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RESEARCH ARTICLE

Study of doppler velocimetry in predicting perinatal outcome of clinically suspected intrauterine growth restricted foetuses

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ABSTRACT

Objectives: To determine and compare the diagnostic performance of doppler sonography of fetal umbilical artery (UA) and middle cerebral artery (MCA) in prediction of adverse perinatal outcome in suspected intrauterine growth retardation (IUGR). **Methodology:** One hundred singleton pregnancies between 28 and 40 weeks of gestation complicated by intrauterine growth restriction were prospectively examined with doppler ultrasonography of the UA and MCA and were correlated with fetal outcome. **Results:** Of the 100 cases, 52 had elevated umbilical systolic/diastolic (S/D) ratio, 58 had elevated umbilical resistance index (RI), 63 had elevated umbilical pulsatality index (PI). 58 had abnormal MCA S/D, 47 had abnormal MCA RI, 43 had abnormal MCA PI and 57 had cerebroplacental ratio (CPR) <1.08. Birth weight <10th percentile was highest (63.1%) in the abnormal CPR group. LSCS for fetal distress incidence was maximum (30.2%) in the abnormal MCA PI group. 53.4% meconium stained liquor was seen in the elevated umbilical RI group. Maximum perinatal mortality was present in the abnormal MCA PI group (41.8%). NICU stay for >48 hrs was maximum (56.1%) in the CPR<1.08 group. CPR had the highest sensitivity (100%) in predicting more than one adverse perinatal outcome. **Conclusion:** Doppler studies of multiple vessels in the fetoplacental circulation can help in the monitoring of compromised fetus and can help us predicting neonatal morbidity and mortality. This is helpful in determining the optimal time of delivery in complicated pregnancies.

Keywords: Doppler, umbilical artery, middle cerebral artery, cerebroplacental ratio.

Intrauterine growth retardation (IUGR) still remains the major cause of fetal wastage inspite of major advances in fetal medicine. IUGR is an indicator of chronic fetal hypoxemia. Detecting the IUGR fetus, which is at risk of perinatal complications, is an ongoing challenge in obstetrics. Prematurity and IUGR are the first and second leading causes of perinatal mortality and morbidities respectively [1]. IUGR is defined as a fetus with a birth weight at or below the 10th percentile or < 2SD for the gestational age and sex [2]. It was reported that, IUGR complicates about 10% of all pregnancies [3]. The IUGR fetuses carry 6-10 times greater risk for the perinatal mortality in comparison to the fully grown fetuses [4]. During the development, the invasion of trophoblasts convert the highly resistance spiral arteries into low impedance utero-placental circulation in a normal pregnancy. However, this transformation remains incomplete in IUGR [2].

Accurate predictors like doppler studies are essential to manage the IUGR for the better fetal outcome. The infants whose birth weight is below the 10th percentile and without exposure to any of the pathological process in the intrauterine life are labelled as the small but healthy babies. The fetus with pathologic growth restriction and at risk of perinatal complications needs to be differentiated from the constitutionally small but healthy fetus [5]. The use of Doppler can offer this information, which is not possible from the

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other conventional tests [6].

The accurate gestational age of the fetus is essential to diagnose the IUGR. This can be accomplished early in pregnancy by the fundal height measurement and ultrasound biometric parameters [7]. These parameters will detect fetal weight but not the fetal health, which can be effectively detected by assessing the fetal circulation using doppler ultrasonography. The normal range of abdominal circumference excludes the IUGR and the measurement below the 5th percentile is suggestive of growth restriction [8]. In high risk pregnancy, consideration has to be given to the repeated ultrasound evaluation.

The aim of the fetal medicine is not just to prevent the occurrence of IUGR in high risk pregnancies, but also to deliver the fetuses before they have suffered from hypoxia [6]. The doppler velocimetry is a non-invasive test, which can provide best information about the hemodynamic status of the fetus. This is an efficient diagnostic test of the fetal jeopardy, which helps in the management of high risk pregnancy [2]. In case of suspected growth restriction and possible fetal hypoxemia, serial doppler examinations have to be performed to identify the best time for the delivery, allowing maximum maturity with minimal hypoxia and acidosis [9].

