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Original Research Article

Cerebro Placental Ratio at 30–34 Weeks' Gestation in the Prediction of Perinatal Outcome in Low-Risk and High-Risk Pregnancy

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Abstract:

Background: Doppler ultrasonography velocimetry of the fetal and umbilical veins is a well-established technique for prenatal monitoring that enables non-invasive evaluation of the neonatal circulatory system. The CPR is becoming a crucial indicator of a poor pregnancy outcome. Therefore, the purpose of this study is to determine whether CPR is effective in evaluating perinatal outcome and whether it should be used as a tool for assessing fetuses having third-trimester Doppler examination. The purpose of this study is to assess CPR in early severe fetal growth restriction and late moderate fetal growth restriction and to predict perinatal outcome in low risk and high risk pregnancies in late onset FGR.

Methods: 82 pregnant women between 30 and 34 weeks of gestation made up the study group. They had an ultrasound Doppler evaluation, as well as other standard tests and CPR calculations. Fetal outcome was recorded after monitoring the women up until delivery and classifying them into high-risk and low-risk pregnancies.

Results: When compared to low risk patients, the period of extension was noticeably shorter with high risk patients. When compared to low risk patients, high risk patients had a considerably higher rate of NIUC hospitalizations. When compared to high risk patients, low risk patients had a much higher percentage of vaginal deliveries. Individuals with faulty CPR have considerably smaller gestational periods, birth weights, and prolonging periods than individuals with normal CPR.

Conclusion: For high risk cases and late onset (beyond 32 weeks) moderate FGR, Doppler velocimetry becomes a crucial technique. CPR can help predict peripartum fetal distress and is helpful in high-risk pregnancies.

Keywords: Doppler, FGR, CPR.

Introduction

Over the past few decades, fetal circulation has been the subject of intense research. For early diagnosis of a pathological condition that could put fetal well-being at risk and prevent fetal morbidity and death, knowledge of normal fetal blood flow in fetuses with sufficient growth for gestational age is crucial. It is mostly dependent on healthy placental structure and development throughout pregnancy for enough fetal blood flow to occur. Fetal circulation may be negatively impacted by an aberrant or dysfunctional placenta. When there is a placental insufficiency, the umbilical artery (UA) is typically the first fetal blood vessel to be impacted. Blood flow resistance in the UA increases retrogradely as a result of the first rise in placental blood flow and vascular impedance. [1]

As placental insufficiency worsens, the descending aorta's blood flow resistance rises, which causes more blood to be diverted through the aortic isthmus shunt to the fetal brain. The second vascular sign in the chain of placental insufficiency, reduced middle cerebral artery pulsatility index (MCA-PI), reflects this event. [2,3] The accurate identification of early placental insufficiency through redistribution of fetal blood flow has been thoroughly researched in the literature. [4,5] For effective prenatal Doppler monitoring, early diagnosis of aberrant blood flow redistribution patterns is essential. It is a component of careful observation with the potential to lower fetal morbidity and mortality. [6-8]

According to research, the most effective vascular measure for identifying the aforementioned fetal redistribution patterns is the cerebroplacental ratio (CPR). [9-12] It measures the degree of cerebral redistribution and is expressed as the ratio of the middle cerebral artery pulsatility index (MCA-PI) to the umbilical artery pulsatility index (UA-PI). CPR varies throughout pregnancy and varies in direct proportion to relative fetal growth. [13]

Material and Methods

From January 2021 to December 2022, this prospective observational study was carried out in the outpatient department of the Department of Obstetrics and Gynecology at Darbhanga Medical College and Hospital, Laheriasarai, Bihar.

After obtaining informed consent, 80 women were finally included in the study out of a total of 82 women. Of these, two women were lost to follow-up.

Pregnant women with gestational ages between 30 and 34 weeks, singleton pregnancies, and a willingness to participate in the study were included; however, pregnant women with multiple pregnancies and fetuses with congenital defects were not included in the study.

Following the selection of cases, a thorough history including age, BMI, obstetric score, gestational age at the time of the study, risks involved, their Doppler studies, CPR, percentile, Amniotic fluid index, gestational age at birth, period of pregnancy prolongation, birth weight, ABG pH at birth, route of delivery, justification for LSCS, instrumental delivery, NICU admission, length of stay, and use of ventilation were noted.

Women's pregnancies were classified as high-risk if they developed gestational diabetes or hypertension, otherwise as low-risk. Up to delivery, they were monitored, and the fetal result was recorded. Additionally, the pH of the fetal arterial blood was measured and associated with the outcome.

