

## Original Article

# Cerebral and umbilical arterial blood flow velocity in normal and growth retarded pregnancy

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### Abstract

**Objectives:** To evaluate the cerebral and umbilical arterial blood flow velocity and its various indices during 3<sup>rd</sup> trimester of pregnancy and to compare these indices in normal and growth retarded pregnancies. **Method :** In this study, 50 women with normal singleton pregnancy and 50 women with intrauterine growth retarded (IUGR) pregnancy with expected birth weight <10<sup>th</sup> percentile of the normal for the gestational age were studied by doppler evaluation of their umbilical artery and middle cerebral arteries (MCA). Pulsatility index (PI), resistance index (RI), S/D ratio, and C/U of the control group were calculated and reference range constructed. Values of doppler indices of IUGR group were compared with those of the control group. Perinatal outcome was evaluated in relation to the indices. **Results:** Umbilical artery showed elevated indices in 47 out of 50 cases of the study group showing its high sensitivity in diagnosing hemodynamically compromised growth retarded fetuses. Absent end diastolic velocity (AEDV) and reversed end diastolic velocity (REDV) were seen in 2 and 1 case respectively and were associated with poor perinatal outcome. MCA values were decreased in 18 cases of the study group and had poor perinatal outcome in terms of need for lower segment cesarean section (LSCS) for fetal distress, apgar <7 at 1 minute, and admission to nursery. Cerebroumbilical (C/U) ratio of <1.08 was similarly associated with poor perinatal outcome. **Conclusions:** In normal pregnancy there is gestational age related fall in impedance in umbilical and middle cerebral arteries. Doppler study of umbilical artery is highly sensitive in the detection of IUGR while MCA doppler is very useful for the prediction of adverse perinatal outcome in small for gestational age.

**Key words:** intrauterine growth retardation, pulsatility index, resistance index, S/D ratio, middle cerebral artery

### Introduction

Doppler velocimetry is a rapid non-invasive test that provides valuable information about the hemodynamic situation of the fetus, is an efficient diagnostic test of fetal jeopardy and helps in the management of high risk

pregnancy. To reduce the perinatal morbidity and mortality of intrauterine growth retarded (IUGR) fetuses, their early detection and therapeutic intervention are important.

Though the failure of a fetus to attain or exceed its expected growth potential may result from numerous different pregnancy complications, the final common pathway most commonly encountered in practice is via uteroplacental insufficiency<sup>1</sup>. In fetal growth retardation the umbilical and intra-cranial arteries are the vessels most commonly examined<sup>2</sup>. When fetal growth

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retardation is diagnosed during the third trimester of pregnancy, the obstetrician must decide whether the fetus is ‘constitutionally’ small or small as a consequence of impaired placental perfusion. Doppler flow velocity analysis can be valuable in resolving this question<sup>3</sup>. In a group of high risk fetuses, doppler assessment of the umbilical artery and in particular the middle cerebral artery (MCA), and the aortic vessels was useful in predicting the fetuses with neonatal wasting<sup>4</sup>. There is significant association between the doppler waveform analysis and clinical outcome. The availability of doppler studies led to better obstetric decision making<sup>5</sup>.

**Aims and objectives**

In this study we evaluated the cerebral and umbilical arterial blood flow velocity waveforms and their various indices during the third trimester of pregnancy, calculated the ratio of pulsatility index (PI) of these two vessels and compared these indices in normal and growth retarded pregnancies.

**Methods**

This study included 50 women with normal singleton pregnancy as the control group and 50 women with singleton IUGR pregnancy as the study group and their gestational age ranged between 28 and 37 weeks. They were registered for delivery with us.

Inclusion criteria for the control group were: Normal pregnant women with known date of last menstrual period and with no medical, surgical or obstetrical complications that can affect fetal growth and normal

intrauterine fetal growth on clinical examination as well as on ultrasonography.

Inclusion criteria for the study group were: Known date of last menstrual period, clinical discrepancy of fundal height of four weeks or more and ultrasonography showing fetal weight less than 10<sup>th</sup> percentile of their gestation age based on femur length (FL) biparietal diameter (BPD) and abdominal circumference (AC)

Exclusion criteria for the control group: Any woman with medical complication e.g. chronic hypertension, chronic nephritis, diabetes, heart disease etc. and one with obstetric complication e.g. pregnancy induced hypertension bad obstetric history, hydramnios etc. were excluded.

Detailed history was taken and clinical examination was recorded in all the cases.

The study was carried out on ultrasound machine LOGIQ 500 MD with the facility of color doppler imaging. BPD, FL, AC and amniotic fluid index were measured and IUGR was corroborated. In the same sitting, doppler flow velocimetry of umbilical and middle cerebral artery was done and pulsatility index (PI), resistance index (RI), systolic diastolic ratio (S/D ratio) were calculated for both the vessels and cerebroumbilical ratio was also calculated. Women were divided into five groups of 28-29 weeks, 30-31 weeks, 32-33 weeks, 34-35 weeks and 36-37 weeks of gestation. All the women were followed until delivery. Mode of delivery and outcome in terms of birth weight, apgar score and admission to nursery were recorded. Data obtained were analyzed statistically using student t test.