Materials and methods

This prospective observational study was conducted in a tertiary care teaching hospital from December 2020 to August 2021. One hundred women with singleton pregnancies between 28 to 40 weeks of gestation complicated by IUGR were selected for the study. Informed consent was taken from all the patients. Detailed history and through examination was done. All relevant investigations were carried out. The relevant data obtained was recorded in the standard proforma.

All pregnant women with clinical findings suggestive of IUGR from 28 weeks onwards (abdominal circumference less than the 5th percentile), normal fetal anatomy, singleton pregnancy, Ultrasonographic estimated fetal weight less than 10th percentile for gestational age, women with obstetric or medical conditions like pregnancy induced hypertension (PIH), multiple pregnancy, anemia, cardiac disease or renal disease were included in the study. All women will be subjected to doppler study. Fetus with congenital anomalies, multifetal gestation and patients with uncertain gestational age were excluded from the study.

Doppler waveform analysis of umbilical artery and middle cerebral artery was done. Umbilical artery doppler waveforms were obtained from a free floating portion of the umbilical cord during minimal fetal activity and the absence of fetal breathing. The angle of insonation was then optimized and the signals obtained. umbilical artery systolic/ diastolic (S/D) ratio was considered abnormal when it was more than 3. Umbilical artery diastolic flow absent and reversed was also considered as abnormal. Umbilical artery resistance index (RI) and pulsatality index (PI) were considered elevated when it was more than 95th percentile. Middle cerebral artery (MCA) S/D, PI, RI were considered abnormal when the values were < 5th percentile. Cerebro placental ratio (CPR) = MCA/UA PI< 1 was considered abnormal [10].

Systolic flow (A) and the diastolic flow (B) for the above mentioned arteries were obtained. Doppler indices were calculated.

S/D ratio = A/B

Resistance index = A-B/A

Pulsatality index = A-B/Mean

Further management of the cases were decided depending on the clinical status of the patients and the Doppler report, and pregnancies were terminated as and when indicated. Patients who continued pregnancy after the Doppler examination, Doppler was repeated at weekly interval. Doppler study done within 7 days prior to termination of pregnancy was taken into consideration for the study. Mode of termination of pregnancy was decided depending on the clinical condition of patients and the indications.

The parameters analyzed were birth weight, APGAR score of less than 7 at 5 minutes, cesarean section due to fetal distress, meconium staining of liquor, neonatal intensive care unit (NICU) admission, duration of admission and perinatal outcome.

Data analysis will be done according to appropriate statistical tests and statistical software. Results obtained were expressed as Mean ± SD, and statistical analysis was done by Chi-square, independent T -test, ANOVA test. P value < 0.05 was considered as statistically significant. The sensitivity and specificity of positive test is also computed wherever required for doppler. All the statistical calculations were done through SPSS for windows (v 20).

Results

A total of 100 women participated in the study. All cases detected to have IUGR clinically were subjected to doppler study. The abnormal doppler group consisted of pregnant women with IUGR with reduced, absent or reversed end

diastolic flow in UA and/or those with increased diastolic flow in MCA.

Table 1: Umbilical artery S/D ratio distribution analysis

S/D ratio	No. of patients	Percentage
<3 (Normal)	40	43.5
>3 (Abnormal)	52	56.5
Total	92	100

The age of the patients in this study ranges from 18 to 36 years of which majority belonged to the age group of 21-25 years with a mean age of 22.8 ±3.6 years. In the present study the incidence of primigravida (69%) was more than that of multigravida (31%). The study group included patients whose gestational age ranged from 28-40 weeks. Mean gestational age was 34 weeks. Maximum number of patients (60) belonged to 37-40 weeks group.

Sixty-three patients of the 100 had elevated PI values whereas remaining 37 patients had normal PI values. Statistical correlation was drawn and found to be significant (P<.05) in most of the parameters (except NICU stay >48hrs) in predicting poor perinatal outcome. PI values had highest sensitivity (96.9%) for predicting low APGAR values and highest specificity (63.8%) for predicting NICU admission (table 4).

Out of the 100 cases studied 5 patient had AEDF in the umbilical arteries. Out of the 5 cases with AEDF, 1 delivered a stillborn fetus, 2 babies were deeply asphyxiated and died within 5 hours of birth. One of the 3 perinatal mortalities was a preterm baby. 4 out of the 5 live births had meconium stained liquor and all 4 had APGAR<7 at 5 minutes. 3 cases had babies weighing <10th percentile.

