

Association between antenatal cerebroplacental ratio and adverse pregnancy outcome

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Abstract

Introduction: Foetuses with an abnormal cerebroplacental ratio, that are appropriate for gestational age may have higher incidence of foetal distress in labour and end up with caesarean section.

Objectives: To find out whether there is a relationship between the Cerebroplacental Ratio (CPR) at gestational age of 34 weeks and adverse pregnancy outcome.

Methods: Cross Sectional Descriptive Study was conducted among 421 pregnant women presented to North Colombo Teaching Hospital, Ragama. Singleton pregnancies with 34 weeks of gestational age were included and two structured data collection sheets were used as study instruments.

Results: Mean age of the study participants was 31.33 years (SD=5.79 years). Majority were multigravida mothers (N=317:75.29%). CPR and birth weight have a relationship to predict a normal or increased birth weight (AUC 0.673:95% CI 0.578:0.76). There is a significant relationship between CPR value and having a birth weight more than 3.5kg (AUC >0.5). Significantly higher number of participants underwent normal vaginal deliveries (N=334:79.3%). A significant difference is observed between the mean CPR values of mothers who underwent NVD and LSCS (t=7.182: p<0.001). Relationship of CPR value is significantly adequate to predict SCBU admissions (AUC 0.761:95% CI 0.695-0.824) and to predict NVD by using the CPR value (AUC 0.743:95% CI 0.663-0.823).

Conclusions: There is a significant relationship between the CPR value calculated by USS at the 34th week of gestation and incidence of NVD. A relationship which is adequate for predicting birth weight status is identified between CPR value and birth weight. Although there is a significant relationship between CPR and adverse prenatal outcomes, there were no factors to elicit a causative association.

Key words: cerebroplacental ratio, prediction, perinatal outcome

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Introduction

Fetal hypoxia is one of the major causes of perinatal morbidity and mortality including cerebral palsy, visual and hearing impairment, attention deficit hyperactive disorders¹. In normal situation, fetal Middle Cerebral Artery (MCA) has high resistance flow than umbilical artery (UA)². In pathologic states, MCA blood flow become low resistance flow as a result of fetal head sparing theory³. Low oxygen supply to the brain cause cerebral vasodilatation and fall in vascular resistance⁴. This finally result in decreased middle cerebral artery resistance index^{1,5}. As the pregnancy advanced middle cerebral artery resistance index should remain higher than umbilical artery resistance index, so the ratio should be higher than 1:1 in uncomplicated pregnancies⁶. Cerebroplacental ratio more than 1:1 is considered normal^{7,8}. Cerebroplacental ratio (CPR) less than 1:1 is considered abnormal⁹. Sensitivity of cerebroplacental ratio is higher if gestational age is less than 34 weeks^{10,11}.

Cerebroplacental ratio can be used to assess fetal wellbeing. CPR is an emerging predictor of adverse pregnancy outcome³. Fetuses with an abnormal cerebroplacental ratio, that are appropriate for gestational age may have higher incidence of fetal distress in labour and end up with cesarean section¹¹. CPR ratio can be used to predict adverse outcome in late onset Small for Gestational Age babies (SGA)^{11,12}. CPR has the strongest association with adverse pregnancy outcome^{13,14}. Some studies have been done in other countries to detect whether cerebroplacental ratio can be used to predict adverse pregnancy outcome. But, no adequate number of studies available regarding this topic. Fetuses with small or average for gestational age with abnormal cerebroplacental ratio may have higher incidence of,

- Increased rate of neonatal intensive care unit admissions.
- Increased perinatal death.
- Lower gestational age at birth.
- Lower birth weight.
- Higher rate of cesarean section due to fetal distress¹⁴.

For this study, patient need to undergo ultrasound scan and it is noninvasive, does not cause any harm to the fetus, nor to the mother, therefore this investigation is

not harmful to the patient and it is acceptable at physical, social, and individual level. Measurement cerebroplacental ratio does not cause any extra expenses to the mother as it is done in hospital free of charge for this study. CPR is not included in guidelines as a diagnostic test as there is no enough evidence for that. Therefore, more and more studies on this topic are needed. If we find this cerebroplacental ratio can be used as a predictor of adverse fetal outcome, it is very much useful for providing antenatal care and we are able to find mothers who are most likely to end up with adverse pregnancy outcome. Finally, this will help the clinicians to get early decisions to have a better pregnancy outcome.