**Table 1. Umbilical artery doppler indices.**

| Period of Gestation (in weeks) | PI   |                        | RI   |                        | S/D  |                        |
|--------------------------------|------|------------------------|------|------------------------|------|------------------------|
|                                | Mean | Upper limit (Mean+ISD) | Mean | Upper limit (Mean+ISD) | Mean | Upper limit (Mean+ISD) |
| 28-29                          | 0.99 | 1.07                   | 0.64 | 0.72                   | 3.07 | 3.57                   |
| 30-31                          | 0.98 | 1.06                   | 0.63 | 0.70                   | 2.86 | 3.16                   |
| 32-33                          | 0.93 | 1.03                   | 0.58 | 0.66                   | 2.55 | 2.9                    |
| 34-35                          | 0.89 | 0.99                   | 0.57 | 0.64                   | 2.43 | 2.83                   |
| 36-37                          | 0.83 | 0.95                   | 0.56 | 0.61                   | 2.37 | 2.64                   |

**Table 2. Middle cerebral artery indices.**

| Period of Gestation (in weeks) | PI   |                        | RI   |                        | S/D  |                        |
|--------------------------------|------|------------------------|------|------------------------|------|------------------------|
|                                | Mean | Lower limit (Mean-1SD) | Mean | Lower limit (Mean-1SD) | Mean | Lower limit (Mean-1SD) |
| 28-29                          | 1.94 | 1.67                   | 0.84 | 0.80                   | 5.78 | 4.98                   |
| 30-31                          | 1.85 | 1.49                   | 0.83 | 0.76                   | 5.68 | 4.49                   |
| 32-33                          | 1.68 | 1.42                   | 0.80 | 0.74                   | 5.66 | 3.99                   |
| 34-35                          | 1.60 | 1.30                   | 0.77 | 0.72                   | 5.17 | 3.9                    |
| 36-37                          | 1.56 | 1.20                   | 0.76 | 0.68                   | 4.66 | 3.7                    |

## Results

PI, RI, S/D ratio of the umbilical artery and MCA were calculated and reference values were constructed for comparison with the study group (Table 1,2). Cerebroumbilical (C/U) ratio was calculated as the ratio of PI of MCA/ PI of umbilical artery (Table 3).

All indices showed progressive fall with advancing gestation in normal pregnancy suggestive of decrease in peripheral impedance and increase in diastolic flow with progression of gestation in both the umbilical artery and MCA. When compared with the control group most (47/50) of the subjects in the study group showed elevated umbilical indices suggestive of decreased diastolic flow. However MCA flow was not decreased indicating brain sparing effect. But 18 subjects showed decreased MCA indices with increase in diastolic flow suggestive of

cerebral vasodilatation in response to hypoxia. Thirty two subjects had normal MCA indices.

Three subjects of the study group had normal umbilical artery indices with normal MCA indices, 29 subjects had elevated umbilical artery indices ( $>\text{mean}+1\text{SD}$ ) with normal MCA indices and 18 subjects had elevated umbilical artery indices with decreased MCA indices ( $<\text{mean}-1\text{SD}$ ).

There was absent end diastolic flow in two subjects and reversed diastolic flow in one subject.

P value of increase in PI, RI, S/D ratio of the study group in comparison to the control group was  $<0.001$  suggesting this to be highly significant.

Mean birth weight was 2030 gm in the study group and 2780 gm in the control group.

Lower segment cesarean section (LSCS) was required in 16 women in the study group (11 of them for fetal distress) and five in the control group (one of them for fetal distress).

Intra uterine death (IUD) occurred in two subjects in the study group.

Low apgar score of  $<7$  at 1 minute was seen in 25% of the study group compared to 6% in the control group.

Incidence of admission to nursery was higher in the study group (35.4%) compared to that in the control group (35.4% vs 6%).

**Table 3. Cerebroumbilical (C/U) Ratio in the control group**

| Period of gestation (in weeks) | C/U ratio |
|--------------------------------|-----------|
| 28-29                          | 1.95      |
| 30-31                          | 1.98      |
| 32-33                          | 1.85      |
| 34-35                          | 1.82      |
| 36-37                          | 1.80      |

There was high incidence of LSCS due to fetal distress, increased admission rate to nursery and low apgar at 1 minute with decreased MCA indices in the study group as compared to those with normal MCA indices in the study group (Table 4).

One subject with reversed end diastolic velocity (REDV) of umbilical artery with decreased MCA values had intrauterine death (IUD). Out of the two subjects with absent end diastolic velocity (AEDV) of umbilical artery with decreased MCA values one had IUD and the other with normal MCA values had a live birth by LSCS (Table 5).