Table 2: Umbilical artery S/D ratio correlation with fetal outcome

Fetal outcome	Increase in S/D ratio		Normal S/D ratio		P value	Sensitivity	Specificity
	No. (N=52)	%	No. (N=40)	%			
Birth weight <10th percentile	30	57.7	10	25.0	<.05	75%	57.6%
LSCS for fetal distress	13	25.0	2	5.0	<.05		
Meconium stained liquor	27	51.9	6	15.0	<.05	81.8%	61.8%
APGAR<7 at 5 min	28	53.8	1	2.5	<.05	96.5%	66.1%
NICU admission	41	78.8	8	20	<.05	83.6%	74.4%
NICU stay >48hrs	27	51.9	3	7.5	NS	90%	26.3%
Perinatal mortality	13	25	0	-			

Table 3: Umbilical RI values correlation with fetal outcome

Fetal outcome	Elevated RI		Normal RI		P-value	Sensitivity	Specificity
	No.(N=58)	%	No. (N=42)	%			
Birth weight <10th percentile	34	58.6	11	26.2	<.05	75%	56.3%
LSCS for fetal distress	16	27.6	1	2.38	<.05		
Meconium stained liquor	31	53.4	6	14.28	<.05	83.7%	64.2%
APGAR<7 at 5 min	33	56.8	0	-	<.05	100%	71.1%
NICU admission	45	77.5	8	19	<.05	84.9%	72.3%
NICU stay >48hrs	29	50	3	7.1	NS	90.6%	23.8%
Perinatal mortality	18	31	0	-			

Out of the 100 patients studied 5 patients had absent end diastolic flow (AEDF) and 3 patients had reversed end diastolic flow (REDF), hence S/D ratio could not be calculated in them. Amongst the remaining 92 patients 43.5% (40 patients) had a normal umbilical artery S/D ratio (<3) while the rest 56.5% (52 patients) had elevated S/D ratio (table 1).

The above data shows a strong statistical correlation with poor perinatal outcome and increased perinatal morbidity and mortality with an increased umbilical artery S/D ratio (>3) (table 2).

58 (58%) patients had elevated RI, whereas 42 of the remaining had normal RI. Analysis of RI values with outcome measures shows all parameters were statistically significant (p<0.05) except NICU stay for >48hrs. In this study elevated RI had 100% sensitivity in predicting APGAR<7 at 5 minutes (table 3).

Three cases out of 100 studied had REDF in the umbilical arteries. All 3 delivered stillborn babies. 2 out of 3 cases were preterm. The finding of REDF is ominous and AEDF also correlated with poor fetal outcome with a perinatal mortality of 60%.

Amongst the 100 cases 58 had abnormal MCA S/D ratio and the remaining 42 had normal S/D ratio values. All outcome measures showed statistical significance (<0.05) and MCA S/D had a highest sensitivity of 96.8% in determining the NICU stay >48hrs and a highest specificity of 70% in determining NICU admissions (table 5).

Forty seven patients had decreased RI values in the fetal MCA and the remaining 53 had normal values. MCA RI had the highest sensitivity (71.8%) for NICU stay >48hrs and highest specificity for predicting NICU admissions (76.5%) (table 6).

Table 4: Umbilical PI correlation with fetal outcome

Fetal outcome	Elevated PI		Normal PI		P-value	Sensitivity	Specificity
	No. (N=63)	%	No. (N=37)	%			
Birth weight <10th percentile	37	58.7	8	21.6	<.05	82.2%	52.7%
LSCS for fetal distress	16	25.4	1	2.7	<.05		
Meconium stained liquor	32	50.7	5	13.5	<.05	86.4%	57.1%
APGAR<7 at 5 min	32	50.7	1	2.7	<.05	96.9%	61%
NICU admission	46	73	7	18.9	<.05	86.7%	63.8%
NICU stay >48hrs	29	46	3	8.1	NS	90.6%	19.0%
Perinatal mortality	18	28.5	-				

After analysis of the 100 cases studied it was seen that normal PI values of MCA doppler was present in 57 cases and the rest 43 had abnormal PI values. All data except two (meconium stained liquor & NICU stay >48hrs) showed statistical significance (<0.05). MCA PI had a highest sensitivity of 66.6% in determining APGAR<7 at 5min and a specificity of 78.7% in determining NICU admissions (table 7).

