ORIGINAL RESEARCH ARTICLE

Role of Colour Doppler in Evaluation of Intrauterine Growth Retardation

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ABSTRACT

Introduction: Most common complication of pregnancy is intrauterine growth restriction which is associated with perinatal mortality, morbidity and neurological impaired development. Doppler of Uterine, umbilical, middle cerebral arteries and cerebro-placental ratio are commonly done for intrauterine growth restriction evaluation. The aim of the study was to evaluate the diagnostic performance of fetal middle cerebral artery and umbilical artery by Doppler ultrasonography in high risk mothers and correlation with perinatal outcome.

Material and Methods: Fifty singleton pregnancies beyond 28 weeks of gestation complicated by intrauterine growth restriction were prospectively examined with Doppler ultrasound of umbilical and middle cerebral arteries.

Results: 40 of the 50 cases included in the study had adverse outcome. The sensitivity of Doppler of the umbilical artery using Pulsatility index was 82.5%, middle cerebral artery Pulsatility index was 77.5% and ratio of middle cerebral artery Pulsatility index / umbilical artery Pulsatility index was 87.5% in predicting perinatal outcome.

Conclusion: Pulsatility index ratio of middle cerebral artery / umbilical artery is the most sensitive index in predicting perinatal outcome (87.5%). Umbilical Systolic /Diastolic ratio is the most specific index (80.9%). Absent and reversed diastolic flow in umbilical artery in prenatal sonography carries grave prognosis and high mortality of fetus. Combined use of both umbilical and middle cerebral arterial doppler study including the cerebro-placental ratio increase the sensitivity of the doppler studies for prediction adverse perinatal outcome.

Keywords: Colour Doppler, Intrauterine Growth Retardation

INTRODUCTION

Intrauterine growth restriction (IUGR) is defined as sonographic estimated fetal weight less than the 10th percentile for gestational age, whereas small for gestational age (SGA) will be used exclusively to describe newborns whose birth weight is less than the 10th percentile for gestational age.[1,2] Low birth weight (LBW) is defined as birth weight less than 2,500 g and should not be confused with IUGR/SGA, as the definition of LBW is based on the irrespective of gestational age, sex, race, and clinical features.[3] The prevalence of low birth weight baby is 33%.

The incidence of IUGR is more in developing countries (6-30%) than developed countries (4-8%). The average incidence of IUGR is about 8% in the general population. More than 50% of stillbirth baby are associated with IUGR and about 10% of perinatal mortality is consequent to undetected IUGR. Placental insufficiency, maternal hypertension, diabetes, infection, low–socioeconomic status and preeclampsia are common risk factors for IUGR. Most common complication of pregnancy is IUGR which is associated with perinatal mortality, morbidity and neurological impaired development.[4] Fetal and maternal doppler ultrasound helps in detection of compromised IUGR fetus by doing timely intervention which is main objective of antenatal care.[5]

IUGR are mainly due to increased resistance within the placental circulation which leads to decrease in velocity in the feeding arteries especially during diastole than systole. Disproportionate slowing of diastolic relative to systolic flow leads to elevation of a number of Doppler indices, including the systolic/diastolic ratio and the pulsatility index.[6] Uterine artery Doppler, umbilical artery Doppler, middle cerebral artery Doppler, cerebro-placental ratio (CPR), ductus venosus Doppler, and aortic isthmus Doppler are commonly done for IUGR evaluation.[7] Uterine arteries provide knowledge of maternal circulation, whereas the umbilical and middle cerebral arteries give information about the fetal circulation. Uterine artery Doppler has limited sensitivity

and specificity to predict adverse outcome in IUGR fetuses diagnosed during the third trimester.[8] The utility of umbilical artery Doppler velocimetry has been extensively reviewed in cases of fetal growth restriction. Absent or reversed end-diastolic flow in the umbilical artery is associated with an increased risk of perinatal mortality.

The purpose of this study was to evaluate the diagnostic performance of fetal middle cerebral artery (MCA) and umbilical artery (UA) by Doppler ultrasonography in high risk mothers with IUGR and correlation with perinatal outcome.

MATERIAL AND METHODS

This was a Prospective observational study conducted from 2017 to 2019 in the Department of Radio-diagnosis, Kalinga Institute of Medical Sciences and Bhubaneswar. This study was approved by the Ethical Committee of our institution. The study included 50 singleton pregnancies with suspected IUGR and 50 healthy uncomplicated pregnant women as control cases.

All Singleton pregnancies of gestational age of above 28 weeks with clinically suspected intrauterine growth retardation were included. Multiple fetal gestations or fetuses having major congenital anomalies were excluded.

