RESEARCH ARTICLE

Study of the Significance of Fetal Doppler Flow Velocimetry in the Perinatal Outcome of Growth-restricted Fetuses

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ABSTRACT

Purpose: To evaluate clinically suspected cases of intrauterine growth restriction (IUGR) for Doppler study of uterine artery, umbilical artery, and fetal middle cerebral artery. To compare the various indices of the three vessels in predicting perinatal outcome. To evaluate the positive predictive value among these parameters. To compare the Doppler findings with fetal outcome.

Materials and methods: One hundred and two singleton pregnancies complicated by IUGR and severe preeclampsia or both were prospectively examined with Doppler ultrasound of the umbilical artery, middle cerebral artery, and umbilical vein which were compared with 104 uncomplicated pregnancies that formed the control group.

Observation and Results: One hundred and two singleton pregnancies included in the study population had at least one major or minor adverse outcome. Major adverse outcome criteria included perinatal deaths – including intrauterine and early neonatal deaths, etc. Minor outcomes included cesarean delivery for fetal distress, APGAR score below 7 at 5 minutes, and admission to neonatal intensive care unit for treatment.

Conclusion: Low diastolic and high indices characterize the pregnancies with abnormal outcomes. The uterine artery had a better sensitivity and specificity as compared with the umbilical arteries and diastolic notch had the highest sensitivity and specificity. Doppler also provides a noninvasive method of assessing the fetal and maternal circulation during pregnancy.

Keywords: Intrauterine growth restriction, Middle cerebral artery, Umbilical artery, Umbilical vein.

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INTRODUCTION

Identification of the pregnancies at risk for preventable perinatal morbidity and mortality is a primary goal of obstetric care provider.[1] Intrauterine growth restriction is a clinical sign of chronic fetal hypoxemia.[1] Intrauterine growth restriction is a syndrome characterized by failure of the fetus to attain its normal growth potential.[2] Intrauterine growth restriction is associated with significant morbidity in the form of meconium aspiration syndrome, hypoglycemia, hyaline membrane disease, early-onset sepsis, intrapartum asphyxia, delayed milestones, and stillbirth in extreme cases.[2] It is estimated that 3 to 10% of the infants are growth restricted.[2] The perinatal mortality rate for these infants is 6 to 10 times greater than that for a normally grown population. This can be lowered by timely identification and management of growth-restricted fetuses.

The use of Doppler flow velocimetry has helped in better management of IUGR fetuses.[2] It provides information on the blood perfusion of the fetoplacental unit.[1] In normal pregnancies, the flow velocity waveforms (FVWs) showed a good diastolic flow and fall in indices as pregnancy progressed.[3] Depending on other clinical factors, reduced, absent, or reversed umbilical artery end diastolic flow is an indication for enhanced fetal surveillance and delivery.[4]

MATERIALS AND METHODS

This prospective study was carried out in the Department of Radiodiagnosis in a tertiary care hospital for a duration of 3 years. Pregnant women with a clinical suspicion of IUGR, patients with decreased fundal height as compared with gestational age by last menstrual period (LMP), a bad obstetrics history, pregnancy-induced hypertension (PIH), gestational diabetes, and severe anemia were taken which formed the study group and comprised of 102 patients. Pregnant women without any evidence of IUGR and normal ultrasound growth parameters formed the control group which comprised of 104 patients.

Routine obstetrical examination in terms of biparietal diameter, head circumference, abdominal circumference, femur length along with amniotic fluid index (AFI), placental grading, and location and expected fetal weight were done prior to the Doppler examination.

DOPPLER VASCULAR TECHNIQUE

Bilateral uterine arteries were identified by obtaining the color flow per abdomen after pointing the probe in the iliac fossa toward the lower paracervical region. In the color mode, uterine artery is seen to cross the external iliac artery and this point was taken as the sampling point. Measurements from the right and left uterine arteries were labeled as placental and nonplacental with respect to their proximity to placenta, and only placental values were considered for statistical analysis.

Umbilical artery was identified within the amniotic fluid by the appearance of parallel line echoes which display a pulsatile activity on real-time images. The recording was taken close to the placental site of the umbilical cord.

Middle cerebral artery was identified by locating the circle of Willis in the longitudinal sagittal section of the fetal skull.

CALCULATION OF INDICES

Only those FVWs that had a sharp and clear outline were accepted. When three waveforms of satisfying quality had been obtained, pulsatility index (PI) and resistance index (RI) values were measured using an onscreen cursor for each FVW. The average of these three FVWs was recorded.

