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Cerebroplacental Ratio on Doppler as a Predictor of Fetuses at Risk of Perinatal Complications

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Doppler velocimetry is the best method of surveillance for fetal hypoxemia during pregnancy. Cerebroplacental ratio (CPR), has been suggested as a useful clinical simplification. It is believed that the CPR better predicts adverse perinatal outcomes than its individual components and better than conventional anthropometric models. Therefore, the aim of this study is to evaluate the significance of the cerebroplacental 10th centile threshold measured weekly from 36 weeks of gestation till delivery as a screening test for prediction of need for Cesarean section for intrapartum fetal compromise and the adverse neonatal outcome in women with normally grown fetuses and uncomplicated pregnancy.

Methods: This study was carried out on 40 pregnant women uncomplicated, singleton pregnancy with appropriately grown fetuses on clinical assessment. The last Doppler indices including cerebroplacental ratio measurement obtained before labor was reported. CPR values below 1.1 were reported as abnormal. Various studies have variably defined the threshold of abnormal CPR ratio as <1.08.

Results: There was significant decrease in the Mean of CPR among patients who had anemia compared to those without anemia. In addition, there was no significant association seen between low CPR and having previous history of abortion or IUGR as well as being a smoker. There was no significant difference between cases who had normal and abnormal CPR regarding gestational age

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at delivery. There was no difference between cases who had normal and abnormal cerebroplacental ratio regarding mode of delivery. there was significant decrease in the prevalence of low birth weight among group who had CPR≥1.08. CPR <1.08 was significantly associated with neonatal complication like NICU admission, and neonatal death. There was no statistically significant relationship between cerebroplacental ratio and neonatal complication like IUFD, and neonatal sepsis. There was no statistically significant association between the mean cerebroplacental ratio and IUFD. There was statistically significant association between the mean cerebroplacental ratio and NICU. There was no statistically significant association between the mean cerebroplacental ratio and neonatal sepsis. The mean cerebroplacental ratio of 0.93± 0.22 has a significant association with neonatal death.

Conclusion: A low cerebroplacental ratio reflects redistribution of the cardiac output to the cerebral circulation and has been shown to improve accuracy in predicting adverse outcome compared with Middle cerebral artery (MCA) or Umbilical artery (UA) Doppler alone. Therefore, integrating CPR in clinical management may help to better identify fetuses at risk for adverse perinatal events, since abnormal CPR has been associated with an increased risk of perinatal complications.

Keywords: Cerebroplacental ratio; fetal risk predictor; perinatal complications; neonatal outcome.

1. INTRODUCTION

Intrapartum fetal hypoxia at term arises because of some events, such as cord prolapse, placental abruption or uterine rupture, in most cases, hypoxia develops gradually due to the inability of the fetus to tolerate the stress of parturition, i.e., the reduced fetoplacental reserve before initiation of labor [1]. Some term babies are more liable to intrapartum compromise. There is no known cause for this, although growth restriction was found in many cases. If not delivered immediately these babies are at risk of hypoxic brain injury and subsequent disability [2].

Fetal cerebroplacental ratio is the middle cerebral artery (MCA) Pulsatility Index (PI) to the Umbilical Artery Pulsatility Index (UA- PI) ratio and it represents fetal blood redistribution. The CPR gradually increases up to the 34th week of gestation and decreases thereafter until term [3]. The fetal cerebroplacental ratio is an independent predictor of intrapartum fetal compromise, poor acid–base status at birth and neonatal unit admission at term. In addition, a low cerebroplacental ratio may also reflect failure of a fetus to reach its genetic growth potential at term despite having a normal birth weight [4].

Screening tests differ from diagnostic tests in that they are aimed at identifying pregnancies that may be at higher risk of a given condition. Positive screening test results are typically followed by a high-specificity diagnostic test, according to the classic serial-testing protocol. Screening tests are characterized by high sensitivity to identify all cases at higher risk of a certain condition [5].

