Hegde Charitable hospital to evaluate the role of Doppler velocimetry of foetoplacental circulation in the prediction of abnormal perinatal outcomes, in Intrauterine Growth Restricted pregnancies.

➢ In cases of IUGR, the Cerebroplacental Ratio (MCA PI/ UAD PI) is less than 1.07 and hence this was taken as the Gold standard for my study.

➢ The study showed significant difference in Gestational Age by Ultrasound between presence and absence of IUGR.

➢ One of the major interpretations obtained while concluding the study is that if the Cerebroplacental Ratio < 0.95

a) The birth weight less than 2.5kg has a sensitivity of 60% and specificity of 55%.

b) Fetuses going for Intrauterine Death/ postnatal NICU death have a sensitivity of 56% and specificity of 80%.

c) Fetuses going for NICU admissions have a sensitivity of 61% and specificity of 56%.

➢ If the Middle Cerebral Artery RI value is ≥ 0.65 in the third trimester, then the fetuses going for IUGR have a sensitivity of 70% and specificity of 45%.

➢ If the Umbilical Artery S/D Ratio is ≥ 2.95 in the third trimester, then the fetuses going for IUGR have a sensitivity and specificity of 70%.

➢ If the Umbilical Artery RI value ≥ 0.65 in the third trimester, then the fetuses going for IUGR have a sensitivity of 50% and specificity of 80%.

➢ The decreased sensitivity and negative predictive value of the ratio of Middle cerebral artery (MCA) and Umbilical
artery (UA) resistance indices is due to increased number of false negative values when compared to umbilical artery S/D ratio. This is explained by the fact that in extreme cases of IUGR, instead of decreased middle cerebral artery resistance, there will be normal or increased resistance due to increase in intra cranial tension because of brain edema. This study suggests that Doppler assessment of fetoplacental circulation including both umbilical and middle cerebral artery is a better prognostic indicator than individual vessels for the prediction of adverse fetal outcomes in Intrauterine Growth Restricted pregnancies.

References


Author Profile

Arjun Rajasekharan received the M.B.B.S. degree from Amrita Institute of Medical Sciences, Kochi, Kerala, India in 2014. He is now pursuing Postgraduation course in M.D Radio-diagnosis at K.S Hegde Medical Academy, Nitte University, Mangalore-575018 India