The patient was initially placed in a recumbent position for a standard B-mode Doppler velocimetry test. The wave shapes of the UA and MCA flow velocities were obtained. By dividing the pulsatility index of MCA by the pulsatility index of UA, the CPR was computed.

The reference value for CPR was a single cut-off value of <1.08.

The Chi-square test was used to determine how category variables were associated. The student's t-test was used to determine the statistical significance of the difference in the mean values of the quantitative variables, such as the CPR ratio between the low-risk and high-risk pregnant women.

Results

The age range in the current study's age distribution was between 18 and 45. The average age was 31.5. The low-risk group (control group) had a mean age of 25.6± 4.31 years, while the high-risk group (study group) had a mean age of 27.4 ±4.1 years.

Women's BMIs in the current study ranged from 17.6 to 39.8 kg/m2. BMI average was 28.7 kg/m^2. 57.32% of cases in the current study were multiparous, and 42.68% were nulliparous. The distribution between primigravida and multigravida is essentially equal. The most frequent risk factors in the current study were hypertension (7.31%) and diabetes (1.22%).

In the current study, 62.5%(50) of the cases resulted in a pregnancy that was carried for a maximum of 4 weeks + 1 day to 6 weeks. Women who were unable to carry their pregnancies to term gave birth on the same day as the Doppler examination in 1.25% (1) of cases. NST, AFI, diastolic flow, Ductusvenosus, and Doppler were used to closely monitor the cases in which pregnancy was continued past the four-week mark. We were able to prolong the pregnancy and achieve improved fetal outcomes with shorter NICU stays.

Table 1: The maternal characteristics of the women enrolled in the study

		No. of cases	Percentage
Duration of Age (in years)	≤20	4	4.88%
	20-24	30	36.59%
	25-29	30	36.59%
	30-34	15	18.29%
	35-39	2	2.44%
	≥40	1	1.22%
	Total	82	100.0%
Duration according to BMI in kg/m^2	<18	1	1.22%
	18-24.9	13	15.85%
	25-29.9	36	43.90%
	30-35	28	34.15%
	>35	4	4.88%
	Total	82	100.0%
Obstetric score	Primi	35	42.68%
	Multi	47	57.32%
	Total	82	100.0%

Risk associated	Preeclampsia	6	7.3%
	Gestational hypertension (PIH)	5	6.09%
	Gestational diabetes mellitus (GDM)	4	4.9%
	Chronic hypertension	1	1.22%
	T2 DM	1	1.22%
	Total	17	
Classification of risk	Low risk	64	80.0%
	High risk	16	20.0%
	Total	80	100.0%
Period of prolongation of pregnancy after 30-34 weeks period of gestation till delivery	0 day	1	1.25%
	<1 week	1	1.25%
	1-2 weeks	3	3.75%
	2+1-4 weeks	23	28.75%
	4+1-6 weeks	50	62.5%
	6+1-8 weeks	2	2.5%
	Total	80	

In the current study, 67.5% (54) of the women gave birth vaginally, with one woman having an abnormal Doppler reading. 26.25% (21) of the women underwent emergency LSCS, with two of them having an abnormal Doppler reading. The beginning of FGR (late-onset FGR) was greater than 32 weeks in the one woman who had abnormal CPR but a vaginal delivery. Of the 21 women who received emergency LSCS, 12.5% (57.14%) did so because of fetal distress; nine of these women (93.5%) had normal Doppler readings, while three (6.25%) had abnormal ones. These three women's babies were moved to the NICU for observation but not for ventilation. Eventually, all of the infants were all released with no apparent illness.

Nine NICU admissions were included in this investigation. The majority of them were premature infants who needed to be given surfactant.

In the current study, the average length of time spent in the NICU was eight days for infants with normal Doppler, compared to 103 days for infants with faulty Doppler.

Table 2: The maternal characteristics of the women enrolled in the study

		No. of cases	**Percentage**
Birth weight (in kg)	<1.5	2	2.5%
	1.5-2.0	4	5.0%
	2.1-2.5	9	11.25%
	2.6-3.0	40	50.0%
	>3	25	31.25%
	Total	80	100.0%
ABG pH at birth	Normal	73	91.25%
	Abnormal	7	8.75%
	Total	80	100.0%
Period of gestation at birth	30-31+6 weeks	2	2.5%
	32-33+6 weeks	4	5.0%
	34-35+6 weeks	9	11.25%
	36-37+6 weeks	37	46.25%
	≥38 weeks	28	35.0%
	Total	80	100.0%
Amniotic Fluid Index at 30-34 weeks	<5	4	4.88%
	5-25	77	93.90%
	>25	1	1.22%
	Total	82	100.0%
Route of delivery	Vaginal	54	67.5%
	Elective LSCS	5	6.25%
	Emergency LSCS	21	26.25%
	Total	80	100.0%
Instrumental delivery	Forceps	0	0.0%
	Vacuum	7	87.5%
	Forceps + Vacuum	1	12.5%
	Total	8	
Indication for emergency	Fetal distress	12	57.14%