The aim of this study is to evaluate the significance of the cerebroplacental 10th centile threshold measured weekly from 36 weeks of gestation till delivery as a screening test for prediction of need for Cesarean section for intrapartum fetal compromise and the adverse neonatal outcome in women with normally grown fetuses and uncomplicated pregnancy.

2. PATIENTS AND METHODS

This prospective study included 40 pregnant females with uncomplicated pregnancy who were recruited from outpatient or the inpatients wards of Obstetrics and Gynecology department, Tanta University during the period from April 2019 to October 2020. Women with uncomplicated, singleton pregnancy and appropriately grown fetuses on clinical assessment were included in this study from 36 weeks of gestation and were followed up till delivery.

Women with maternal age < 18 or >35 years, with any pregnancy complications or with malpresentation were excluded.

All patients were subjected to the following: Complete history was taken with special emphasis on: personal history, menstrual history, date of last menstrual period (LMP) for confirming of gestational age, past history for Diabetes Mellitus, hypertension, cardiac problems, bleeding tendency, blood disease, bronchial asthma, allergy …..etc, previous operations (especially previous uterine scar as cesarean), past obstetric history: especially details of previous pregnancies (date, outcome, onset& mode of delivery, gestational age at delivery and any associated complication), history of drug intake, patient complaint and history of the current pregnancy and history of satisfaction of fetal kicks were asked about as a method to estimate fetal wellbeing.

Then clinical examinations were done including general examination especially measurement of weight, height and body mass index (BMI) using the formula: BMI = weight (kg) / [height (m)]2, assessment of vital signs (body temperature, pulse and blood pressure) to assess the hemodynamic status, cardiac and chest examination, abdominal examination was done: (fundal level, lie and presentation of the fetus, auscultation of fetal heart rate (FHR), presence of scar of previous laparotomy).

Ultrasound Examination: The ultrasound equipment used was (MINDRAY DC-N2, China) using a 3.5- 5-MHz transabdominal at the ultrasound unit of the Obstetrics and Gynecology department at Tanta University Hospitals, Egypt. All cases had a Transabdominal ultrasound examination at admission for assessment of gross anatomical defects, fetal viability, fetal number, and fetal biometry [biparietal diameter (BPD), head circumference (HC)] - fetal length (FL) - abdominal circumference (AC)].

Method of estimation: The BPD was measured as the distance between the outer edge of the cranium nearest to the transducer and the inner edge of the cranium distal to the transducer at the level of the paired hypoechoic thalami and cavum septum pellucidum. The HC was measured using the elliptical calipers over the four points of BPD and occipital frontal diameter in the same plane as BPD, between the leading edge of the frontal bone and the outer edge of the occiput. The AC was measured as the length of the outer perimeter of fetal abdomen at the level of umbilical vein junction with the portal vein in a transverse plane perpendicular to the spine, and the FL was measured as the length of the ossified diaphysis of the fetal femur from the greater trochanter to the femoral condyles. The mean of three different values for each measurement was recorded [6]. The estimated fetal weight was determined by measurement of BPD, AC, and FL (in cm) adopting the formula devised by Hadlock: EFW = 10** (1.326−0.00326*AC*FL + 0.0107*HC + 0.0438*AC + 0.158*FL. Placental (site & maturity), Liquor (amount described as amniotic fluid index (AFI) & turbidity).

Doppler velocimetry: Patients were first scanned in the routine fashion using B-mode. Then, the vessels of interest were confirmed by color Doppler. The Doppler signal was then obtained by placing the Doppler gate directly over the vessel of interest. The flow velocity waveforms were obtained in periods of fetal inactivity and apnea.

