

# Doppler Waveform Study: A Useful Diagnostic and Prognostic Tool in IUGR

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## ABSTRACT

**Introduction:** Intrauterine growth restriction (IUGR) is responsible for significant proportion of perinatal morbidity and mortality in developing countries. Doppler waveform study of fetal blood vessels and uterine artery (fetoplacental circulation) is an useful non invasive test to predict, diagnose and manage IUGR cases. Doppler waveform indices (S/D, pulsatility index, resistive index, positive and negative predictive values) help in deciding time of intervention and thereby help in decreasing perinatal mortality and morbidity. Present study aimed to study the Doppler wave form as a diagnostic and prognostic tool in IUGR

**Material and methods:** This prospective study was conducted over 100 singleton pregnancies between January 2015 and April 2017. First grey scale ultrasound was performed and fetal weight, amniotic fluid index and placental grading was calculated. Umbilical artery, uterine artery and middle cerebral artery waveforms were studied with Doppler ultrasound and doppler indices like S/D ratio, pulsatility index (PI), Resistive index (RI), sensitivity, specificity, positive and negative predictive values were calculated.

**Result:** Among all Doppler indices, cerebral – umbilical pulsatility ratio has proved to be more sensitive (sensitivity-74.01%) and specific (specificity-76.3%) indicator to predict fetal outcome in IUGR. Umbilical artery PI is also moderately sensitive (sensitivity- 57.4%) and specific (specificity-83.2%) indicator for IUGR prediction. MCA PI alone should not be used for screening purposes due to poor sensitivity (55.2%). Among grey scale indices HC/AC had the highest sensitivity (84.09) in diagnosing IUGR.

**Conclusion:** Doppler indices provide a useful non invasive modality for diagnosis and management of IUGR. Cerebral/umbilical pulsatility ratio has emerged as a more sensitive and specific Doppler indicator to predict fetal outcome.

**Keywords:** Pulsatility Index, Resistive Index, Cerebral/ Umbilical Ratio, Amniotic Fluid Index

uterine and middle cerebral artery as well as grey scale ultrasound indices like HC/AC ratio and oligohydramnios in diagnosis of IUGR as well as in prediction of adverse perinatal outcome. High incidence of IUGR in India is an important and significant contributor of high percentile morbidity and mortality. But it has also been suggested that screening of low risk women is not cost effective with no significant improvement in perinatal outcome.<sup>2</sup> Present study aimed to study the Doppler wave form as a diagnostic and prognostic tool in IUGR

## MATERIAL AND METHODS

This prospective study was conducted over 100 singleton pregnancies (after excluding dropout cases) between January 2015 and April 2017. The patients were recruited from Rajendra Institute of Medical Sciences, Seva Sadan and CIC (Chandrama Imaging and Health Center) outdoor and referred high risk cases for doppler study. Informed consents taken from all the patients and proper ethical and PNDT guidelines were followed. First grey scale Ultrasound was performed by transabdominal approach using the 3.5 Mhz curvilinear transducer color doppler machine with 1-3 mm sample volume and low filter. First fetal weight, Amniotic Fluid Index (AFI) and placental grading was calculated. Umbilical artery, uterine artery and middle cerebral artery wave forms were studied in all patients using Pulsed Doppler Ultrasound. The pregnancies were followed up till delivery and following data's were collected:-

1. Mode of delivery.
2. Gestational age at birth.
3. Birth weight.
4. 5- min Apgar score.
5. Number of fetal and perinatal death.
6. Admission to NICU with its duration.
7. Neonatal Complications or Morbidity

## Inclusion Criteria

- (a) Known LMP or 1<sup>st</sup> trimester USG should be available.
- (b) Singleton Pregnancy.

## INTRODUCTION

Doppler ultrasound has been in obstetrics since 1977 to study fetoplacental circulation (umbilical) and since 1980s to study the uteroplacental (uterine artery) circulation. Doppler ultrasound velocimetry provides a non invasive method of measuring changes in blood flow in uteroplacental and in fetoplacental circulation, thus assessing foetal wellbeing.<sup>1</sup>

Intrauterine growth retardation (IUGR) is defined as an estimated foetal weight below the 10<sup>th</sup> percentile for the gestational age. In India high incidence of IUGR is due to lack of awareness, late presentation for antenatal care in third trimester, illiteracy and poverty. Aim of this study was to determine the role of Doppler wave form indices of umbilical,

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- (c) Gestational Weeks between 28-37 weeks.
- (d) Clinically diagnosed case of IUGR (insufficient weight gain or no increase in abdominal girth)
- (e) High risk pregnancy: Mother of Preeclampsia, gestational hypertension. Essential hypertension, cases of previous history of IUGR baby, cases of previous or present Obstetric Cholestasis, cases of heart disease.

**Exclusion criteria**

- (a) Cases of unknown or unreliable LMP or unavailability of 1<sup>st</sup> T.M USG report.
- (b) Congenital Anomalies.
- (c) Multiple pregnancy.