Methods

Cross Sectional Descriptive Study conducted in, antenatal clinic-A and ward 18 of North Colombo Teaching Hospital, Ragama. Patients with gestational age of 34 weeks, who attend antenatal clinic-A and those who admitted to ward 18 North Colombo Teaching Hospital, Ragama. Patients with singleton pregnancies, Gestational age 34 weeks and gestational age confirmed by dating scan between 10 to 14 weeks were included. Patients with small for gestational age fetuses [SGA] and pregnancies complicated by fetal anomalies were excluded from the study. 423 participants were selected through convenient sampling technique during one year study period.

Ultrasound scan (USS) was done for each participant. Biparietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference (AC), Femur Length (FL) and Expected Fetal Weight (EFW) was taken as measurements. Pregnancy outcome, whether normal vaginal delivery or cesarean section, gestational age at delivery, birth weight, whether baby admitted to neonatal intensive care unit, whether ended with perinatal death were recorded. Data was analyzed at the end of one-year duration.

Umbilical artery Doppler and Middle cerebral artery Doppler was done and Doppler indices were measured at 34 weeks of gestation. Pulsatility Indexes were taken for CPR calculation.

Pulsatility Index was calculated according to Gasling and King method⁹. It is calculated by dividing the difference between peak systolic velocity and end diastolic velocity by mean velocity²⁰.

$$\text{Pulsatility Index [PI]} = \frac{\text{peak systolic velocity (S)} - \text{end diastolic velocity (D)}}{\text{mean velocity (M)}}$$

The cerebroplacental ratio was computed by dividing middle cerebral artery pulsatility index by umbilical artery Pulsatility Index¹³.

$$\text{Cerebroplacental Ratio (CPR)} = \frac{\text{Middle Serebral Artery Pulsatility Index (MCA - PI)}}{\text{Umbilical Artery Pulsatility Index (UCA - PI)}}$$

The middle cerebral artery [MCA] was examined when the head was kept in transverse plane, middle cerebral artery was detected by colour Doppler. Doppler wave was taken as MCA passes the sphenoid wing, close to the circle of Willis. Reading was taken close to its origin¹⁵. Umbilical artery was examined at a free loop of the umbilical cord.

Data was entered into an Excel 2010 data sheet. After data has been cleaned, it was analyzed by SPSS 25:0 statistical software. Initially a univariate analysis was conducted and for selected variables a bivariate analysis was conducted later.

Results

Age of the study participants was ranged from 17 years to 44 years. Mean age of the study participants was 31.33 years (SD=5.79 years). Majority of the study participants age above 30 years (N=237:56.3%). Parities of the participants were ranged from primi-gravidae to 7th pregnancy. Majority of the study participants were multigravida mothers (N=317:75.29%).

Birth weight ranged from 1.8kg to 3.9kg. Mean birth weight was 2.928kg (SD=0.412kg). Significantly higher majority represented the normal birth weight range ($z > 1.96$). CPR and birth weight have a relationship which is suitable to predict a normal or increased birth weight (AUC 0.673:95%: CI 0.578:0.76). Therefore, ROC curves show that CPR value can be used to predict absence of low birth weight (AUC >0.5). But to predict the birth of a newborn with a birth weight 2.5kg to 3.57kg, the relationship between CPR and range of birth weight from 2.5kg to 3.57kg is not adequate (AUC 0.566:95% CI 0.496-:636). But relative to the reference line of the ROC curve, a good and positive relationship is observed between CPR and 2.5kg to 3.57kg birth weight range.

There is a significant relationship between CPR value and having a birth weight more than 3.5kg (AUC >0.5). But it does not appear to be an adequate relationship to predict birth weight more than 3.5kg (AUC 0.538:95%

CI 0.452-0.624). Significantly higher number of participants underwent normal vaginal deliveries (N=334:79.3%). 12.6% of the study participants had to admit their babies to SCBU (N=53). Only 3 participants were observed to have IUD (0.7%).