Doppler velocimetry for the umbilical artery: Doppler examination of fetal Umbilical artery was done with patients placed in a semi recumbent position with a left lateral tilt, and selected area of amniotic cavity with several loops of cord seen by color Doppler. Then using a pulsed wave Doppler which free-floating loop of the mid portion of the umbilical cord away from the placental and fetal cord insertion, the characteristic sound and shape of the umbilical artery was identified. When the screen showed at least 3 consecutive wave forms of similar height, the image was taken and Doppler umbilical artery Resistant index (RI) and pulsatility index (PI) was estimated. A minimum of 3 separate readings were averaged before the final value were obtained. Umbilical artery Doppler studies were avoided during fetal breathing because of effect of fetal breathing movements on waveform variability. The normal wave of umbilical artery is saw tooth appearance. Decreased diastole, absent diastole or reversed diastole were considered as abnormal waves. The measurement of RI, PI of umbilical artery was considered normal or abnormal according to percentiles for gestational age [7].

Doppler velocimetry for the Middle cerebral artery: For Doppler examination of Middle cerebral artery, transverse view of the fetal brain was obtained immediately caudal to the trans-thalamic plane used to obtain the biparietal diameter (BPD) and head circumference (HC) biometric data. The transducer was then moved towards the base of the skull at the level of the lesser wing of the sphenoid bone. Using color flow imaging, the middle cerebral artery was seen as a major lateral branch of the circle of Willis, running anterolaterally at the borderline between the anterior and the middle cerebral fossa. The pulsed Doppler sample gate was then placed on the middle portion of this vessel to obtain flow velocity waveforms. When the screen showed at least 3 consecutive wave forms of similar height, the image was taken and Doppler

Middle cerebral artery Resistant index (MCA-RI) and pulsatility index (PI) was estimated. A minimum of 3 separate reading was averaged before the final values were obtained. Care should be taken to apply minimal pressure to the maternal abdomen with the transducer, as fetal head compression is associated with alterations of intracranial arterial waveforms. In normal pregnancies the diastolic component in the cerebral arteries is lower than in the umbilical arteries at any gestational age. Therefore, the cerebral vascular resistance remains higher than the placental resistance. The measurement of RI and PI of Middle cerebral artery was considered normal or abnormal according to percentiles for gestational age [8].

Calculation of Cerebroplacental ratio: Cerebroplacental ratio was calculated as MCA PI divided by UA PI (MCA PI/UA PI). Cerebroplacental ratio was calculated at each attendance as previously described and the 5th and 10th centiles will be calculated from women in the study.

Follow up: Follow up of the cases was done. A single course of antenatal corticosteroids was administered when delivery was being considered. Mode of delivery was recorded. After delivery, birth weight (immediately within six hours) fetal distress, meconium-stained amniotic fluid or even still birth were assessed. Composite adverse neonatal outcome was defined as acidosis (pH < 7.18 and/or lactate ≥ 6 mmol/L) at birth and/or 5-min Apgar score < 7 and/or neonatal intensive care unit (NICU) admission.

2.1 Statistical Analysis

In the present study, statistical analyses of data was carried out using SPSS version 23. Shapiro –Wilks test was used to test normal distribution of variables. Numerical data were expressed as mean ± standard deviation or median and range. Categorical data were summarized as percentages. The significance for the difference between groups was determined by using two-tailed Student's t test and one way ANOVA (analysis of variance) test or for quantitative data as appropriate. Also Qualitative variables were assessed by Chi-square χ^2 test.

3. RESULTS

Among the forty cases included in the study, 37 women of 30 years old or younger, and 3 had age above 30 years. The mean age of the study group was 25.38 with a standard deviation of 3.54. Also, the results showed that there were women of all parity included in this study. Majority of the women were para 1 or more (72.5%) [Fig: 1].

There was significant decrease in the Mean CPR among patients who had anemia compared to those without anemia. In addition, there was no significant association seen between low CPR and having previous history of abortion or IUGR as well as being a smoker [Fig: 2].

There was no difference between cases who had normal and abnormal CPR regarding gestational age at delivery. Also, there was no difference between cases who had normal and abnormal cerebroplacental ratio regarding mode of delivery [Table 1].