**Doppler indices**

$$S/D \text{ ratio} = \frac{\text{Peak Systolic Velocity}}{\text{End diastolic Velocity}}$$

$$\text{Resistance Index} = \frac{\text{Peak Systolic} - \text{End Diastolic}}{\text{Peak Systolic Velocity}}$$

$$\text{Pulsatility Index (PI)} = \frac{\text{Peak Systolic} - \text{End Diastolic Velocity}}{\text{Mean Velocity}}$$

Data collected was analyzed using sensitivity, specificity and predictive values.

$$1) \text{ Sensitivity} = \frac{\text{True positive (TP)}}{(\text{True positive} + \text{false negative})} \times 100$$

$$2) \text{ Specificity} = \frac{\text{True negative (TN)}}{(\text{True negative} + \text{false negative [FN]})} \times 100$$

$$3) \text{ Positive Predictive Value} = \frac{\text{True positive}}{(\text{False positive [FP]} + \text{True positive})} \times 100$$

$$4) \text{ Negative Predictive Value} = \frac{\text{True negative}}{(\text{True negative} + \text{false negative})} \times 100$$

**STATISTICAL ANALYSIS**

The data was analyzed statistically using the Microsoft Excel Software. We calculated the sensitivity, specificity, predictive values of above indices.

Interpretation of Doppler finding:

Doppler study was considered abnormal when- Uterine Artery (on the side of placenta)

- Bilateral diastolic notches in Uterine Artery.
- Or
- Mean RI > 0.56
- Or
- S/D ratio > 2.6

Umbilical Artery:

- S/D ratio >3
- Or
- S/D Value more than 95<sup>th</sup> percentile of reference values<sup>3</sup>.
- Or
- Pulsatility index more than 95<sup>th</sup> percentile.
- Or

- If diastolic flow was absent or reversed.

Middle Cerebral Artery:

- MCA/UA PI ratio (called C/U ratio) less than 1 or less than 2 S. D.
- MCA / UA, S/D ratio less than 1.

**RESULTS**

In our study maximum patient were between 21-25 years (62%). Maximum patient were multiparous (60%). Delivery was by Lower Segment Caesarean Section in 54% of cases. Maternal hypertension was associated in 46% of cases. In 8% of cases there was preterm delivery. Neonatal death was in 4% of cases and still born in 8%. Mean birth weight was 2119 ± 1211. In our study maximum deliveries (72%) were between 34-37 weeks. One delivery was at 30 weeks of gestation.

Birth weight between 2-2.5 kg in 42%, between 1.5-2 kg in 34% and in 18% birth weight was above 2.5 kg, Mean between weight was 2211 ± 1211 (grams ± 2 SD). In 82% birth weight was below 10<sup>th</sup> percentile. In 27%, APGAR score was less than 7 in 5 min. Neonatal complication was found in 27% and in 22% duration of NICU stay was more than 24 hrs. Perinatal mortality was 14%. Hypoglycemia was in 2%, neonatal hyperbilirubinemia in 8%, intracranial hemorrhage in one case and early onset septicemia was in 3% of cases. Predictive values, sensitivity, specificity of HC/ AC and oligohydramnios are shown in table 2 and table 3. Summary of predictive values of different Doppler indices

Maternal characteristics	No. of patients	Percentage (%)
Age groups(in years)		
≤20	9	9
21-25	62	62
26-30	24	24
≥31	5	5
Parity		
primiparous	37	37
multiparous	63	63
Pregnancy complications		
maternal hypertension	46	46
suspected fgr	14	14
Bad obstetric history	10	10
oligohydramnios	16	16
heart disease	2	2
post term pregnancy	2	2
anemia	10	10
Mode of delivery		
Full term spontaneous vaginal delivery	10	10
Induced full term vagina delivery	28	28
Induced preterm vaginal delivery	8	8
Caesarean section	54	54
Indication for caesarean section		
Fetal distress	22	40.75
Severe preeclampsia	20	37.03
Others	12	22.22

**Table-1:** Maternal characteristics of study population

Fetal outcome	No. of findings				Sensitivity	Specificity	Predictive value	
	TP (a)	FP (b)	TN (d)	FN (c)	a/(a+c)	d/(b+d)	Positive a/(a+b)	Negative d/(c+d)
Low birth weight	74	2	10	14	84.09%	83.33%	97.36%	41.66%

**Table-2:** Predictive value of HC/AC ratio for detecting abnormal fetal outcome

Fetal outcome	No. of findings				Sensitivity	Specificity	Predictive value	
	TP (a)	FP (b)	TN (d)	FN (c)	a/(a+c)	d/(b+d)	Positive a/(a+b)	Negative d/(c+d)
Low birth weight	20	0	12	68	22.72%	100%	100%	15%