Quantitative indices were calculated from the peak systolic velocity (V_{peak}), mean flow velocity (V_{mean}), and diastolic velocity (V_{diast}). These indices are independent of the beam angle and, therefore, are unaffected by the imprecise angle data.

$$PI = \frac{V_{peak} - V_{diast}}{V_{mean}}$$

$$RI = \frac{V_{peak} - V_{diast}}{V_{peak}}$$

MEASUREMENT OF PERINATAL OUTCOME

Outcome was divided into intrauterine death, poor, and good. Poor and good outcome were measured in terms of 5 minutes APGAR score.

The outcome was labeled as
- Poor when the 5 minutes APGAR score was <7
- Good when the 5 minutes APGAR score was ≥7

Analysis for the perinatal outcome was done by calculating the sensitivity, specificity, positive predictive value (PPV), and the negative predictive value (NPV).

Sensitivity measures the proportion of actual positives which are correctly identified as such:

$$Sensitivity = \frac{Number\ of\ true\ positives}{Number\ of\ true\ positives\ +\ Number\ of\ false\ negatives}$$

Specificity measures the proportion of negatives which are correctly identified:

$$Specificity = \frac{Number\ of\ true\ negatives}{Number\ of\ true\ negatives\ +\ Number\ of\ false\ positives}$$

Positive predictive value is the proportion of patients with positive test results who are correctly diagnosed. It is the most important measure of a diagnostic method as it reflects the probability that a positive test reflects the underlying condition being tested for.

$$PPV = \frac{Number\ of\ true\ positives}{Number\ of\ true\ positives\ +\ Number\ of\ false\ positives}$$

Negative predictive value is the proportion of patients with negative test results who are correctly diagnosed.

$$NPV = \frac{Number\ of\ true\ negatives}{Number\ of\ true\ negatives\ +\ Number\ of\ false\ negatives}$$

OBSERVATION AND RESULTS

One hundred and two singleton pregnancies with clinical suspicion of IUGR comprised the study group, which included patients with decreased fundal height as compared with gestational age by LMP (29), a bad obstetrics history (11), PIH (41), gestational diabetes (5), and severe anemia (14). Patients in the study group as well as control group mostly belonged to a low socioeconomic status. Majority of the patients (52.9%) in the study group had liquor index between 6 and 8 cm. For poor perinatal outcome, raised value of uterine artery RI and raised systolic/diastolic (S/D) ratio of umbilical artery showed maximum sensitivity and PPV, which suggests high diagnostic accuracy (Fig. 1). Prediastolic notch in the uterine artery also showed a high sensitivity and PPV in predicting poor outcome (Fig. 2). Raised umbilical artery PI and RI and absent/reversed diastolic flow in umbilical artery showed significant specificity and NPV for poor perinatal outcome, which helped us to exclude IUGR (Figs 3 to 5). Abnormal values of RI, PI, and S/D in the fetal MCA also showed a significant specificity for poor perinatal outcome (Fig. 6). A comparative analysis of the indices of uterine, umbilical, and middle cerebral artery was done and it was found that uterine and umbilical artery are most sensitive in determining IUGR (Table 1).
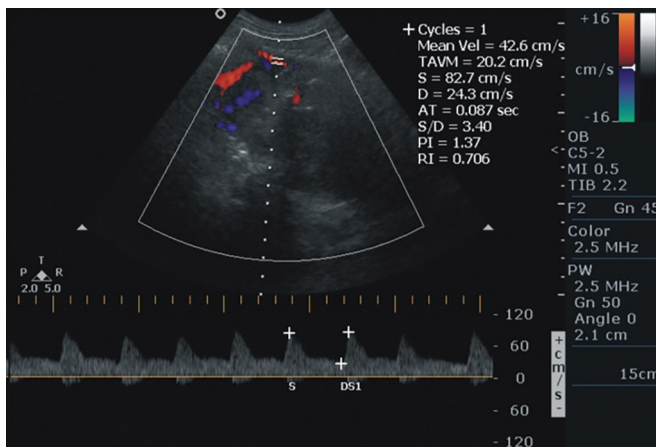
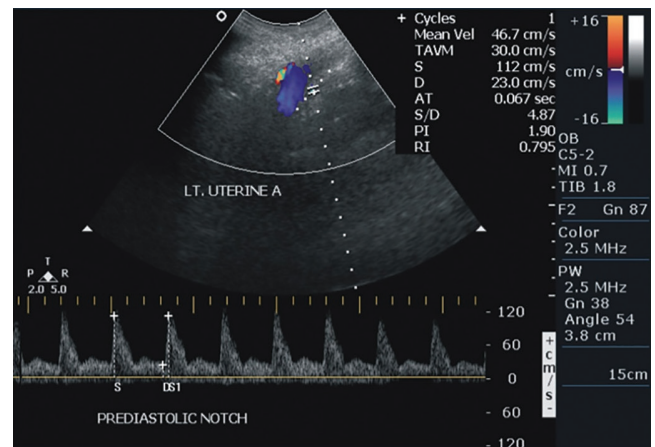**Fig. 1:** Raised value of RI, PI, and S/D in uterine artery
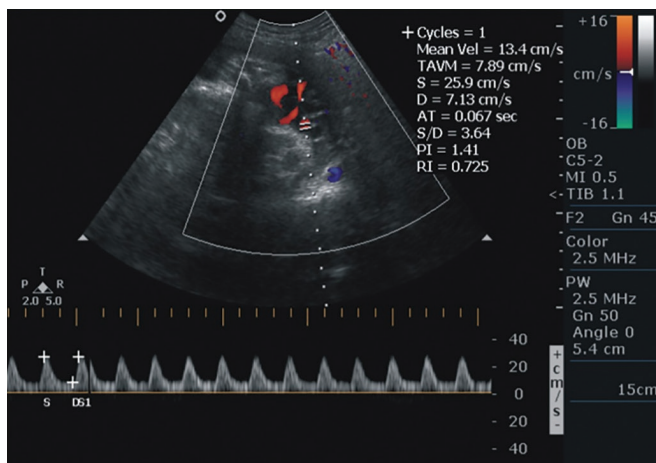