There was significant decrease in the prevalence of low birth weight among group who had CPR≥1.08. There was no statistically significant relationship between cerebroplacental ratio and neonatal complication like IUFD and neonatal sepsis [Fig: 3].

There was no statistically significant association between the mean cerebroplacental ratio and IUFD while there was statistically significant association between the mean cerebroplacental ratio and NICU. Also, there was no statistically significant association between the mean cerebroplacental ratio and neonatal sepsis. The mean cerebroplacental ratio of 0.93± 0.22 has a significant association with neonatal death with a p value 0.025 [Table 2].

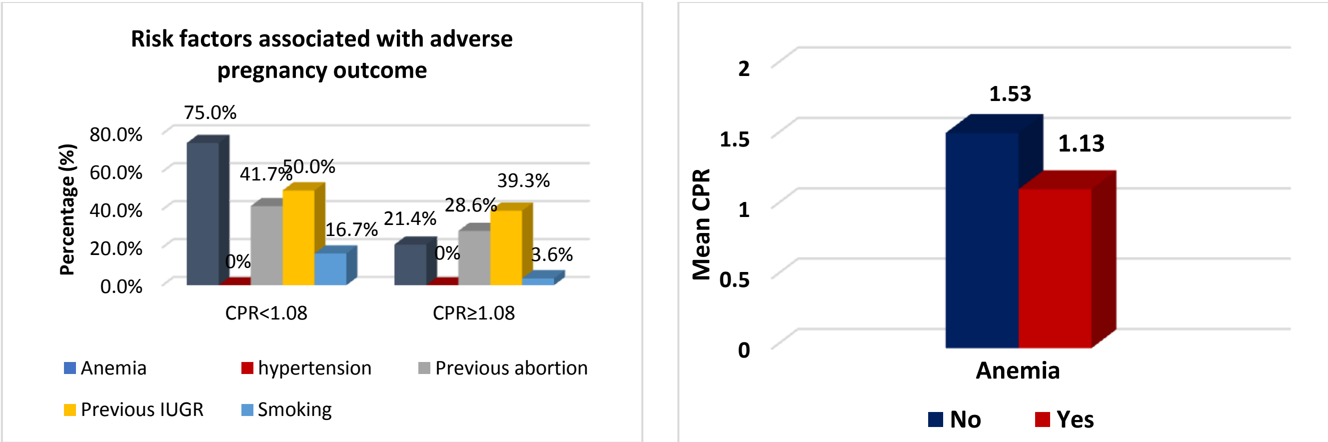
Table 1. Mean gestational age in all cases included in this study and Comparison between cases that had normal and abnormal CPR according to mode of delivery

	Total (n=40)	CPR<1.08 N=12	CPR≥1.08 N=28	P-value
Gestational age (weeks)	37.98±0.97	37.67±0.65	38.1±1.07	0.194
Mode of delivery:				0.736
- Normal	19(47.5%)	5(41.7%)	14(50%)	
-Cesarean section (CS)	21(52.5%)	7(58.3%)	14(50%)	

CPR: cerebroplacental ration

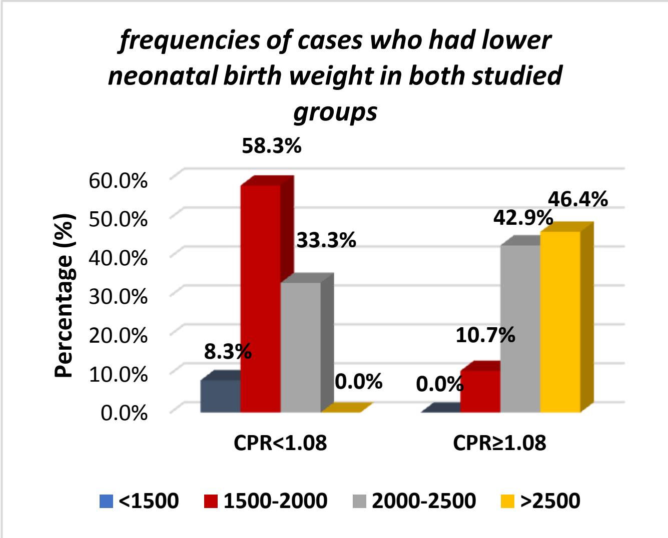
(A) (B)