A significant difference is observed between the mean CPR values of mothers who underwent NVD and LSCS ($t=7.182$; $p < 0.001$). Significantly low CPR value was observed with the study participants who had to admit their newborns to SCBU ($t=4.61$ $p < 0.001$). Mean CPR value of the mothers who did not experience an IUD did not show a significant difference ($t=0.266$ $p=0.79$) (Table 1). CPR and birth weight have a relationship which is suitable to predict a normal or increased birth weight (AUC 0.673:95%: CI 0.578-0.76). Therefore, ROC curve included in figure 1 shows that CPR value can be used to predict absence of low birth weight (AUC >0.5) (Figure1).

But to predict the birth of a newborn with a birth weight 2.5kg to 3.57kg, the relationship between CPR and range of birth weight from 2.5kg to 3.57kg is not adequate (AUC 0.566: 95% CI 0.496-636). But relative to the reference line of the ROC curve, a good and positive relationship is observed between CPR and 2.5kg to 3.57kg birth weight range (Figure 2). Relationship between CPR value and having a birth weight more than 3.5kg (AUC >0.5). But it does not appear to be an adequate relationship to predict birth weight more than 3.5kg (AUC 0.538:95% CI 0.452-0.624) (Figure 3).

Relationship between CPR value and NVD is good and positive. This relationship is significantly adequate to predict NVD by using the CPR value (AUC 0.761:95% CI 0.695-0.824) (Figure 4). Relationship between CPR value and SCBU admissions is good and positive. This relationship is significantly adequate to predict SCBU admissions by using the CPR value (AUC 0.743:95% CI 0.663-0.823). But it is not possible to observe an adequate relationship to predict an IUD with CPR value (AUC 0.490:95% CI 0.149-0.831) (Figure 5).

Table 1. Mean comparison of CPR value between selected exposure variables

	Parameter	Mean CPR	t	P value
MOD	NVD LSCS	1.3532 .8730	7.182	<0.001
SCBU	Yes No	.9140 1.3029	4.61	<0.001
IUD	Yes No	1.1633 1.2542	0.266	0.790

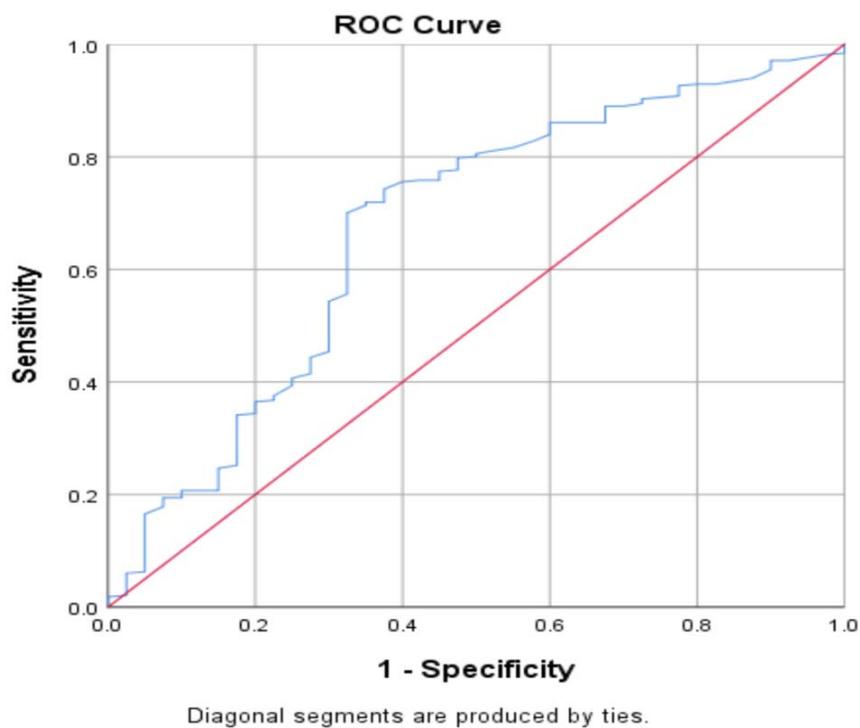


Figure 1. Prediction ability of cerebroplacental ratio on normal birth weight babies.