Method of Collection of Data

A prospective study of 50 antenatal patients with IUGR and 50 control cases was done after considering the inclusion and exclusion criteria. All the subjects in the study were followed up from first visit up to the time of delivery. Gestational age was confirmed by LMP or by first trimester ultrasound if available. Ultrasound was performed on GE colour Doppler ultrasound scanner with a curvilinear transducer, having a variable frequency of 3.0–5.0 MHZ.

All the subjects were first evaluated by grey scale imaging to assess fetal biparietal diameter, head circumference, abdominal circumference, femur length, amniotic fluid index, head/abdominal circumference ratios in the third trimester of pregnancy i.e. after 28 weeks.

Flow velocity waveforms of the umbilical artery (UmbA) and middle cerebral artery (MCA) were obtained from all the cases and were analyzed. Umbilical artery showing normal wave forms and good diastolic flow (Fig.1 A) and Middle cerebral artery showing normal wave forms and velocimetry (Fig.1 B) are illustrated in Fig.1

Color Doppler UA and MCA were done in standard plane. The umbilical artery (cord) was located using a duplex scanner and will identify as twin parallel white lines in the pool of amniotic fluid. To locate MCA the first step was obtaining plane for BPD measurement. Remaining in same

plane probe moved to the base of brain until the sphenoid bone was seen and circle of Willis was located. The MCA conveniently courses along the greater wing of sphenoid and readily seen by Color Doppler imaging. The MCA in the near field was insonated about 1 cm distal to its origin from the internal carotid artery.

The Pulsatility index (PI), presence or absence of end-diastolic flow and reverse diastolic flow were noted. The UmbA PI was used in progressive absence or end diastolic or reverse diastolic flow (Fig-2 A) as it continues to reflect changes in resistance. The MCA PI/UmbA PI ratio was calculated. In our study a single cutoff value of 1.08 for MCA/UmbA PI ratio (cerebral-umbilical ratio) was used, above which velocimetry was considered normal and below which it was considered abnormal, according to reference values.[9,10,11]

Outcome Criteria

Outcome variables included were birth weight (less than 10th percentile), perinatal death, emergency CS for fetal distress, 5 minute Apgar score less than 7, low birth weight with NICU admissions. Pregnancy was considered to have "Adverse outcome" when any of the following complications were present such as perinatal death, emergency CS for fetal distress and admission to NICU for complications of low birth weight. When the above complications are absent pregnancy outcome will be considered as uneventful or favorable Umbilical artery showing normal wave forms e. The outcome for each pregnancy was observed in NICU and labor ward along with medical records.

STATISTICAL ANALYSIS

The diagnostic statistics were used to find the diagnostic value of Umb A PI, MCA PI and MCA/UmbA PI in relation to perinatal outcome. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were determined for all Doppler measurement. The statistical software namely Stata-15.1 version was used for the analysis of the data and Microsoft Word and Excel have been used to generate graphs, tables etc.

RESULTS

Distribution of age of the patients

All our patients ranged from 20 years to 38 years. Majority of the patients (58%) were in 26-30 years age group. The average age of the patients was 28.16 years. Least number of patients were seen in the age group of more than 30 years.

Distribution of gestational age at doppler examination

In our study group of 50 antenatal mothers, the gestational age at the time of Doppler examination ranged between