**Table 4. Outcome in relation to middle cerebral artery indices (Study group).**

|   | Decreased | Normal | $\chi^2$ | DF | p     | Significance |
|---|-----------|--------|----------|----|-------|--------------|
| Cesarean delivery for fetal distress    | 7         | 4      | 5.89     | 1  | <0.01 | HS           |
| Apgar score <7 at 1 minute <sup>a</sup> | 7         | 5      | 4.50     | 1  | <0.05 | S            |
| Admission to nursery <sup>a</sup>       | 9         | 8      | 4.55     | 1  | <0.05 | S            |
| Intrauterine death                      | 2         | -      | 3.7      | 1  | >0.5  | NS           |
| Total                                   | 16        | 32     |          |    |       |              |

<sup>a</sup> Two patients of IUD not included in evaluating postnatal outcome.  
DF – Degree of freedom

**Table 5. Profile of women with AEDV/REDV.**

| Umbilical artery |                       |    | Middle cerebral artery |      |     | C/U ratio | Fetal outcome         | Birth weight(g) | Apgar at . 1.5 min | Adm. to nursery |
|------------------|-----------------------|----|------------------------|------|-----|-----------|-----------------------|-----------------|--------------------|-----------------|
| PI               | RI                    | SD | PI                     | RI   | SD  |           |                       |                 |                    |                 |
| 1.57             | REDV at 28 wks 5 days |    | 1.1                    | 0.52 | 3.3 | 0.70      | IUD at 30 wks         | 1000            | -                  | -               |
| 1.33             | AEDV at 36 wks 4 days |    | 1.35                   | 0.72 | 3.6 | 1.01      | LSCS at 36 wks 5 days | 2000            | 6 and 8            | Needed          |
| 1.9              | AEDV at 36 wks 4 days |    | 0.94                   | 0.52 | 2.4 | 0.49      | IUD at 36 wks 5 days  | 1400            | -                  | -               |

REDV – Reversed end diastolic velocity  
AEDV – Absent end diastolic velocity  
PI – Pulsatility index RI – Resistance index  
SD – Systolic / Diastolic ratio  
IUD – Intrauterine death  
LSCS – Lower segment cesarean section

**Table 6. Perinatal outcome with cerebroumbilical (C/U) ratio of 1.08 as cut off value.**

|                                   | C/U ratio<br><1.08 | C/U ratio<br>>1.08 | c2    | DF | p      | Significance       |
|-----------------------------------|--------------------|--------------------|-------|----|--------|--------------------|
| LSCS due to fetal distress        | 10                 | 1                  | 9.54  | 1  | <0.01  | Significant        |
| Apgar <7 at 1 minute <sup>a</sup> | 11                 | 1                  | 11.1  | 1  | <0.001 | Highly significant |
| Admission to nursery <sup>a</sup> | 13                 | 4                  | 10.89 | 1  | <0.001 | Highly significant |
| IUD                               | 2                  | -                  | 0.38  | 1  | >0.05  | Not significant    |

<sup>a</sup> Out of the 26 cases of C/U ratio <1.08, two cases with IUD were not included in the evaluation of outcome.

LSCS – Lower segment cesarean section

IUD – Intrauterine death

Absent end diastolic velocity and reversed end diastolic velocity also had poor perinatal outcome.

Cut off values of C/U ratio of <1.08 was associated with poor perinatal outcome (Table VI).

### Discussion

The gestational age related decrease of the PI in the umbilical artery has been reported by many authors and reflects a reduction of flow resistance in the placental villous circulation. Wladimiroff et al<sup>6</sup> constructed the reference range for PI of umbilical artery in the third trimester. The values calculated in our study corroborate with the values of Wladimiroff et al<sup>6</sup>, Lakhkar and Ahamed<sup>7</sup> who calculated the mean RI values at different gestational age amongst the normal pregnant women to be 0.70 at 28 weeks and 0.65 at 37 weeks. These are comparable to our values of 0.64 and 0.56 at 28 and 37 weeks respectively. S/D ratio calculated by Khurana et al<sup>5</sup> was 3.07 at 28 weeks and 2.64 at 37 weeks corresponding to our value of 3.07 at 28 weeks and 2.37 at 37 weeks.

Diastolic flow was seen to be reduced or even absent/reversed in growth retarded fetuses with consequent significant increases in PI, RI and S/D ratio values compared to the normal fetuses by Wladimiroff et al<sup>6</sup>, and Lakhkar and Ahamed<sup>7</sup>. These increases were highly significant in our study also.

Kirkinen et al<sup>8</sup>, Gramellini et al<sup>3</sup> and Chandran et al<sup>9</sup> studied MCA indices in normal and growth retarded pregnancies and constructed reference limits of PI and RI which showed progressive decline with advancing gestation. However in growth retarded pregnancy, they

observed that low PI and RI were associated with increase in perinatal risk. Our study observed that though MCA doppler indices were not sensitive in identification of IUGR, they were highly suggestive of poor perinatal outcome in fetuses with altered hemodynamics.

Thus umbilical artery doppler study is highly sensitive in detection of IUGR while MCA Doppler is very useful in predicting small for gestational age babies with adverse perinatal outcome when umbilical velocimetry is abnormal and low cerebroumbilical ratio (C/U) of <1.08 is a good predictor of adverse perinatal outcome.

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