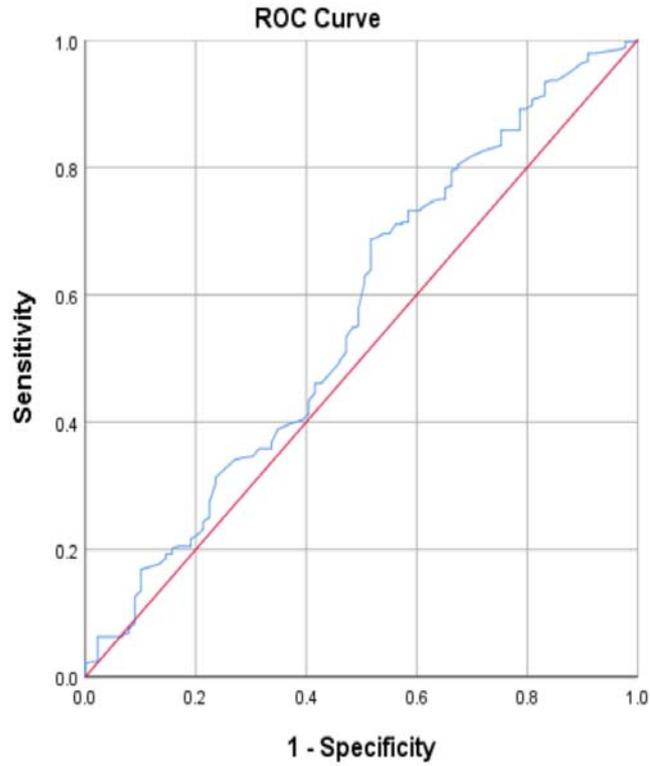


Figure 2. Prediction ability of cerebroplacental ratio on birth weight between 2.5kg to 3.57kg babies.

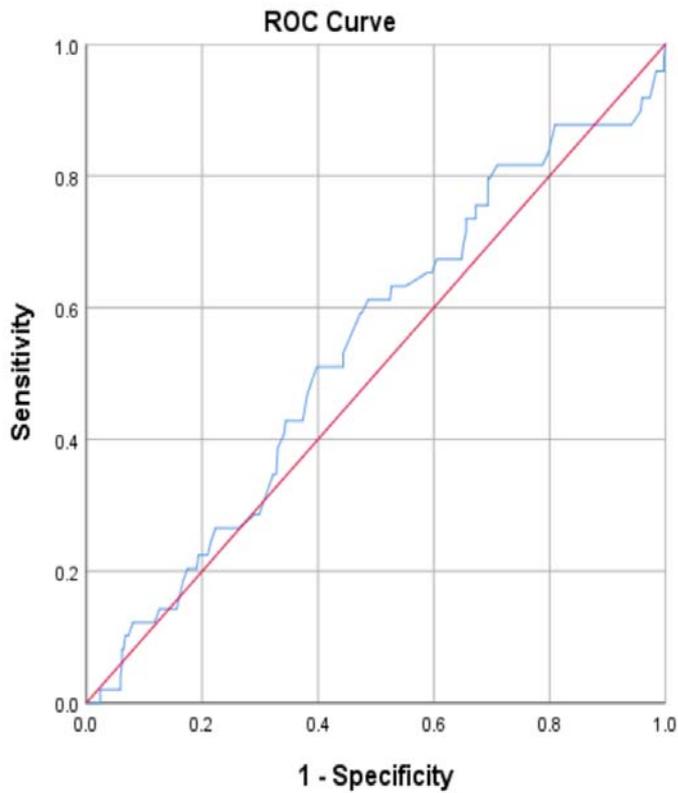


Figure 3. Prediction ability of cerebroplacental ratio on birth weight more than 3.5kg of babies.