Fig. 2: Prediastolic notch in uterine artery

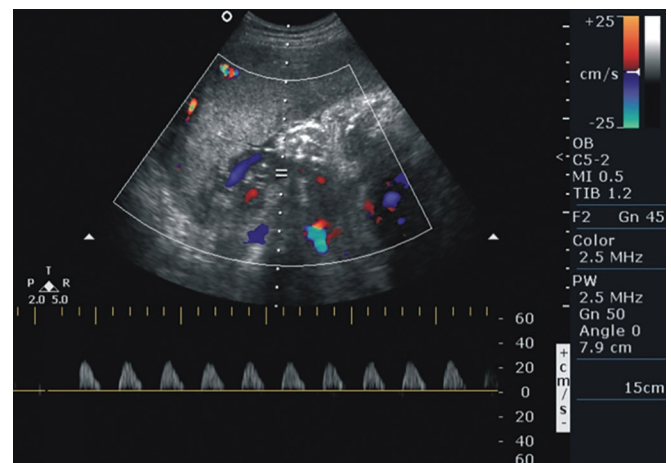**Fig. 3:** Raised PI and RI in umbilical artery

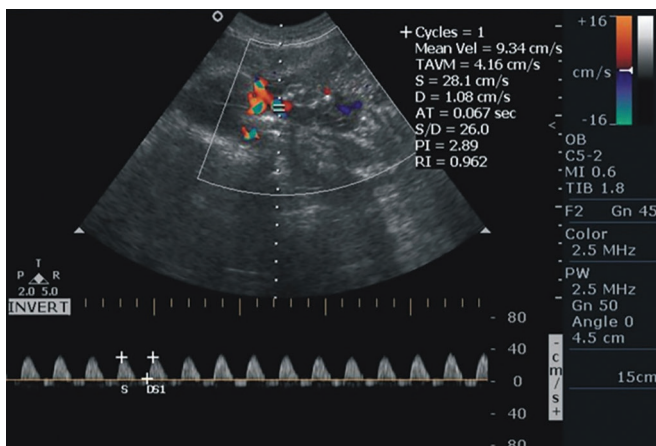**Fig. 4:** End diastolic flow in umbilical artery

Fig. 5: Reversed end diastolic flow in umbilical artery

Fig. 6: Decreased RI in middle cerebral artery

DISCUSSION

The present study was carried out in the Department of Radiodiagnosis and Imaging where patients with clinical suspicion of IUGR and normal singleton pregnancies underwent routine obstetric and Doppler evaluation. The Doppler findings were correlated with the perinatal outcome which was categorized as intrauterine device (IUD), poor, and good based on the APGAR score.

Economic Status

In our study, maximum number of cases in the study group (62.7%) as well as the control group (66.3%) were having their monthly income between Rs. 2,500 and Rs. 4,000. This implies that the majority of the population is from low socioeconomic status. Our study was correlated with that of McCowan et al[5] who also showed that newborn morbidity is associated with malnutrition.