LSCS	NPOL	6	28.57%
	Patients choice Scar dehiscence	1	12.5%
	Breech presentation	1	12.5%
	Cord prolapsed	1	12.5%
	Total	21	

Table 3: Association of outcome in late-onset FGR with risk factors

Risks associated	POG atbirth (mean)	Vaginal	LSCS	CPR Normal/ Abnormal	ABG pH Normal/ Abnormal	Birth weight <2.5KG/>2.5Kg	NICU stay (duration in days) (mean)	Ventilation(yes/no)
Preeclampsia [n=6]	36	4	4	4/2	2/4	3/0	3,13,4(6.6)	0/6
Gestational hypertension(PIH)(n=5)	36	3	2	5/0	3/2	3/2	7,12(9.5)	0/5
GDM + Preeclampsia/ PIH(n=15)	37+3	12	3	12/3	11/4	4/11	6,35,0.5,5 (11.6)	4/11

Table 4 demonstrates that women in the low-risk group delivered vaginally substantially more often than women in the high-risk group (74.22% vs. 44.87%, p <0.001).High-risk patients were substantially more likely to be admitted to the NICU (22.22% vs. 9.4%, p=0.002) than low-risk patients. When compared to women in low-risk groups (3.12%), women with abnormal Doppler are in high-risk cases (12.5%). In the high-risk group, the length of the pregnancy was considerably shorter than in the low-risk group (31.09±13.9 vs. 37.79±15.1, p=0.003).

Table 4: The association of high risk and low risk pregnancies with various variables

Variables	High risk n (%) 16(20.0%)	Low risk n (%) 64(80.0%)	Total n (%) 80(100%)	Chi-square	p-value
Route of delivery					<0.0001
Emergency CS	6(37.5%)	14(21.88%)	20(25.0%)	38.71	Significant
Elective CS	2(12.5%),	2(3.1%)	4(5.0%)		
Vaginal	8(50.0%)	48(75.0%)	56(70.0%)		
NICU admission					
Yes	6(37.5%)	3(4.69%)	9(11.25%)	9.35	0.002
Mean stay days	8.42	5.89			significant
Ventilation (Y/N)	2/14	1/63			
No	9(56.25%)	61(95.31%)	70(87.5%)		
CRP					
Normal	14(87.5%)	62(96.88%)	76(95.0%)	3.5	0.061 Not
Abnormal	2(12.5%)	2(3.12%)	4(5.0%)		significant
POG at Birth day (Mean±SD)	262.36±16.7	266.3±18.1	265.58±17.16	-1.78 (t-value)	0.075 not significant
Birth weight (Mean±SD)	2.73±0.39	2.79±0.41	2.79±0.48	-0.98	0.33 not significant
Period of prolongation weeks	31.09±13.9	37.79±15.1	36.5±14.5	-3.62	0.0003 significant

Table 5 shows the CPR in both late mild fetal growth restriction (FGR) and early severe fetal growth restriction (FGR).

Table 5: CPR in early severe fetal growth restriction (FGR)and late mild fetal growth restriction (FGR)

	Early-onset FGR (<32 weeks) with abnormal Doppler = CPR abnormal (mean)	Late-onset FGR (>32 weeks) withabnormal Doppler (mean)
Total cases = 9	2	7
CPR (Percentile)(mean)	1	2.2
Duration of prolongation of pregnancy(mean)	2 days	2weeks+3days (mean)
Vaginal	0	3
LSCS	2	4

ABG pH (Normal/Abnormal)	0/2	2/5
NICU Stay =Yes	1	8
Duration: mean days	20	8.5

Discussion

The age distribution in the present study was in the range of 18 to 45 years. The mean age was 31.5 years. The mean age in the low-risk group (control group) was 25.6 ± 4.31 years, while in the high-risk group (study group) was 27.4 ± 4.1 years.