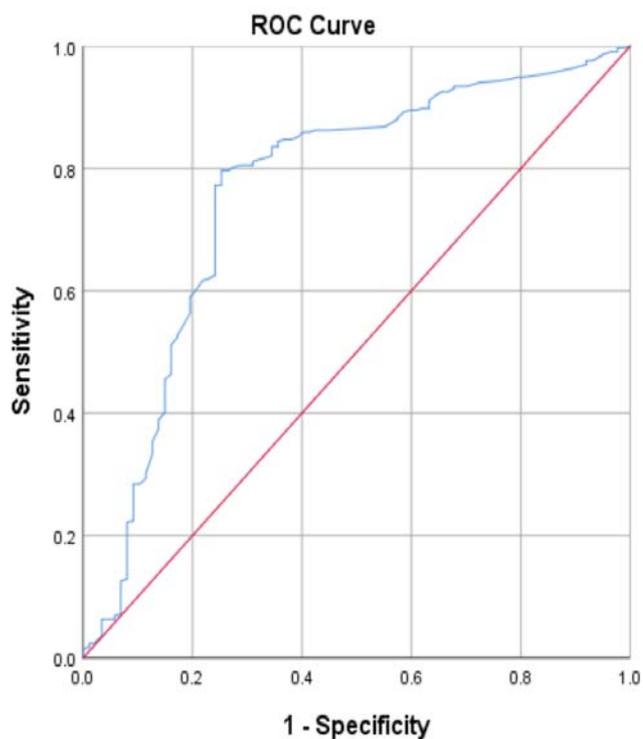


Figure 4. Prediction ability of cerebroplacental ratio on occurrence of normal vaginal delivery of babies.

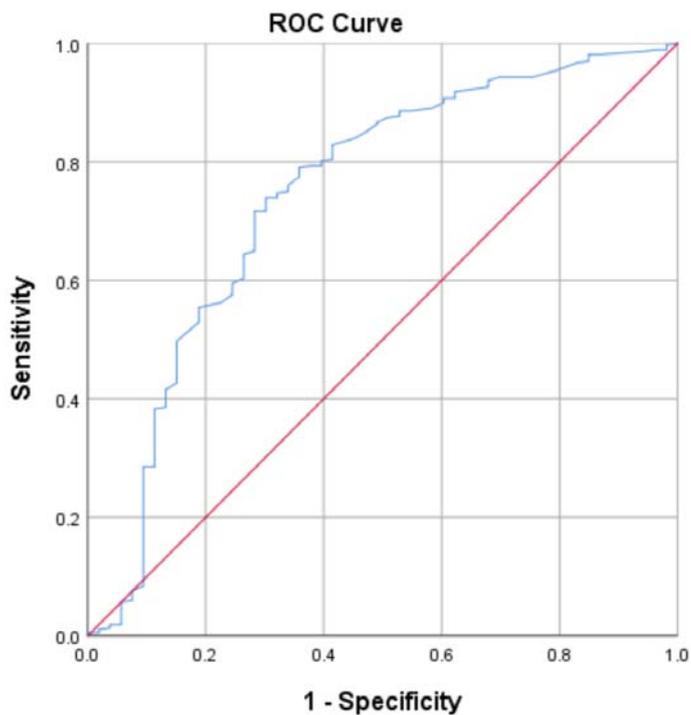


Figure 5. Prediction ability of cerebroplacental ratio on SCBU admissions of babies.

Discussion

According to the study done by Odibo et al in 2005. The perinatal adverse events were detected in 70 participants out of 183 study subjects with intra uterine growth restriction babies. But in present study addressed randomly selected pregnant women in third trimester. The predictive ability of the cerebroplacental ratio value in the study done by Odibo et al is considerably high. Present study findings are compatible with the findings of Odibo et al. But present study determined the predictive ability only for selected adverse events⁸.

Dunn et al in 2017, strongly emphasized that fetal cerebroplacental ratio value is strongly predict intrauterine growth restriction, special care baby unit admission, foetal heart rate abnormality, meconium stained liquor, low APGAR score birth asphyxia during labour. These findings were based on systematic review of thirteen prospective and eight retrospective studies. Present study also agreed with the predictability of the cerebroplacental ratio. But all perinatal outcomes addressed in the previous study were not considered due to methodological limitations¹⁶.