Non stress test was studied in relation to doppler findings. Out of the 52 cases with abnormal umbilical artery doppler, 82% had a non-reactive NST. Out of the 58 cases with abnormal MCA doppler, 84% had a non-reactive NST.

Table 5: MCA S/D ratio with fetal outcome

Fetal outcome	Abnormal S/D ratio		Normal S/D ratio		P- value	Sensitivity	Specificity
	No.(N=58)	%	No. (N=42)	%			
Birth weight <10th percentile	35	60.3	10	23.8	<.05	77.7%	58.1%
LSCS for fetal distress	15	25.8	2	4.76			
Meconium stained liquor	29	50.0	8	19.0	<.05	78.3%	60.7%
APGAR<7 at 5 min	31	53.4	2	4.76	<.05	93.9%	67.7%
NICU admission	44	75.8	9	21.4	<.05	83%	70.2%
NICU stay >48hrs	31	53.4	1	2.3	<.05	96.8%	38.0%
Perinatal mortality	18	31	-				

Discussion

The role of doppler ultrasound in the study of uteroplacental and fetoplacental circulation is well known. It helps in detecting the extent of placental pathology and also predicts the fetal outcome. Numerous studies have been conducted to know the association between doppler waveforms and perinatal outcome and have had variable results.

The present study showed that abnormal doppler waveforms was associated with adverse perinatal outcome. When umbilical artery velocimetry was correlated to fetal outcome in the present study, it was shown that there was an

Table 6: MCA RI with fetal outcome

Fetal outcome	Abnormal RI		Normal RI		P- value	Sensitivity	Specificity
	No. (N=47)	%	No. (N=53)	%			
Birth weight <10th percentile	27	57.4	18	34	<.05	60%	63.6%
LSCS for fetal distress	12	25.5	5	9.4	<.05		
Meconium stained liquor	21	44.6	16	30.2	BS	56.7%	66.0%
APGAR<7 at 5 min	23	48.9	10	18.8	<.05	69.6%	72.8%
NICU admission	36	76.5	17	32.1	<.05	67.9%	76.5%
NICU stay >48hrs	23	48.9	9	16.9	NS	71.8%	38.0%
Perinatal mortality	16	34	2	3.7			

Table 7: MCA PI with fetal outcome

Fetal outcome	Abnormal PI		Normal PI		P - value	Sensitivity	Specificity
	No. (N=43)	%	No. (N=57)	%			
Birth weight <10th percentile	26	60.4	19	33.3	<.05	57.7%	65.4%
LSCS for fetal distress	13	30.2	4	7	<.05		
Meconium stained liquor	19	44.1	18	31.5	NS	51.3%	67.8%
APGAR<7 at 5 min	22	51.1	11	19.2	<.05	66.6%	76.2%
NICU admission	33	76.7	20	35	<.05	62.2%	78.7%
NICU stay >48hrs	13	30.2	18	31.5	NS	41.9%	57.1%
Perinatal mortality	18	41.8	-				

Fifty-seven cases out of 100 had a CPR <1.08 showing redistribution of blood flow (Brain sparing effect). Statistical correlation was drawn and found to be significant (P<0.05) in all the parameters in predicting poor perinatal outcome. CPR had the highest sensitivity (100%) when compared to other indices in predicting NICU stay >48 hours and APGAR<7 at 5 minute compared to all other indices (table 8).

increase in the perinatal morbidity and mortality in cases with an abnormal umbilical artery S/D ratio. Diagnostic performance of UA S/D ratio in detecting birth weight<10th percentile was compared to Adil Fleisher study[11], and was noted that the sensitivity was comparable with the present study. Brar et al[12] noted that when umbilical artery S/D ratio is >3 than there is a greater chance of IUGR, APGAR score <7 at 5 minutes, caesarean section for fetal distress and thick meconium in labour that correlated with the present study.

Assessment of end diastolic flow is useful because when it is reduced it detects 30% severe hypoxia, when there is AEDF is very alarming sign and detects 50% severe hypoxia and in case of REDF is ominous which detects 70% severe hypoxia and fetal death occurs within 7 days.[13]

When the fetoplacental flow is severely affected there is an increased impedance to flow resulting in end diastolic flow becoming absent. With further hemodynamic compromise there will be reversal of flow in the umbilical arteries. Such a development is ominous and results in a profoundly adverse perinatal outcome. In our study it was seen that AEDF or REDF correlated with poor perinatal outcome with an increase in the perinatal mortality and morbidity.

