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Role of Cerebroplacental Ratio in Detection of Perinatal Outcome in High Risk Pregnancy

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Abstract: ***Objective: To assess the predictive value of cerebroplacental ratio in detection of perinatal outcome with its components in high risk pregnancy. Materials and method: A total of 150 high risk pregnant women underwent color Doppler ultrasound after 28 weeks of gestation, Doppler indices (S/D ratio of MCA and UA) were noted. Cerebroplacental ratio was calculated, CPR of less than 1 was considered abnormal. Perinatal outcome was noted and predictive value of cerebroplacental ratio calculated using SPSS software. Results: Cerebroplacental ratio is having higher sensitivity and negative predictive value for detection of poor Apgar score, IUGR, meconium aspiration syndrome, HIE, neonatal death and operative interference for fetal distress. Conclusion: CPR has better predictive value in detection of perinatal outcome.***

Keywords: Cerebroplacental ratio (CPR). Systolic/diastolic ratio (S/D). Middle cerebral artery (MCA). Umbilical artery (UA). Meconium aspiration syndrome (MAS). Hypoxic ischemic encephalopathy (HIE)

1. Introduction

A pregnancy is considered high risk when there are potential complications that could affect the mother, baby or both. High risk pregnancies require management by a specialist to help ensure the best outcome for the mother and the baby. Doppler ultrasound enables a better understanding of the hemodynamic changes and has, therefore, become one of the most important clinical tools for feto-maternal surveillance in high risk pregnancies. It can be credited with causing a significant decrease in perinatal mortality and morbidity[1]

The fetal cerebroplacental ratio (CPR) is the ratio of S/D ratio of Middle cerebral artery to S/D ratio of Umbilical artery. It is believed to be a proxy for suboptimal fetal growth. It quantifies both suboptimal placental function and subsequent fetal circulatory adaptations. [2-4]An abnormal cerebroplacental ratio reflects redistribution of cardiac output to the cerebral circulation and has been associated with intrapartum fetal distress, increased rate of emergency cesarean section and NICU admission and poorer neurological outcomes.

2. Materials and methods

The present study was a hospital based prospective study conducted on high risk pregnant women attending OPD and IPD in the Department of Obstetrics and Gynecology of Bebe nanki mother and child care centre, Amritsar from April 2019 to June 2020. A total 150 high risk pregnant women were enrolled in the study after taking written and informed consent.

Inclusion Criteria
Patients with high risk singleton pregnancies like pregnancy induced hypertension (PIH), intrauterine growth restriction (IUGR), diabetes mellitus, bad obstetrics history (BOH), Rh iso immunization, pregnant women with age <18 years or >35 years, thyroid disorders of pregnancy, thrombophilias, chronic kidney disease.

Exclusion Criteria
Twin pregnancy, early pregnancy up to 28 weeks, congenital anomalies in fetus.

3. Methodology

Study was conducted on 150 high risk pregnant women with gestational age between 28 – 40 weeks of gestation attending IPD and OPD of department of Obstetrics and Gynecology.

All cases were subjected to detailed history taking, complete general physical examination, systemic examination and obstetric examination. All routine and specific investigations done and cases were subjected to serial color Doppler (S/D ratio, CPR).

Middle cerebral artery (MCA) and umbilical artery (UA) were visualized by transabdominal color Doppler. Pulsed wave Doppler was then used to assess impedance to flow. The UA color Doppler waveforms were obtained from a free floating portion of the umbilical cord during minimal fetal activity and the absence of fetal breathing. All measurements were performed in the semi-recumbent position with head and chest slightly elevated. For measurement MCA, an axial view of the fetal head was obtained at the level of cerebral peduncles and then the color Doppler was used to visualize the circle of Willis, Doppler sample volume was placed 1cm of the origin of the MCA that was easily identified as a major branch running anterolateral from the circle of Willis toward the lateral edge of the orbit and having best reproducibility.

The angle between the ultrasonic beam and the direction of flow was always <30 degree. The color Doppler signals were recorded with a 3.5mHz curved array duplex transducer. The color Doppler parameters (S/D ratio of MCA and UA) were noted. S/D ratio of MCA less than 3 and S/D ratio of UA more than 3 was considered as abnormal. Once Doppler study was done, cerebroplacental ratio (S/D ratio of MCA divided by S/D ratio of UA) was calculated. Although PI, RI and S/D ratio have been reported

when computing the CPR, we have used S/D ratio in our study. Cerebroplacental ratio of less than 1 was considered abnormal. Doppler ultrasound was repeated every weekly. Patients were managed and followed up. Details regarding the mode of termination of pregnancy, gestational age at the time of termination of pregnancy, number of caesarean section due to fetal distress and perinatal outcome were noted. Adverse perinatal outcome was defined as presence of one or more of the following conditions like IUGR, 5 min Apgar score < 5, hypoxic ischemic encephalopathy, meconium aspiration syndrome, NICU admission, neonatal death, stillbirth. Statastical analysis performed using SPSS software. Predictive value was calculated.

