**Research Article**

# Study of Doppler waveforms in pregnancy induced hypertension and its correlation with perinatal outcome

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**ABSTRACT**

**Background:** Objectives of current study were to study the significance of Doppler in PIH using middle cerebral artery and umbilical artery blood flow and to analyze the role of Doppler in PIH in predicting perinatal outcome.
**Methods:** Hundred cases of women with pregnancy induced hypertension between 28-40 weeks of gestation were studied for umbilical artery and middle cerebral artery Doppler waveforms. The perinatal outcome results were documented and analyzed statistically using percentage and Chi-square test.
**Results:** Adverse perinatal outcome was significantly associated with oligohydramnios (P <0.0001) and grade 3 placental maturity (P <0.01). Absent end diastolic flow waveform in umbilical artery was associated with mortality of 27.78% and reverse end diastolic waveform with mortality of 100%. UA PI has the highest sensitivity (88.88%) and positive predictive value (69.56%) in predicting low birth weight. Cerebroplacental ratio (MCA/UA) had highest sensitivity (94.42%), PPV (86.42%), accuracy (90%) for predicting adverse perinatal outcome than UAPI and MCA PI. MCA PI had low specificity in predicting adverse perinatal outcome.
**Conclusions:** Pregnancy induced hypertension is associated with significant fetal morbidity and mortality. Oligohydramnios in PIH patients is associated with adverse pregnancy outcome. Presence of absent end diastolic flow and reversed end diastolic flow in umbilical artery is an ominous sign with high perinatal mortality. Reversed end diastolic flow is more ominous than absent end diastolic flow. Cerebroplacental ratio (MCA/UA PI) is a better predictor of adverse perinatal outcome, with highest diagnostic accuracy, sensitivity, and positive predictive value, than either vessel Doppler indices considered alone. Colour Doppler study is a simple, quick, non-invasive procedure and is found to be the most accurate among the other tests for antepartum fetal surveillance.

**Keywords:** Umbilical artery Doppler, Middle cerebral artery Doppler, Cerebroplacental ratio, IUGR, Absent end diastolic flow, Reversed end diastolic flow, Perinatal outcome

## INTRODUCTION

Hypertensive disorders complicating pregnancy are common and form one of the deadly triad, along with hemorrhage and infection, that contribute greatly to maternal morbidity and mortality. The incidence of various hypertensive disorder of pregnancy varies widely from 5 to 15% throughout the globe. It accounts for a total of 7-10% of perinatal mortality in developed countries and 20% in developing countries. The perinatal mortality is 5% in mild PIH and 15 to 25% in severe PIH.

Satisfactory development of uteroplacental and fetoplacental circulation is necessary for a normal pregnancy outcome. Alternative in its development can be associated with hypertension during pregnancy, which can lead to impaired circulation causing prematurity, subnormal growth (IUGR) or fetal death.

Doppler ultrasound velocimetry provides a non-invasive method of measuring changes in blood flow in the uteroplacental circulation and fetoplacental circulation, thus assessing fetal wellbeing.[1]

Management protocols for women with PIH include frequent prenatal visits with ultrasound and fetal heart monitoring. Ultrasound biometry helps to identify a heterogeneous group of small for gestational age fetuses. With the use of Doppler velocimetry, correct detection of compromised IUGR fetus is possible, which allows for timely intervention to improve perinatal outcome.[2] Evidence from randomized trials suggest that, if women with suspected intrauterine growth restriction and preeclampsia are offered Doppler studies of the umbilical artery, a clinically significant reduction in perinatal mortality may be expected. It has also been suggested that screening of low risk women is not cost effective and also no significant improvement was observed in perinatal outcome.[3]

### Aims and objectives

1. To study the significance of Doppler in pregnancy induced hypertension using middle cerebral artery and umbilical artery blood flow.

2. To analyze the role of Doppler in predicting perinatal outcome.

## METHODS

### Source of data

Patients with pregnancy induced hypertension who attend antenatal clinic and admitted to antenatal ward at KIMS, Bangalore in various units of obstetrics and gynaecology between January 2012 and December2013.