Fig. 1. Distribution of study subjects according to age (A) and Previous parity in cases included in the present study (B)

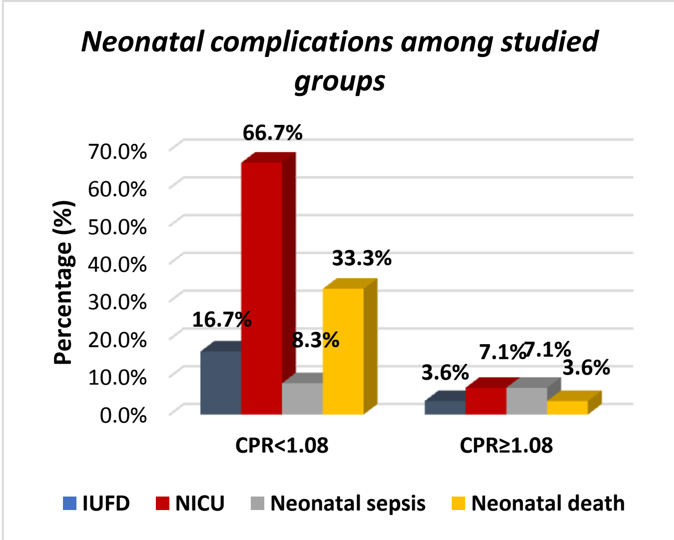


(A) (B)

Fig. 2. Risk factors in cases that had normal and abnormal CPR (A) and Mean CPR in cases that had anemia (B).



(A)



(B)

Fig. 3. Frequencies of cases that had lower neonatal birth weight in relation to CPR (A) and frequencies of cases that had neonatal complications in relation to CPR (B)

Table 2. Mean cerebroplacental ratio in cases that had IUFD, NICU, neonatal sepsis and neonatal death

		N	Mean	Std. deviation	P-value
IUFD	**No**	37	1.39	0.47	0.358
	Yes	3	1.13	0.66	
NICU	**No**	30	1.51	0.48	**<0.001***
	Yes	10	0.966	0.17	
Neonatal sepsis	**No**	37	1.4	0.49	0.303
	Yes	3	1.09	0.17	
Neonatal death	**No**	35	1.44	0.48	**0.025***
	Yes	5	0.93	0.22	

IUFD: Intrauterine fetal demise, NICU: Neonatal Intensive Care Unit
**: statistically significant as P value < 0.05*