The perinatal mortality rate in those with a REDF in our study was 100%. Hence from the above correlation and the results of the present study it is evident that in women with AEDF/REDF, if the baby is salvageable and NICU facilities are available, it is safer to deliver the baby for a better perinatal outcome. Delivery can be delayed by 1-2 weeks if desired, with very intensive fetal surveillance in cases of AEDF, but immediate delivery is advocated when REDF sets in. REDF is a terminal event associated with an extremely high perinatal mortality [14,15].

Redistribution of blood flow occurs as an early stage in fetal adaptation to hypoxemia (brain-sparing reflex), wherein there will be an increased end diastolic flow resulting in decrease in PI and RI[16]. Our study showed similar findings of decrease in the MCA Doppler indices with an elevated umbilical artery resistance.

Low index of pulsatality in the MCA associated fetal compromise has been described by many authors. In our study it was found that low MCA PI was associated with 60.4% of IUGR babies and 41.8% of perinatal mortality.

Table 8: CPR correlation with fetal outcome

Fetal outcome	CPR<1.08		CPR>1.08		P- value	Sensitivity	Specificity
	No. (N=57)	%	No. (N=43)	%			
Birth weight <10th percentile	36	63.1	9	20.9	<.05	80%	61.8%
LSCS for fetal distress	16	28.1	1	2.3	<.05		
Meconium stained liquor	30	52.6	7	16.3	<.05	81%	64.2%
APGAR<7 at 5 min	33	57.8	0		<.05	100%	72.8%
NICU admission	46	80.7	7	16.2	<.05	86.7%	76.5%
NICU stay >48hrs	32	56.1	0		<.05	100%	33.3%
Perinatal mortality	18	31.5					

Diagnostic performance of pulsatality indices of UA, MCA & MCA/UA (CPR) in detecting IUGR shows that sensitivity of MCA PI is low (57.7%), compared to UA PI (82.2%) this may be due to late response of the MCA. When compared with MCA PI, maximum diagnostic accuracy shown by UA PI (82.2%) and CPR (80%). Low sensitivity to MCA PI, is explained by the term pseudo normalization it is disappearance of brain sparing effect i.e. if hypoxia persist, the diastolic flow in the MCA returns to normal presumably this reflects terminal decompensation in the setting of acedemia and cerebral edema. Relatively higher sensitivity of the UA PI probably because it directly reflects the resistance in the placental vascular bed. Thus in suspected IUGR cases UA PI may be enough to detect IUGR as recommended in the study of Shahina Bano et al[17].

MCA/UA pulsatality index (CPR ratio) ratio is potentially more advantageous in predicting perinatal outcome as it not only incorporates data on the placental status but also on fetal response. Gramellini et al[18] calculated the MCA/UA ratio and found that it remains constant in the last 10 weeks of pregnancy. They have also shown that it provides a better diagnostic accuracy than either vessels PI considered alone.

Diagnostic performance of CPR in relation to perinatal death was comparable to the study of Rozeta et al[19] although it varied from that of Gramellini et al[18]. CPR had the highest sensitivity of 100% in predicting adverse fetal outcomes. Because CPR incorporates data not only on the placental side but also the fetal response it can be considered potentially more advantageous. Doppler patterns follow a longitudinal trend with early changes in the umbilical artery followed by middle cerebral artery. Doppler reveals changes of hypoxia atleast a week before the non-stress test or biophysical profile. It has therefore become the gold standard in the management of a growth restricted fetus[14].

IUGR is a clinical sign of chronic fetal hypoxemia. Detecting the IUGR fetus at risk of perinatal complications is an ongoing challenge in obstetrics. All cases with IUGR should be followed up by ultrasonography and fetal doppler. This multiparametric approach helps us to optimize the timing of delivery without compromising the well being of fetus.

Conclusion

Doppler velocimetry helps in early assessment of IUGR, provides information regarding fetal well being, which helps in early intervention and therapy thereby reducing perinatal morbidity and mortality. Doppler serves as an important yardstick for the obstetricians when dealing with pregnancies complicated with growth restriction.

Conflict of interest: None. **Disclaimer:** Nil.

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