### Inclusion criteria

All pregnant women with PIH between 28-40 weeks of gestation.

### Exclusion criteria

Multiple pregnancy, hydramnios, vesicular mole, pregnant women with hypertension due to other medical conditions like chronic hypertension, renal disorder, diabetes mellitus and other chronic disorders.

### Method of collection of data

Hundred cases of women with pregnancy induced hypertension were studied after applying exclusion criteria patients with pregnancy induced hypertension between 28-40 weeks of gestation were subjected to investigations for PIH. The patients were explained the non-invasive atraumatic nature of the procedure. Initially routine obstetric scan was performed. Doppler wave form patterns of umbilical and middle cerebral arteries were obtained. Patients were followed up till delivery and perinatal outcome was also studied. Examination was performed with the patient in supine position with slight left lateral tilt. The wave forms were obtained during fetal

inactivity and apnoea. Umbilical artery Doppler flow velocity waveform was obtained from a free loop of cord and measurements taken when a clear waveform was acquired. The pulsatility index was measured and the presence or absence of end diastolic frequencies was noted. The PI was used as it continues to reflect changes in resistance with progressive absence of end diastolic frequencies or reverse flow, and the values are normally distributed in third trimester. For MCA Doppler US, a transverse image of the fetal head was obtained at the level of the sphenoid bones. Color flow imaging was used to display the circle of Willis. The MCA in the near field was insonated about 1 cm distal to origin from the internal carotid artery.

The UA pulsatility index ratios were considered abnormal if the value was above the 95th percentile of previously published values for gestational age[4] and the MCA pulsatility index ratios were considered abnormal if the value was below the 5th percentile of previously published values for gestational age.[4]

The MCA/UA PI ratio (Cerebroplacental ratio) is usually constant during the last 10 weeks of gestation. It is possible to use a single cut off value after 30th week as reported by Wladimiroff et al[9] who observed no significant differences in cerebroplacental ratio after 26 weeks, Arbeille et al[10] also found the cerebroplacental ratio constant during the pregnancy and suggested 1 as the cut off value; all values below 1 were considered abnormal. Gramellini et al[6] also used a single cut off value of 1.08. Therefore in our study a single cut off value (1.08) was used above which velocimetry was considered normal and below which it was considered abnormal.

### Outcome criteria

Adverse perinatal outcome was defined as the presence of any of the following:

1. Emergency cesarean delivery for fetal distress.

2. 5 minute Apgar score of less than <7.

3. Admission to NICU.

4. Perinatal death/IUD.

Pregnancy outcome was considered to be uneventful or favorable when the above complications were absent. The outcome for each pregnancy was obtained by examining the labour ward records and NICU records.

### Statistical methods[11]

The results were analyzed statistically using Chi-square and Fisher exact test. Diagnostic statistics namely, sensitivity, specificity, PPV, NPV and accuracy were calculated to find the diagnostic value of ultrasound and

Doppler findings to diagnose the adverse pregnancy outcome.

## RESULTS

100 cases of women with PIH were studied between January 2012 to December 2013.

### Table 1: Age distribution.

| Age in years | Number | % |
|---|---|---|
| ≤20 | 20 | 20.0 |
| 21-25 | 58 | 58.0 |
| 26-30 | 21 | 21.0 |
| ≥30 | 1 | 1.0 |
| | 23.41 ± 3.1 | |

### Table 2: Gestational age.

| Gestational age | Number | % |
|---|---|---|
| <37 weeks | 96 | 96.0 |
| ≥37 weeks | 4 | 4.0 |

### Table 3: Severity of PIH.

| PIH | Number | % |
|---|---|---|
| Severe PIH | 62 | 62.0 |
| Mild PIH | 38 | 38.0 |

### Table 4: Adverse outcomes.

| Adverse outcome | Number (n=46) | % |
|---|---|---|
| Low APGAR | 16 | 34.7 |
| NICU admission | 21 | 45.65 |
| Caesarean section | 21 | 45.65 |
| IUD | 10 | 21.74 |
| Perinatal death | 3 | 6.52 |

Pregnancy outcome was abnormal in 46 patients. More than one adverse outcome observed in some cases (n=23).