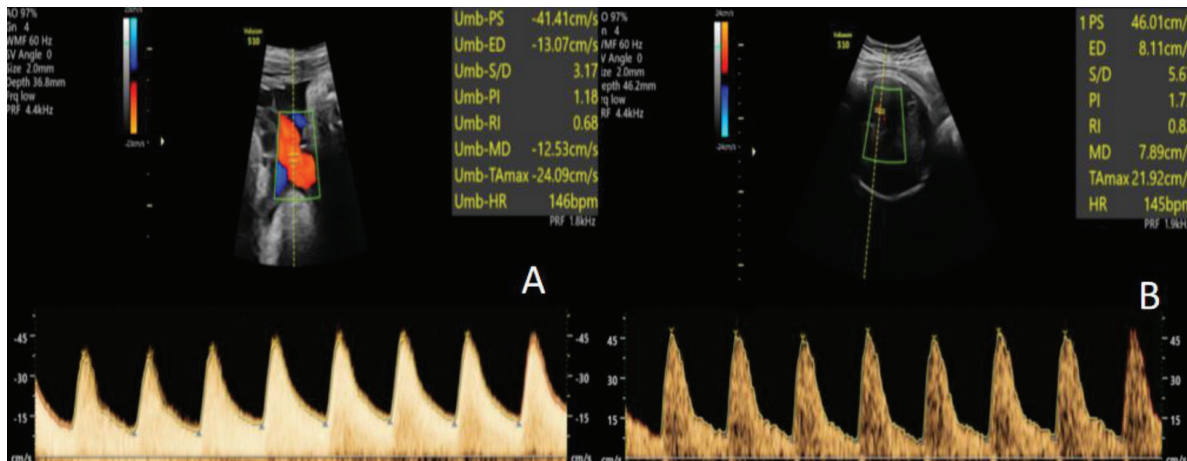| S. N	Type of wave form		Umbilical artery			Middle cerebral artery		
			PI	RI	S/D	PI	RI	CPR
1	Study group	Mean	1.51	0.70	3.37	1.46	0.70	0.95
		Standard deviation	0.8	0.136	0.16	0.13	0.13	0.39
2	Control group	Mean	0.98	0.62	2.7	1.75	0.79	1.81
		Standard deviation	0.18	0.07	0.55	0.37	0.09	0.47
Test of significance (P-value)			<0.001	<0.001	=0.002	=0.042	<0.001	<0.001
Table-1: Showing comparison of mean value of Doppler indices between study and control								

Figure-1: Umbilical artery showing normal wave forms and good diastolic flow.(A) Middle cerebral artery showing normal wave forms and velocimetry. (B)
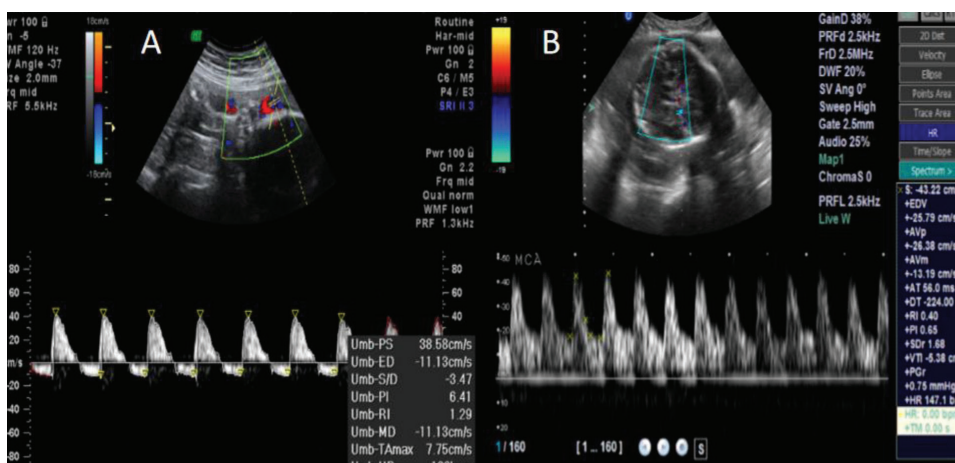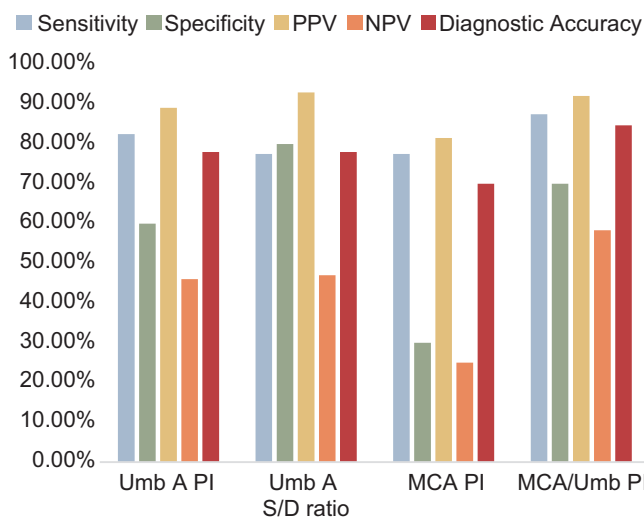

Figure-2: Umbilical artery showing reverse diastolic flow (A). MCA showing continuous forward flow with increased diastolic flow and decreased PI in IUGR fetus (B).

Graph-1: Showing comparison of Doppler indices with adverse perinatal outcome

28- 38 weeks. 70% of the antenatal mothers examined were between 31-35 weeks of gestation, 18% between 28-30 weeks gestation and 12% with gestational age between 36-40 weeks. None of the antenatal mothers were examined before 28 weeks of gestational age.