A study done by Flatley et al.[13] reported the mean age group of women included in the study observational to be 31.5±5.8 years and that in the reference observational study was 30.3 ± 5.8 years. This was statistically significant. Another study done by Pe´rez-Cruz et al. [14] reported that age distribution was 32±5 in the study group and 31±6 in the IUGR group, which was not statistically significant. The mean age in our study was lower as compared to the other two studies.

In the present study, the BMI of women ranged from 17.6 to 39.8 kg/m2. The mean BMI was 28.7 kg/m2. In a study done by Flatley et al. [13] the mean BMI of women in the control group was 23.9 kg/m2 (20.8–28.9 kg/m2), and the BMI of women in the reference group was 22.7 kg/m2 (20.0–26.6 kg/m2), and it was statistically significant. The higher BMI noted in our study could be due to the increased urbanization of our study population.

In the present study, 57.32% of cases were multiparous, and 42.68% were nulliparous. There is an almost equal distribution among the primigravida and multigravida. In a study done by Flatley et al. [13] 41.6% of women were nulliparous. In another study done by Pe´rez-Cruz et al. 57% of women were nulliparous in the control group, and 67% were nulliparous in the high-risk group. The high risk/ FGR group had more nulliparous women than the low-risk/ control group.

In the present study, the commonest risk factors were hypertension (7.31%) and diabetes (1.22%).In a study conducted by Flatley et al., [13] 11.5% of women had hypertension in the study group, and 35.8% of women had diabetes. The incidence of hypertension is similar in both studies. But there was a considerable difference in the incidence of diabetes.

In the present study, the maximum prolongation of pregnancy was achieved in 62.5% (50) of cases for a period of 4 weeks +1 day to 6 weeks. In 1.25% (1) of cases, pregnancy could not be prolonged, women delivered on the same day of the Doppler study. The cases in which pregnancy was extended beyond four weeks were closely followed up with NST, AFI, diastolic flow, Ductusvenosus, Doppler, and we were able to prolong the pregnancy and had a better foetal outcome with a reduced duration of NICU stay.

In the present study, the mean birth weight of babies among the normal Doppler group was 2.82 Kg. However, Pe´rez-Cruz et al. [14] reported the mean birth weight to be 3.35 Kg in the reference group.

In the present study, the mean birth weight of babies among the FGR babies was 1.94 Kg. However, Pe´rez-Cruz et al. [14] reported the mean birth weight to be 2.14 Kg in the study group.

In the present study, the difference between the mean birth weight of FGR babies and normal babies was statistically significant.

In the present study, the ABG pH of babies with normal Doppler was in the range of 7.3 to 7.5, while the babies with abnormal Doppler had a pH of less than 7.3. In comparison, the study by Perez Cruz et al. [14] reported the pH range to be 7.23 ± 0.08 for babies with normal Doppler and 7.24 ± 0.08 for babies with abnormal Doppler.

In the present study, in babies with normal Doppler, 6.2% (4 babies among 64 babies) had abnormal ABG pH, which may be due to the perinatal insult. Of these, 3 babies were shifted to NICU, and only one baby was on ventilation (CPAP). The mean duration of NICU stay was 5.89 days.

In the babies with abnormal Doppler (FGR), 33.3% (1 baby among 3 babies) had abnormal ABG pH, which is in line with the result reported by Pe´rez-Cruz et al. [14] Babies having abnormal Doppler were shifted to NICU, of which six babies were on ventilation (three babies were on SIMV mode, and three babies were on CPAP), with a mean duration of NICU stay of 20 days.

In the present study, the period of gestation (POG) at birth is as shown in Table 2. The mean POG at birth was 38 weeks (266 days) for babies who had normal Doppler, and it was 35 weeks (245 days) for babies with FGR. These results coincide with those reported by Pe´rez-Cruz et al.

In the present study, 67.5% (54) of women had a vaginal delivery, of which one woman had abnormal Doppler reading; 26.25% (21) of women underwent Emergency LSCS of which 2 women had an abnormal Doppler reading, and 6.25% (5) underwent Elective LSCS. Among the one woman who had abnormal CPR but had a vaginal delivery, the onset of FGR was more than 32 weeks (late-onset FGR). Of the 21 women who underwent emergency LSCS, 57.14% (12) underwent LSCS

for foetal distress, of which 9(93.5%) had normal Doppler and three women (6.25%) had abnormal Doppler. The babies of these three women were shifted to NICU for observation but not on ventilation. All babies were eventually discharged without any immediate morbidity.

In a study by Perez-Cruz et al., [14] 79.3% (238) had a vaginal delivery. 20.6% (62) underwent Emergency LSCS. Elective LSCS was not mentioned in this study. Of the 62 women who underwent emergency LSCS, 47 had abnormal Doppler, while 15 women had normal Doppler.