### Table 5: Mode of delivery.

| Mode of delivery | Number | % |
|---|---|---|
| Spontaneous | 30 | 30.0 |
| Induction | 43 | 43.0 |
| C section | 27 | 27.0 |
| All cases | 100 | 100.0 |

### Table 6: Association of amniotic fluid with pregnancy outcome.

| Amniotic fluid | Pregnancy outcome | | | | Total |
|---|---|---|---|---|---|
| | Normal | | Abnormal | | |
| | Number | % | Number | % | Number |
| Normal | 22 | 91.67 | 2 | 8.33 | 24 |
| Abnormal | 28 | 36.84 | 48 | 63.16 | 76 |
| Total | 50 | 50.0 | 50 | 50.0 | 100 |
| Inference | Abnormal amniotic fluid is significantly related to the abnormal pregnancy outcome with P <0.0001** | | | | |

### Table 7: Association of Doppler findings with pregnancy outcome.

| Doppler findings | Pregnancy outcome | | | | Total |
|---|---|---|---|---|---|
| | Normal | | Abnormal | | |
| | No. | % | No. | % | No. |
| MCA-PI (Abnormal) | 26 | 38.24 | 42 | 61.76 | 76 |
| UA-PI (Abnormal) | 8 | 16 | 42 | 84 | 45 |
| MCA/UA (Abnormal) | 7 | 12.73 | 48 | 87.27 | 58 |
| AEDF/REDF | - | - | 26 | 100.0 | 26 |

### Table 8: Association of UA Doppler with birth weight.

| UA-PI | Birth weight | | | | Total |
|---|---|---|---|---|---|
| | Normal (>2.5 kg) | | Low birth (<2.5 kg) | | |
| | Number | % | Number | % | Number |
| Normal | 32 | 69.57 | 14 | 30.43 | 46 |
| Abnormal | 4 | 7.4 | 50 | 92.60 | 54 |
| Total | 36 | 36.0 | 64 | 64.0 | 100 |
| Inference | UA-PI is significantly related to the low Birth weight with P<0.0001** | | | | |

### Table 9: Association of C/P ratio with birth weight.

| MCA/UA | Birth weight | | | | Total |
|---|---|---|---|---|---|
| | Normal (>2.5 kg) | | Low birth (<2.5 kg) | | |
| | Number | % | Number | % | Number |
| Normal | 24 | 57.14 | 18 | 42.86 | 42 |
| Abnormal | 12 | 20.68 | 46 | 79.32 | 58 |
| Total | 36 | 36.0 | 64 | 64.0 | 100 |
| Inference | MCA/UA is significantly related to the low Birth weight with P<0.0001** | | | | |

**Table 10: Diagnostics value of Doppler findings for low birth weight.**

| Doppler findings | Low birth weight (<2.5 kg) | | | | | |
|---|---|---|---|---|---|---|
| | Sensitivity | Specificity | PPV | NPV | Accuracy | P value |
| MCA- PI | 38.88 | 71.87 | 43.75 | 67.64 | 60 | >0.05 |
| UA-PI | 88.88 | 78.12 | 69.56 | 92.59 | 92 | <0.0001 |
| MCA/UA | 66.66 | 71.87 | 57.14 | 79.31 | 70 | <0.0001 |

**Table 11: Diagnostics value of Doppler findings for adverse pregnancy outcome.**

| Doppler findings | Adverse Pregnancy outcome | | | | | |
|---|---|---|---|---|---|---|
| | Sensitivity | Specificity | PPV | NPV | Accuracy | P value |
| MCA- PI | 86.24 | 50.63 | 62.23 | 80.24 | 64 | <0.05 |
| UA-PI | 90.26 | 80.57 | 82.24 | 88.35 | 84 | <0.001 |
| MCA/UA | 94.42 | 82.65 | 86.42 | 96.41 | 90 | <0.001 |

**Table 12: Association of absent EDF/Reverse EDF with mortality.**

| Spectral characteristics | Number of cases | IUD/Perinatal mortality | % |
|---|---|---|---|
| Absent EDF | 18 | 5 | 27.78% |
| Reverse EDF | 8 | 8 | 100% |
| Inference | Incidence of mortality is higher with reverse EDF with P is <0.05 ** | | |