Clinical presentation and indication for doppler study
In the study group of 50 antenatal mothers, 50% of patients had pregnancy-induced hypertension which is the most common cause for IUGR in our series. Only IUGR as the indication for the Doppler study was seen in 24%. IUGR with anemia complicating pregnancy was found in 20% of cases. Bad obstetric history was seen in 6% of cases.

Fetal umbilical artery doppler study
Umbilical Artery Pulsitility Index (PI): Umbilical artery PI was elevated in 37 patients (74%) and was normal in 13(26%) patients.

Umbilical artery end diastolic velocity flow pattern: Three fetuses (6%) showed absent diastolic flow and 1 fetus (2%) had reversal of end diastolic umbilical artery flow (Fig.2 A) with the total of 46 fetuses (92%) having less positive diastolic flow.

Umbilical artery systolic/diastolic (S/D) ratio: 33 out of 50 fetuses (66%) showed elevated S/D ratio, 17 fetuses (34%) showed normal S/D ratio.

Fetal middle cerebral artery doppler study
Middle Cerebral Artery PI: 38 out of 50 fetuses (76%) had decreased Pulsatility index and 12 fetuses (34%) had normal Middle cerebral artery Pulsatility index.

Ratio of middle cerebral artery pi to umbilical artery PI: 40 out of 50 fetuses (80%) had evidence of redistribution of blood to the brain as evidenced from the ratio of PI in the MCA and umbilical arteries.

Analysis of perinatal outcome: There was one intrauterine death, and 49 live births. One baby died in postnatal day 1 and another baby died in post natal day 3. Of the 47 live births 5 neonates were admitted to NICU, 35 neonates had 5 min APGAR score of less than 7 and 30 babies were born by emergency cesarean section. Mean birth weight at delivery was 2006±451 gm (2SD). There were 41 neonates with birth weightless than 2.5kg. 40 fetuses had at least one adverse perinatal outcome. Remaining 10 fetuses had favourable outcome. Absence or reversal of the end diastolic flow velocity was seen in 4 fetuses (8%) in our study. There were 3 deaths in whom two cases had absent diastolic flow and one had reverse diastolic flow. The mortality in cases of reverse and absent end diastolic flow was 100% and 66% respectively.

Comparison of mean value of doppler indices between study and control group
In umbilical artery, S/D ratio, PI and RI of IUGR fetuses were significantly higher han that of normal fetuses (3.37 ± 0.16 vs 2.7 ± 0.55; $p<0.01$, 1.51 ± 0.8 vs 0.98 ± 0.18; $p<0.001$, 0.70 ± 0.136 vs 0.62 ± 0.07; $p<0.001$). In middle cerebral artery, PI of IUGR fetuses was significantly lower than that of normal fetuses (1.46 ± 0.13 vs 1.75 ± 0.37; $p<0.42$). Cerebro-placental ratio (PI OF MCA /PI OF UA) of IUGR fetuses was significantly lower than that of normal fetuses (0.95 ± 0.39 vs. 1.89 ± 0.47; $p<0.001$ (Table-1).

DISCUSSION

Intrauterine growth restriction has multifactorial etiology associated with events occurring along several different pathways. Hence, accurate antenatal diagnosis must conclude whether the fetus is constitutionally small for gestational age or small as a consequence of impaired placental perfusion. Doppler flow velocity analysis can be valuable in solving aforementioned problem, by examining umbilical arteries (fetoplacental circulation) and middle cerebral artery (fetal circulation).

In our study, color Doppler study of 50 pregnant women with suspected IUGR fetuses based on clinical suspicion and grey scale ultrasound examination. 50 normal pregnancies after 28 weeks were taken as healthy control cases. Numerous studies with different techniques and criteria and with varying results have been published in small to large sized population, in high and low risk area. No universally accepted criterion is established for defining abnormal Doppler indices in relation to pregnancy outcome and therefore conflicting observations continue to emerge.

Age Incidence
We observed that the maximum number of pregnant women were in the age group of 26-30 years (58%), with a mean age group of 28.16 years. This could be attributed for the increased rate of pregnancies in this age group.

Distribution of gestational age
In our study all patients underwent Doppler study in third trimester of their pregnancy with maximum of 70% being investigated between 31 - 35 weeks of gestation. The earliest study was done at 28th week of gestation. Hence most pregnancies were monitored between 31-35 weeks, when the fetus would have begun developing sufficient lung maturity to survive outside the uterus.