4. Results

In our study group out of 150 patients 94 (62.67%) patients were multigravida and 56 (37.33%) patients were primigravida. 61 (40.67%) patients were between the age group of 20 to 25 years of age. Maximum subjects (54%) in the study group were between the gestational age of 37 to 40 weeks.

Table 1: Distribution of cases with respect to risk factors in the study group

Risk factors	No. of cases	% age
PIH	70	46.67
IUGR	23	15.33
PIH with IUGR	16	10.67
GDM	14	9.33
Rh negative pregnancy	10	6.67
Thyroid disorders	10	6.67
BOH	5	3.33
PIH with GDM with BOH	2	1.33
Total	150	100.00

Maximum number of patients (46.67%) had pregnancy induced hypertension as risk factor in the study group followed by IUGR (15.33%). Our study is comparable to study conducted by Najam R et al.[5]

Table 2: Abnormal Doppler findings in high risk patients

Risk factor	Total no of cases	Normal doppler		Abnormal Doppler					
		No	% age	MCA		UA		CPR	
				No	% age	No	% age	No	% age
PIH	70	46	65.71	20	28.57	19	27.14	19	27.14
IUGR	23	10	43.47	7	30.43	11	47.82	10	43.27
PIH with IUGR	16	5	31.25	5	31.25	11	68.75	10	62.50
GDM	14	11	78.57	3	21.42	3	21.42	3	21.42
Thyroid disorders	10	10	100	0	0	0	0	0	0
Rh negative pregnancy	10	10	100	0	0	0	0	0	0
BOH	5	3	60	1	20	2	40	2	40
PIH with GDM and BOH	2	1	50	1	50	1	50	1	50

In our study incidence of abnormal color Doppler is maximum in patients with PIH with IUGR. Out of 16 patients of PIH with IUGR, 11 patients had abnormal Doppler. Our study is comparable with the study conducted by Najam R et al.[5]

Table 3: Mode of delivery in relation to abnormal Doppler parameters.

S. No	Doppler findings	No of cases	NVD		Caesarean section	
			No	%	No	%
1.	Normal Doppler	96	82	85.41	14	14.58
2.	Abnormal Doppler	54	12	22.22	42	77.77
a.	MCA Doppler					
i.	Decreased S/D ratio	37	14	37.83	23	62.16
b.	UA Doppler					
i.	Raised S/D ratio	36	14	38.88	22	61.11
ii.	AEDF	7	3	42.85	4	57.14
iii.	REDF	4	0	0	4	100
c.	Decreased CPR	45	16	35.55	29	64.44

In our study sensitivity, specificity, positive predictive value and negative redictive value of middle cerebral artery for detection of operative interference for fetal distress were 20.72, 86.20, 62.10 and 22.10%, while that for UA Doppler were 60.41, 82.35, 61.70 and 81.55%. For abnormal cerebroplacental ratio, values were 60.41,84.31, 64.44 and 81.90%. So cerebroplacental ratio has most sensitive and negative predictive value for detection of operative interference for fetal distress.

Increased need for operative interference was required when cerebroplacental ratio was abnormal compared to other individual color Doppler indices. Our study is comparable to study conducted by Amin B et al. In a study conducted by Amin B et al,[6] 16 out of 28 patients with abnormal Doppler were delivered by caesarean section.

Table 4: Perinatal outcome in relation to Doppler findings

Neonatal features	Normal Doppler (n=96)		Abnormal Doppler(n=54)									
			Decreased MCA S/D ratio (n=37)		Increased UA S/D ratio (n=36)		AEDF (n=7)		REDF (n=4)		Decreased CPR(n=45)	
	No.	% age	No.	% age	No.	% age	No.	% age	No.	% age	No.	% age
IUGR	11	11.45	21	56.75	20	55.55	6	85.71	4	100	29	64.44
Poor Apgar score	1	1.04	12	32.43	11	30.55	4	57.14	3	75	19	42.22
Hypoxic ischemic encephalopathy	1	1.04	18	48.64	13	36.11	7	100	4	100	25	55.55
Meconium aspiration	1	1.04	18	48.64	15	41.66	4	57.14	3	75	23	51.11
NICU admissions	8	8.33	31	83.78	31	86.11	7	100	4	100	42	93.33
CS for fetal distress	14	14.58	23	62.16	22	61.11	4	57.41	4	100	29	64.44
Neonatal death	1	1.04	8	21.62	5	13.88	2	28.57	2	50	10	22.22
Still birth	0	0	1	2.7	1	2.77	0	0	0	0	1	2.22

Perinatal morbidity (low Apgar score, IUGR, NICU admission, HIE and MAS) and perinatal mortality were maximum, when cerebroplacental ratio was abnormal.

In our study sensitivity, specificity, positive predictive value and negative predictive value of middle cerebral artery Doppler for detection of poor Apgar score were 61.11, 79.25, 30.50 and 91.22%, while that for umbilical artery Doppler were 90, 78.46, 39.13 and 98.07%. For abnormal cerebroplacental ratio, values were 94.44, 77.61, 37.77 and 99.04%. So, CPR has higher sensitivity and negative predictive value for detection of poor Apgar score. In the present study CPR had higher sensitivity and negative predictive value for detection of poor Apgar score compared to MCA and UA Doppler S/D ratio. Our study comparable to study conducted by Najam R et al[5] with sensitivity, specificity, positive predictive value and negative predictive value of CPR for detection of poor agar score were 95.00 70.76 33.33 98.92%

In the present study CPR had higher sensitivity and NPV for detection of HIE compared to MCA and UA Doppler S/D ratio. For abnormal CPR sensitivity, specificity, PPV and NPV for detection of HIE were 95.45, 83.20, 46.66 and 99.04%.