**Table-3:** Predictive value of oligohydramnios for detecting abnormal fetal outcome

Criterion	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
Bilateral notches in Ut A	15.2	93.6	71	56.1	57.2
Ut A Mean Ri >0.56	71.3	82.7	78	76.2	76.8
Ut A S/D ratio >2.6	47.2	91.8	79.9	65.8	70
Ua S/D >95 <sup>th</sup> percentile	38.9	87.2	70.9	68.2	69
Ua S/D >3	70.4	68.3	60.8	77.2	68
Ua Pi >95 <sup>th</sup> percentile	57.4	83.2	74.3	70.1	70
Aedv/Redv	20	100	100	59.2	62.5
Mca Pi <lower limits	55.2	72.2	66.3	62.8	67
Mca Pi/Ua Pi < (Mean-2SD)	74.01	76.3	72.7	78.3	74
Mca Pi/Ua Pi <1	54.1	89.9	82.1	69.2	73
Mca/Ua [SD] <1	46.2	85.3	68.2	70.01	68
Dv abnormality	14.9	100	100	57	60
All parameters	93.6	45.3	60.2	88.9	68

**Table-4:** Predictive ability for adverse outcome of doppler indices

are shown in table 4.

## DISCUSSION

One of the main aims of routine antenatal care is to identify the 'at risk' fetus in order to apply clinical intervention which could result in reduced perinatal morbidity and mortality. In our study maximum patients were of PIH (46%) which shows high incidence of IUGR association in maternal hypertension.

In IUGR cases "Brain Sparing Effect" of blood circulation is responsible for growth retardation of foetal body in comparison to head. As reported by Kajrak et al<sup>4</sup> in his study AC was found to be a better indicator of IUGR as compared to HC and BPD. In our study Predictive values and sensitivity, specificity is shown in table 2 and 3. This shows that HC/AC ratio is quite sensitive and oligohydromnios is a highly specific grey scale USG indices to diagnose IUGR. HC/AC has however lower specificity and oligohydromnios has very poor sensitivity. After introduction of Doppler, umbilical artery has been the most studied artery. In normal pregnancy, the three indices, S/D, PI and RI decreases with advancing gestation in umbilical artery.<sup>5</sup> But in IUGR, first there is decreased diastolic flow in the umbilical artery due to increase in the resistance that occur in the small arteries and arterioles of the tertiary villi, this raises the S/D ratio of PI and RI of Umbilical Artery. As the placental insufficiency worsens, the diastolic flow decreases, then become absent and later reverses. This absence of diastolic flow is often associated with adverse outcome e.g. IUGR and foetal

hypoxia. The prevalence of perinatal death in fetuses with absent or reversed end diastolic flow velocity is reported to be over 40%.<sup>6</sup> Yoon et al<sup>7</sup> demonstrated in their study that absent umbilical artery waveform is a strong and independent prediction of adverse perinatal outcome. Umbilical artery PI > 95<sup>th</sup> percentile was associated with adverse perinatal outcome which was comparable with study of Gramellini D et al.<sup>8</sup> In our study adverse perinatal outcomes have been found when uterine artery S/D was 2.6 with or without bilateral diastolic notches. R/I > 0.56 in uterine artery was found in all the patients with bilateral diastolic notches. The result of our study for uterine artery S/D ratio > 2.6 are associated with poor fetal outcome. Recently the cerebral/umbilical pulsatility ratio (C/U ratio) has proved to be more sensitive and specific indicator to predict foetal outcome in IUGR. This has been demonstrated by Bano et al<sup>9</sup>, Jurisic et al<sup>10</sup> and Banu et al.<sup>11</sup> Among all indices HC/ AC had the highest sensitivity (84.09) in diagnosing an abnormal outcome. Among different Doppler indices, C/U ratio is found to be best of all (Sensitivity = 74.01 and NPV = 78.3). The presence of oligo hydromnios and abnormal C/U ratio had the highest specificity in diagnosing an adverse perinatal outcome. Presence of oligohydromnios and abnormal C/U ratio had the highest positive predictive value in predicting abnormal perinatal outcome in IUGR. Increased HC/AC had the highest negative predictive value (41.66).

## CONCLUSION

In diagnosis as well as in prediction of adverse perinatal

outcome Doppler indices of umbilical uterine and middle cerebral artery provides practical and reasonably reliable information and helps in determining the appropriate time of intervention or delivery. The C/U ratio is a more sensitive as well as specific parameter to diagnose and predict adverse outcome in IUGR<sup>12</sup> than the umbilical artery PI, which is also a moderately sensitive and specific indicator of foetal compromise in IUGR. The MCA PI should not be used for screening purposes in IUGR, as alone it is not a sensitive indicator. C/U ratio is also more sensitive than oligohydromnios and more specific than HC/AC for diagnosis of IUGR. But still more and more studies are required of different foetal blood vessels to standardize the different reference values and to allow the standard comparison.

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