Table 1: Comparative analysis of indices of uterine artery, umbilical artery, and middle cerebral artery for perinatal outcome

Perinatal outcome		Uterine artery				Umbilical artery					Middle cerebral artery					
		RI%	PI%	S/D%	Diastolic notch %	RI %	PI %	S/D %	Absent diastolic flow %	Reversed diastolic flow %	RI raised %	RI reduced %	PI raised %	PI reduced %	S/D raised %	S/D reduced %
IUD	Sensitivity	100	100	100	100	100	100	100	50	50	66.0	33.3	66.6	33.3	66.6	33.3
	Specificity	40.4	46.4	48.8	36.9	58.1	52.3	48.8	96.5	100	93.0	69.7	95.3	76.7	96.5	62.7
	PPV	10.7	11.7	12.2	10.1	14.2	12.7	12.0	50	100	40.0	7.1	50.0	9.0	57.1	5.8
	NPV	100	100	100	100	100	100	100	96.5	96.6	97.5	93.7	97.6	94.25	97.6	93.1
Poor	Sensitivity	86.9	77.8	79.4	78.8	68.4	78.9	82.8	7.8	0	11.15	40.7	7.8	29.4	5.3	41.0
	Specificity	63.9	57.4	60.7	52.9	70.3	68.5	63.1	94.1	95.3	89.4	84.2	90.2	82.9	88.8	69.4
	PPV	71.4	54.9	55.1	69.4	61.9	63.8	58.0	50.0	0	60.0	78.5	50.0	68.1	42.8	67.6
	NPV	82.3	79.4	82.9	64.5	76.0	82.2	85.7	57.8	69.6	41.4	50.0	40.0	48.55	37.6	43.1
Good	Sensitivity	26.3	35.4	32.0	37.5	20.8	22.9	29.4	0	0	0	12.5	0	14.2	0	30
	Specificity	11.5	19.0	17.5	18.9	27.3	18.2	14.6	85.3	95.0	83.3	6.0	86.0	70.1	88.7	59.6
	PPV	17.8	33.3	32.6	20.3	23.8	23.4	30.0	0	0	0	14.2	0	22.7	0	26.4
	NPV	17.6	20.5	17.0	35.4	24.0	17.8	14.2	42.1	66.2	60.9	56.2	58.3	57.1	64.7	63.7

IUD: Intrauterine device

Amniotic Fluid Volume

In our study, most of the cases in the study group (53%) were having AFI in the range of 6 to 8 cm. Twenty-four percent patients had severe oligohydramnios. Only 20 of them had normal liquor. Those with oligohydramnios were more commonly associated with IUGR and this was in accordance with the findings of Divon et al[6] and Doubilet and Benson[7] who concluded that patients with oligohydramnios were highly associated with IUGR fetuses and patients with normal liquor do not guarantee an average gestational age fetus.

Effective Fetal Weight

In our study comprising the study group (suspected IUGR) and control group, it was noted that 72% cases in the study group were <10th percentile for that gestational age; however, 28% were >10th percentile. In the control group, patients with <10th percentile effective fetal weight were 18%.

Our study showed a sensitivity of 72% and specificity of 82% which is comparable to the studies by Benson et al[8] who found a sensitivity of 89% and a specificity of 88% by use of effective fetal weight in diagnosing IUGR.

Uterine Artery Doppler Analysis

Raised Uterine Artery RI

The RI value for uterine artery had 100% sensitivity and 100% NPV for IUD.

For poor perinatal outcome, raised RI value showed 86.9% sensitivity, 63.9% specificity, and an NPV of 82.3%.

Steel et al[9] studied 200 primiparae who underwent continuous wave Doppler investigation of the uteroplacental circulation. Seventy-five women with abnormal waveforms suggestive of the high uteroplacental resistance (RI ≥ 0.58) were tested again later in gestation when 21 demonstrated a persistent abnormality. Only nine of these went on to have an uncomplicated pregnancy, as compared with 150 of the remainder. They showed a sensitivity of 33%, specificity of 91%, and PPV of 40% and NPV of 89.0% for poor perinatal outcome.

Raised Uterine Artery Pulsatility Index

Raised value for PI was 100% sensitive and 100% NPV for IUD. However, for poor perinatal outcome, it was 77.8% sensitive, 57.4% specific, 54.9% PPV, and 79.4% NPV.

Lakhkar and Ahamed[3] studied the PI of uterine arteries during pregnancy. They concluded that the uterine artery had a better sensitivity and specificity as compared with the umbilical artery. They concluded that raised PI value is 50% sensitive and 90% specific for poor perinatal outcome. It had a 91% NPV.

Prediastolic Notch in Uterine Artery

Prediastolic notch was 100% sensitive and NPV for IUD.