In our study CPR had higher sensitivity and NPV for detection of MAS compared to MCA and UA Doppler S/D ratio. For abnormal CPR sensitivity, specificity, PPV and NPV for detection of MAS were 90, 79.23, 40 and 98%.

In our study sensitivity, specificity, positive predictive value and negative predictive value of middle cerebral artery Doppler for detection of IUGR were 41.1, 85.71, 48 and 81.8%, while that for UA Doppler were 55.88, 75.14, 54.28 and 85.27%. For abnormal cerebroplacental ratio, values were 94.44, 77.61, 37.77 and 99.04%.In our study CPR had higher sensitivity and NPV for detection of IUGR compared to MCA and UA Doppler S/D ratio. Our study is comparable with the study conducted by Khanduri et al.[7]In a study conducted by Khanduri S et al sensitivity and specificity of CPR for detection of adverse perinatal outcome were 82.1% and 96.7%.

In our study sensitivity, specificity, positive predictive value and negative predictive value of middle cerebral artery for detection of NICU admission were 53.48, 93.70, 79.30 and 81.81%, while that for UA Doppler were 75.92, 94.79, 89.75 and 87.50%. For abnormal CPR, values were 77.35, 95.87, 89.13 and 88.57%. In the present study CPR had higher sensitivity and NPV for detection of NICU admission compared to MCA and UA Doppler S/D ratio. Our study is comparable with the study conducted by Gibbons A et al [8](p-value< 0.0001, OR 3.39, 95% CI: 2.16-5.42).
In the present study CPR had higher sensitivity and NPV in detection of neonatal death compared to MCA and UA Doppler S/D ratio. For abnormal CPR sensitivity, specificity, PPV and NPV for detection of neonatal death were 90.90, 74.87, 22.22 and 99%.

In the present study CPR did not show better predictive value for detection of *stillbirth compared to MCA and UA Doppler S/D ratio.*

5. Discussion

Doppler investigation of the fetal circulation can give important information on fetal well being in a number of pathological conditions. Doppler examination is an important diagnostic technique if there is suspicion of intrauterine growth retardation (IUGR), pregnancy induced hypertension. Other indications for color Doppler are multiple pregnancy, chronic maternal disease such as nephropathy or autoimmune diseases, diabetes mellitus.[9] Application of Doppler ultrasound for early detection of hemodynamic changes in feto-maternal vasculature has led to decrease in the perinatal mortality and morbidity in recent years.[5]

Maternal disorders or Placental conditions that are known to obliterate small muscular arteries in the placental tertiary stem villi result in changes in umbilical artery Doppler. During an episode of fetal hypoxaemia, there will be central redistribution of blood flow, which results in increased blood flow to the vital organs like brain, heart and adrenal glands and reduction of flow to peripheral circulation. This blood flow redistribution is called as the brain sparing effect. This change in the blood flow pattern seen as abnormal color doppler findings in middle cerebral artery.[10-13]

Umbilical arteries are the common vessels assessed, but recent studies confirm the efficacy of middle cerebral artery (MCA) Doppler assessment. MCA Doppler measurement is a well-known modality for detecting fetal compromise. Studies have shown that MCA blood flow abnormalities were associated with hypoxia and adverse perinatal outcome. MCA/UA ratio reflects not only the circulatory insufficiency of the umbilical artery manifested by

alterations in the umbilcal S/D ratio but also the adaptive changes resulting in modification of middle cerebral artery S/D ratio.[5]

An abnormal cerebroplacental ratio has been associated with intrapartum fetal distress, increased rate of emergency caesarean section, NICU admissions, meconium aspiration syndrome, poorer neurological outcome (Hypoxic ischemic encephalopathy) and neonatal mortality

Color doppler of middle cerebral artery in combination with umbilical artery seems to improve the perinatal outcome. It is believed that the CPR is a better predictor of adverse perinatal outcome than its individual components.

6. Conclusion

Colour flow Doppler imaging has already found its place in studying the pathological vascular flow patterns in high risk pregnancies. Doppler indices provide important information on the hemodynamics of the vascular area under study. Hemodynamic changes which are detected reflects certain fetal Doppler waveforms, that predicts adverse perinatal outcome.
In the present study cerebroplacental ratio is having higher sensitivity and negative predictive value for detection of poor Apgar score, IUGR, meconium aspiration syndrome, HIE, neonatal death and operative interference for fetal distress. So cerebroplacental ratio has better predictive value in detection of perinatal outcome in high risk pregnancy.

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Conflict of interest: The authors declare that there is no conflict of interest.

Ethical approval: Institutional ethical committee clearance was obtained for study

Informed consent: Informed consent was taken from all individual participants included in the study.

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