**Table 13: Association of amniotic fluid with pregnancy outcome.**

| Amniotic fluid | Pregnancy outcome | | | | Total |
|---|---|---|---|---|---|
| | Normal | | Abnormal | | |
| | Number | % | Number | % | Number |
| Normal | 22 | 91.67 | 2 | 8.33 | 24 |
| Abnormal | 28 | 36.84 | 48 | 63.16 | 76 |
| Total | 50 | 50.0 | 50 | 50.0 | 100 |
| Inference | Abnormal amniotic fluid is significantly related to the abnormal pregnancy outcome with P <0.0001** | | | | |

## DISCUSSION

In patients with preeclampsia due to inadequate trophoblastic invasion of the maternal spiral arterioles there is abnormal placentation. This in turn causes increased vascular resistance in uteroplacental circulation and decreased perfusion, resulting in increased incidence of IUGR, fetal hypoxia and perinatal death.

Several investigators like Gramellini et al,[6] Berkowitz et al and Fairlie et al[8] have demonstrated the correlation between abnormal Doppler indices of fetal vessels and adverse perinatal outcome and fetal distress. Yoon BH et al demonstrated that an abnormal umbilical artery Doppler waveform is a strong and independent predictor of adverse perinatal outcome in patients with preeclampsia.[12] Mari G et al, have suggested that cerebral Doppler indices are associated with adverse perinatal outcome, while others like Gramellini et al[6] and Ozeren

M et al[14] have proposed the cerebral-umbilical ratio as a better predictor of adverse perinatal outcome.

In our study we studied umbilical artery PI, middle cerebral artery PI and MCA/UA PI ratio, a Doppler index that reflects both umbilical-placental and cerebral vascular beds for identifying compromised fetus.

It is important that the intra cranial artery be identified precisely and with certainty as PI varies in relation to the intra cranial artery considered, so in the evaluation of fetal cerebral circulation we used middle cerebral artery, as it is most accessible vessel and it can be easily located on color Doppler. It is the branch of the circle of Willis and carries 80% of the blood flow to the ipsilateral cerebral hemisphere, a constant 3-7% of cardiac output flows through it, during entire gestational period.

It is difficult to define normal and abnormal umbilical flow velocity before 30th week, except the absent EDFV after 20 weeks. Therefore we studied the Doppler indices of umbilical artery only after 30th week in agreement with Schulman[13] and Gramellini.[6]

Wladimiroff et al[9] reported that CP ratio does not vary significantly between 30 and 40 weeks of gestation Hence it is possible to use a single cut off value for CP ratio after 30 weeks. Arbeille et al[10] also found CP ratio to be constant during last 10 weeks of gestation and suggested a cut off value of 1.08 above which values are considered normal and below 1.08 values are abnormal.

In our study incidence of perinatal death/IUD, emergency LSCS for fetal distress, NICU admission and low Apgar score at 5 min were the criteria for adverse perinatal outcome, in concurrence with previous studies.

In the literature the criteria for cerebral redistribution vary, including MCA PI below the 5th percentile,[5] MCA pulsatility index below 2SD, UA/MCA pulsatility index ratio above 95th percentile,[5] UA/MCA resistance index above 1.0, MCA/UA RI ratio below 1.0 and MCA/UA

ratio of less than 1.08.[6] Comparison between different studies would be more meaningful if uniform or standardized criteria are used.

In present study of 100 cases, 46% had an adverse perinatal outcome, 68 patients had an abnormal MCA PI out of which 42 (61.76%) had at least one adverse perinatal outcome and others had normal outcome. 50 patients had abnormal UA PI (95th Centile) out of which 42 (84%) developed at least one adverse outcome. Abnormal MCA/UA PI ratio was seen in 55 patients of which 48 (87.27%) had an adverse perinatal outcome.

### Cerebroplacental ratio

In present study the MCA/UA pulsatility index ratio has high sensitivity and positive predictive value, 94.42% and 86.42% respectively, in predicting adverse perinatal outcome, compared to that of UA pulsatility index and MCA pulsatility index.