Bahado et al also determined the predictive ability of the cerebrospinal ratio value in perinatal outcome. But that study also applied to pregnancies with intra uterine growth restrictions. So the comparison of present study findings might have some implementation errors¹⁷. The findings of Akolekar et al are compared with present study. But it applied in 35 to 37 weeks of gestation of the participants. But present study confined to 34th week of gestation. But some comparison can be implemented¹⁸. The study done by Bakalis et al the Doppler ultrasound scan was done between 30 to 34 weeks of gestation. That study predicts special care baby unit admissions and determined predictability was compatible with present study¹⁹.

By using the associated relationship with adverse perinatal outcomes, it is possible to obtain a more accurate adverse event prediction. Due to these adverse event predictions an opportunity is created to plan the precautions which is accepted as an extremely successful primary prevention strategy. Present study findings are not adequate to elicit a causative relationship between CPR and adverse perinatal outcomes. To generate a causative association with CPR and adverse perinatal outcomes, it is essential to have clearly identified several types of evidences.

Among them, greater significance is identified with internal consistency of findings and comparisons with existing knowledge. But according to the study findings generated within the present study design, it is possible to state that there is an indication to identify association between CPR and selected adverse events.

Although there isn't a causative relationship, there are no obstacles to use this relationship between CPR and perinatal outcome as a decision-making tool for primary prevention strategies. By using this method, it is possible to achieve a reduction in incidence of adverse perinatal events. It directly creates a positive effect on pregnant mothers, generates a better socio-economic impact on her family and a significant health economical influence on the health care delivery system of the country.

On the other hand, methodology used in this can be easily implemented within the routine Sri Lankan antenatal care package. Usually pregnant mothers attend their antenatal clinic at 34th week of gestation. Performing an ultrasound scan at this clinic and visit is feasible during this event and it is performed at the current antenatal practices at present. Even mothers who do not receive the government health care services, tend to acquire this routine antenatal management procedure through public sector.

In the current antenatal setup, a pregnant mother is subjected to at least a single ultrasound scan during her third trimester. Apart from that, almost all the mothers who admit for confinement without any emergency are subjected to an abnormal ultrasound scan within the hospital setup. Therefore, there is room to insert the procedure used during this study to the routine clinical practice as a guideline.

On the other hand, it is not essential to seek contribution from external clinical specialists for this ultrasound scanning procedure. Routine antenatal ultrasound scans are performed by the consultant obstetrician gynecologist of the specific unit or by a post graduate trainee or a senior house officer under the supervision of the responsible consultant. Therefore, resources or procedural requirements are not required for this strategy. CPR, MCPI and UAPI are findings generated during routine abdominal USS of pregnant mothers. Therefore, there is a clear opportunity of gaining an extra advantage through this data both for the patient and health care delivery system.

Ultra sound scanning is a biomedical instrumental technology which advances day by day. At present USS technique is predominantly used for detection of congenital abnormalities, analysis of maternal and fetal risk factors and confirmation of gestational age. Current study findings provide clear signals of feasibility of using USS for many other clinically important diagnoses and predictions.

Relationship between CPR values and both weights appear to be another important implimentary finding recognized during this study. With a prediction of a low birth weight baby it is possible to anticipate a specially prepared delivery with necessary facilities. It gives the opportunity to plan the child birth process with pre-arranged contribution of pediatric teams and availability of SCBU facilities. But more reliable findings regarding intra uterine growth restrictions are obtained by direct observation through the USS. Therefore, a logic could arise that need of CPR value is less useful but consistency of predictions obtained by many diagnostic methodologies increases the ability of securing an accurate confirmatory decision. Clinical impact created by this situation appears more positive.

Conclusion

There is a significant relationship between the CPR value calculated by USS at the 34th week of gestation and incidence of NVD. A relationship which is adequate for predicting birth weight status is identified between CPR value and birth weight. Although there is a significant relationship between CPR and adverse prenatal outcomes, there were no factors to elicit a causative association. It helps to take necessary precautions for deliveries with a higher possibility of adverse perinatal outcomes. Health care delivery staff should be informed regarding this predictive ability of the CPR value.

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