In a study by Ganju et al., [15] in 117 study women, abnormal CPR (<1.08) was found in 65 cases with a statistically significant correlation for prediction of cesarean section delivery (p<0.001). A systematic review of 13 prospective and eight retrospective studies by Dunn et al. concluded that Fetal CPR was predictive of caesarean section for intrapartum fetal compromise, small for gestational age and fetal growth restriction and neonatal intensive care unit admission.

However, in our study, abnormal CPR value was not a contraindication for vaginal delivery. In the present study, the number of NICU admissions was 9. Most of them were premature babies who required surfactant administration. In the present study, in the babies with normal Doppler, the mean duration of NICU stay was eight days, while in babies with abnormal Doppler, the NICU stay was 103 days.

Of the 18 babies who had abnormal CPR, 13 babies were admitted to the NICU (72%). Ganju et al. [15] also noted a strong association of CPR < 1.08 with admission to the NICU (86%). In a study by Perez-Cruz et al., [14] none of the babies with normal Doppler required NICU admission, while the mean duration in the NICU for babies whose mothers had abnormal Doppler was 14 days, which was very much less as compared to our study.

The association of risk factors with the outcome in late onset FGR is given in Table 3. The association of high risk and low-risk pregnancies with various variables is given in Table 4. In our study, high-risk pregnancy was defined as having at least one of the following conditions: preeclampsia or gestational hypertension or gestational diabetes mellitus.

As shown in Table 4, significantly more women in the low-risk group had vaginal deliveries than women in the high-risk group (74.22% vs 44.87%, p <0.001).

NICU admissions significantly increased with high-risk patients than low-risk patients (22.22% vs 9.4%, p=0.002). Women with abnormal Doppler are (12.5%) in high-risk cases compared to women belonging to low-risk groups (3.12%). The period of prolongation of pregnancy was significantly lower in the high-risk group as compared to the low-risk group (31.09 ± 13.9 vs 37.79 ± 15.1, p=0.003).

The CPR in early severe fetal growth restriction (FGR) and late mild fetal growth restriction (FGR) is shown in Table 5 .

Women with normal CPR values had neonates whose birth weight was higher than women with abnormal CPR (2.82 Kg vs 1.94 Kg). Similar to our study, a study by Ganju et al. [15] reported that abnormal CPR (<1.08) had a statistically significant correlation for the prediction of low birth weight (p<0.001). A higher period of prolongation of pregnancy was achieved in women who had normal CPR compared to women who had abnormal CPR (37.56 weeks vs 14.64 weeks).

The mean period of gestation was significantly higher for babies with normal CPR values than those who had abnormal CPR values (266.47 days vs 245.41 days).

The above three results indicate that period of gestation, birth weight, and prolongation period are significantly lower with patients with abnormal CPR compared to patients with normal CPR.

Conclusion

Doppler ultrasound velocimetry of the umbilical and fetal veins has established itself as a reliable technique for prenatal surveillance, enabling non-invasive evaluation of the neonatal circulation and its perinatal outcome. Doppler monitoring of patients is less important in low-risk circumstances than it is in high-risk cases. However, as late-onset FGR has a higher morbidity and death rate than early-onset FGR, Doppler velocimetry should be performed in high-risk individuals at 30 to 34 weeks to detect FGR.

Doppler velocimetry makes a substantial contribution to the early detection and follow-up of late-onset FGR, as well as the timing of delivery or pregnancy extension.

Daily AFI and NST can be used to follow up with or monitor infants who have abnormal CPR. Even yet, at lung maturity, Doppler velocimetry becomes a crucial technique for deciding when to deliver a baby.

Additionally, it is an important characteristic to distinguish between early-onset severe FGR and late-onset mild FGR, which are both challenging to detect without Doppler velocimetry but relatively simpler to treat. In contrast to early onset fetuses, late-onset FGR newborns do not adapt well to the rapid onset of hypoxia.

If we monitor them with other indicators like NST, AFI, and flow in the Ductus Venosus, such as in low risk instances with abnormal Doppler, there is

no contraindication against vaginal birth. Doppler velocimetry consequently becomes a crucial technique for high-risk cases and mild FGR that manifests late (after 32 weeks).

The necessity for routine Doppler at 30 weeks or more to identify and treat FGR in both high-risk and low-risk instances, however, requires more thorough research. Additionally, long-term morbidity in our population's early-onset and late-onset FGR has to be researched.

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