**Table 14: Comparison of CP ratio in predicting adverse perinatal outcome.**

| Study (year) | Sensitivity | Specificity | PPV | NPV |
|---|---|---|---|---|
| Gramellini et al.[6] (1992) | 68.0% | 98.4% | 94.4% | 88.8% |
| Fong KW et al.[15] (1999) | 51.3% | 80.6% | 48.1% | 82.5% |
| Ozeren et al.[14] (1999) | 81.0% | 89.0% | 84.0% | 86.0% |
| Present study | 94.42% | 82.65% | 86.42% | 96.41% |

Our study is comparable with that of Ozeren et al[14] and Gramellini et al[6] who also concluded that CP ratio had higher sensitivity and positive predictive value compared to MCA/PI and UA PI.

Present study is not correlating with Fong KW et al[15] who showed a sensitivity and PPV of 51.3% and 48.1% respectively, the difference may be because they included small for gestational age cases in there study.

### Umbilical artery pulsatility index

In present study, the UA PI had sensitivity and positive predictive value of 90.26% and 82.24% respectively.

Our findings are comparable with that of Yoon et al,[12] Gramellini et al[6] and Ozeren et al,[14] they concluded that abnormal umbilical artery Doppler is a strong and independent factor for predicting adverse perinatal outcome in women with PIH.

Present study is not correlating with Gutierrez et al[16] who showed a sensitivity of 44.0%. The difference may be because they used Doppler ultrasonography profile which included amniotic fluid volume, fetal movements, placental grading, and fetal growth pattern along with umbilical artery velocimetry.

**Table 15: Comparison of UA-PI in predicting adverse perinatal outcome.**

| Study (year) | Sensitivity | Specificity | PPV | NPV |
|---|---|---|---|---|
| Gramellini et al.[6] (1992) | 68.9% | 98.4% | 94.4% | 88.8% |
| Yoon et al.[12] (1994) | 89.0% | 86.0% | 86.0% | 89.0% |
| Ozeren et al.[14] (1999) | 69.0% | 97.0% | 95.0% | 81.0% |
| Gutierrez et al.[16] (2001) | 44.0% | 99.0% | 80.0% | 97.0% |
| Present study | 90.26% | 80.57% | 82.24% | 88.35% |

### Comparison of diagnostic accuracy

Our study shows highest diagnostic accuracy for CP ratio, followed by umbilical artery pulsatility index and least for middle cerebral artery pulsatility index.

**Table 16: Comparison of diagnostic accuracy.**

| Doppler index | Gramellini et al.[6] (1992) | Ozeren et al.[14] (1999) | Present study |
|---|---|---|---|
| CP ratio | 90.0% | 85.0% | 90.0% |
| UA PI | 83.3% | 85.0% | 84.0% |
| MCA PI | 78.8% | 58.0% | 64.0% |

Our study is comparable with that of Ozeren et al[14] and Gramellini et al.[6]

### Absent and reverse diastolic flow in umbilical artery

In our study of 100 cases there were 10 IUDs and 3 perinatal deaths. Out of which 8 had reverse end diastolic flow and 5 had absent end diastolic flow. A mortality rate of 27.78% in cases of AEDF and 100% in cases of REDF was observed.

**Table 17: Comparison of mortality with REDF and AEDF.**

| Study (year) | Mortality in % (AEDF) | Mortality in % (REDF) |
|---|---|---|
| Mandruzzato et al.[17] (1991) | - | 63.6% |
| Failrlie et al.[8] (1991) | 43.0% | - |
| Eronen et al.[18] (1993) | 30.0% | - |
| Yoon et al.[12] (1994) | 36.0% | - |
| Karsdrop et al.[19] (1994) | 41.0% | 75.0% |
| Chauhan et al.[20] (2005) | 26.0% | - |
| Present study | 27.78% | 100% |

Our results correlate with that of Chauhan et al,[20] Yoon, Fairlie[8] and Eronen[18] et al. The difference seen between our study and Mandruzzato et al[17] and Karsdrop[19] et al study may be because of better perinatal care available in their setup.

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