Etiology of IUGR
About 20% of cases had anemia complicating the pregnancy. Hypertensive disorders were present in maximum of 50% of pregnancies complicated with IUGR. Bad obstetric history as a cause is seen in 6% of cases. Twelve patients (24%) of the study group had no detectable cause for IUGR. Similar findings were seen in Deepti et al[12] with 50% cases having pre-eclampsia, 35% had anemia.

Umbilical artery
In the present study the umbilical artery PI had a sensitivity of 82.5%. (Graph) According to D. Gramellini et al[13], the sensitivity of Umbilical artery PI in predicting perinatal outcome was 64%. Another study by K W Fong et al[14] showed the sensitivity of the umbilical artery PI as 58.3%. Umbilical artery was the main vessel used for monitoring high risk pregnancies. This is because umbilical artery represents feto-placental system and primarily reflects placental resistance. In present study, as there is more number of PIH cases probably this can be attributed for difference in the studies.

Fetal blood circulation and redistribution
In the present study, fetal middle cerebral artery (MCA) PI had a sensitivity of 77.5%.(Graph) In a study by Arduini and Rizzo[15], the sensitivity of MCA PI in predicting perinatal outcome was 68% and 72.4% in a study done by K.W Fong et al.
The redistribution calculated from the ratio of the PI of MCA to PI of umbilical artery showed 80% of the fetuses to redistribute their cardiac output. The sensitivity of MCA PI / UmbA PI of our study is 87.5% (Graph) in predicting perinatal outcome. These results are slightly higher than that of study done by D Gramellini et al[13] (68%) and Odibo et al[16] (65%), probably this may be due to small sample size.

Prediction of perinatal outcome
40 fetuses (80%) had at least one adverse outcome. Remaining 10 (20%) fetuses had favorable outcome. There was one intra uterine death showing reversal of umbilical artery diastolic flow in prenatal Doppler study. Out 49 live births, 2 cases died within 3 days of delivery and were showing absent diastolic flow on umbilical artery Doppler study prenatally. The mortality in cases of reversed and absent end diastolic flow was 100% and 66% respectively, indicating grave prognosis. 5 neonates (10%) were admitted to NICU, 35 (70%) neonates had 5 min APGAR score less than 7, and 30 babies (60%) were born by emergency cesarian section. A study done by Gramellini et al[13] showed 55% cases required emergency caesarian section and another study done by Eslamian et al[17] showed 14.4% of NICU admission which are showing similar results as that of ours.
By using Doppler ultrasound results for analysis, the MCA/

UmbA pulsatility index ratio had a higher sensitivity and positive predictive value for predicting the adverse perinatal outcome than the MCA and the UmbA pulsatility indices. Our findings agree with the results of the studies such as Bano S et al[18] (with sensitivity of 83.3%) that have shown MCA/UmA PI Doppler ratio to be more useful than UmbA PI or MCA PI in predicting the adverse outcome.

CONCLUSION

The umbilical-placental and cerebral vascular beds are directly involved in the hemodynamic adjustments of fetal growth restriction. A Doppler index that reflects both of these areas can be useful for identifying fetuses with increased placental and/or decreased cerebral resistance.

Assessment of both the utero-placental and the feto-placental circulations together is more sensitive to predict to perinatal outcome, than assessment of each alone. In suspected IUGR, cerebro-placentalratio (MCA/UA PI) is a better predictor of adverse perinatal outcome than an abnormal MCA PI or UmbA PI. Best results are obtained when we use MCA/UmbA PI Ratio, rather than PI values of middle cerebral artery and Umbilical artery separately. Presence of absent/reversal of diastolic flow in umbilical artery is an ominous sign since it carries a grave prognosis and high mortality. Doppler imaging is of value for monitoring the pregnancy because it can provide indirect evidence of fetal compromise and is known to improve outcomes of high risk pregnancies with intrauterine growth restriction. Hence Doppler evaluation is complementary to all other surveillance modalities.

Limitation of the study: Our study included less number of cases of IUGR of fetuses with evaluation of umbilical and MCA only. Prospective study including more number of cases will help to defined more definite criteria of Doppler indices for predicting adverse perinatal outcome.

Summary

The sensitivity of Doppler examination of the umbilical artery using PI in predicting perinatal outcome was 82.5%. Doppler studies of the umbilical artery and uterine artery together had a better sensitivity than that of the individual vessels.

The MCA/Umb PI ratio showed more fetuses to redistribute their cardiac output than the abnormal MCA PI or UmbA PI. The cerebro-umbilical ratio provided a better predictor of intrauterine growth restriction and adverse perinatal outcome than either the middle cerebral artery or umbilical artery alone.

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