It showed 78.8% sensitivity for poor perinatal outcome. Specificity was 52.6% and PPV of 69.4% and NPV being 64.5%.

McLeod[10] found that presence of an early diastolic notch in the waveform is associated with associated with adverse outcomes and low APGAR scores.

S/D Ratio of the Uterine Artery

Raised S/D ratio had 100% sensitive and NPV for IUD. However, for poor perinatal outcome, it showed 79.4% sensitivity, 60.7% specificity, and PPV of 55.1% and a NPV of 82.9% which correlates with the findings of Trudinger et al[11] who evaluated maternal uteroplacental as well as placental circulation and concluded that neonatal morbidity occurred in those who had abnormal studies with low diastolic flow velocities, indicating high resistance (S/D ratio > 3). They showed a sensitivity of 82.4%, specificity of 74.1% for raised S/D ratio in predicting poor perinatal outcome.

Umbilical Artery Doppler Analysis

Raised Umbilical Artery RI

Raised value for RI showed 100% sensitivity and NPV for IUD. It had 68.4% sensitivity, 70.3% specificity, 61.9% PPV, and 76.0% NPV for poor perinatal outcome.

McCowan et al[5] evaluated 186 women and compared umbilical artery Doppler parameters between small-for-gestational age (SGA) fetuses with normal and abnormal Doppler parameters. They showed that abnormal umbilical artery Doppler studies reflect earlier onset and more severe growth restriction and are not independently associated with newborn morbidity. The SGA babies with normal Doppler studies had a high rate of newborn nursery admission and malnutrition at birth.

Raised Umbilical Artery PI

Raised value for PI was 100% sensitive for IUD. For poor perinatal outcome it was 78.9% sensitive and 68.5% specific. Positive predictive value for it was 63.8% and NPV was 82.2%.

Gramellini et al[12] gave sensitivity of 64%, specificity of 90.7%, PPV of 72.7%, and NPV of 86.7% for raised PI value in predicting adverse perinatal outcome.

Diastolic Flow in the Umbilical Artery

Reversed diastolic flow was 100% specific and positive predictive for IUD; however, it was 50% sensitive for IUD.

Poor perinatal outcome was most sensitive with absent end diastolic flow and most specific with reversed end diastolic flow.

Arabin et al[13] studied 137 high-risk fetuses and found that there was evidence of high rate of perinatal mortality in patients with absent end diastolic flow and also there was evidence of higher rate of cesarean section in the group with absent diastolic flow.

Raised Umbilical Artery S/D Ratio

Raised S/D ratio was 100% sensitive and NPV for IUD; however, for poor perinatal outcome, it was 82.8% sensitive. Specificity was 63.1%. It had a PPV of 58.0% and a NPV of 85.7%.

Rochelson et al[14] described that patients with abnormal S/D ratio had a significantly higher incidence of abnormal fetal heart distress (55%). There were six perinatal deaths with elevated ratio and none in the group with normal ratio.

Middle Cerebral Artery Doppler Analysis

Resistance Index

Raised RI value had a sensitivity of 11.1% for poor outcome and 66.0% for IUD. However, sensitivity for reduced RI value was 40.7% for poor outcome and 33.3% for IUD.

However, the specificity for raised RI value for poor outcome was 89.4 % and for IUD it was 93%. For reduced RI value, specificity was 84.2% for poor perinatal outcome.

Mathias[15] in his studies also showed that raised value of RI in middle cerebral artery is an indicator for chronic fetal hypoxia and poor perinatal outcome. He obtained a specificity of 79% for raised RI value in predicting poor perinatal outcome.

Pulsatility Index

Reduced value of PI was 29.4% sensitive for poor perinatal outcome and 82.9% specific for poor outcome. However, for raised PI value, sensitivity was 7.8% and specificity was 90.2 %.

Detti et al[16] stated that in IUGR fetuses with MCA PI below the normal range, there is a greater incidence of adverse perinatal outcome. The disappearance of the brain sparing effect seems to precede fetal death and showed a significant specificity for IUD (70.1%) and poor perinatal outcome (85.0%).

S/D Ratio

Raised value of S/D ratio had a low sensitivity for poor outcome; however, it had a very high sensitivity for IUD. Reduced value for S/D ratio had a sensitivity of 93.3% for IUD and 69.4% for poor perinatal outcome.

In studies done by Sterne et al[17] abnormal values S/D were highly predictive for poor outcome and there was an emergent need from delivery for raised value of S/D ratio.

CONCLUSION

Single artery Doppler evaluation can predict the perinatal outcome. Combination of different arterial waveform study enhances the diagnostic accuracy in identifying those intrauterine restricted fetuses that were at risk.

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