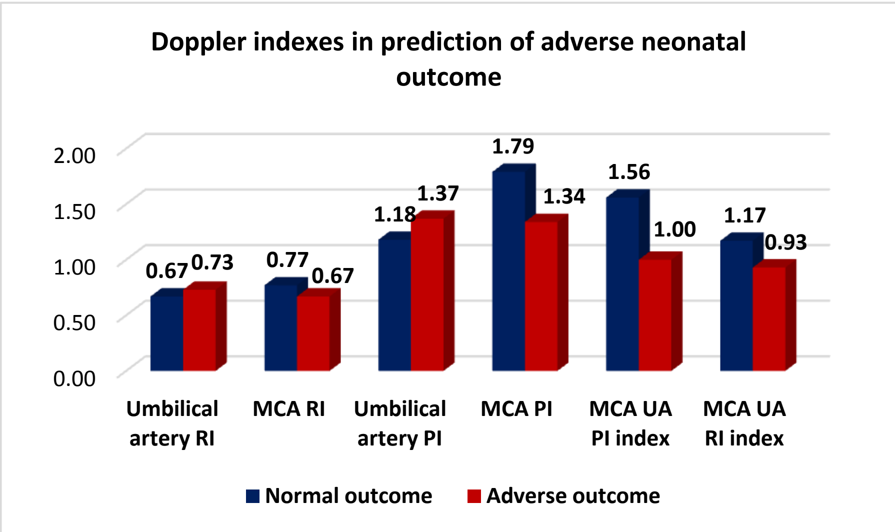
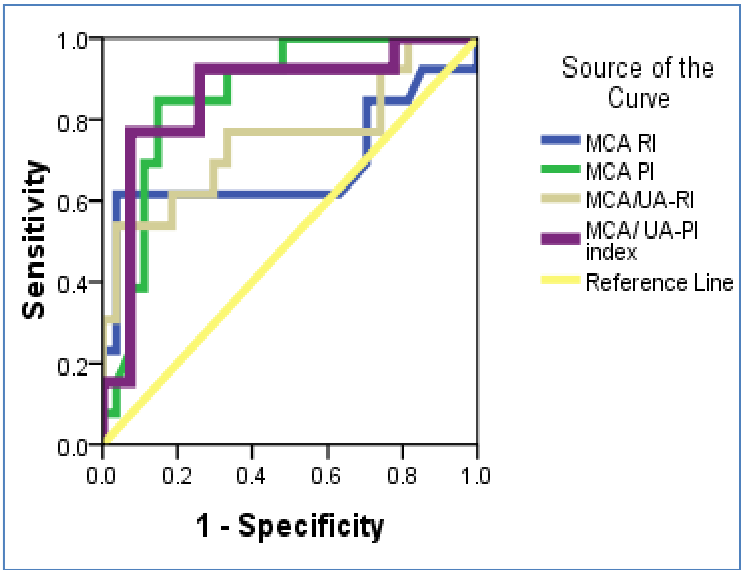
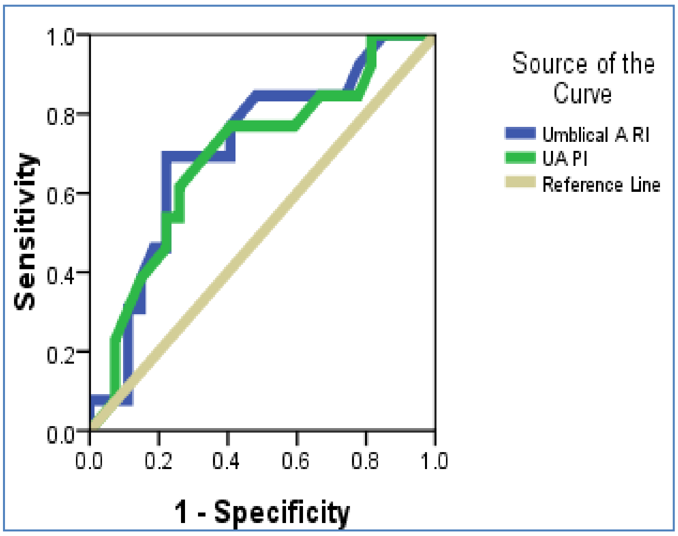


Fig. 4. Doppler indexes in prediction of adverse neonatal outcome



(A)



(B)

Fig. 5. ROC curve of Doppler indices MCA_RI, MCA-PI, MCA/UA-RI and CPR for predicting outcome of pregnancy and ROC curve of dopplar indices UA-RI, and UA -PI for predicting outcome of pregnancy

All Doppler indices except umbilical artery RI and umbilical artery-PI were significantly lower in women who had adverse neonatal outcome compared to their levels in women with normal neonatal outcome whereas umbilical artery RI was significantly higher in women who had adverse neonatal outcome compared to their levels in women with normal neonatal outcome. In addition, there was no statistically significant difference in the mean umbilical artery-PI between women who had normal and adverse neonatal outcome [Fig. 4].

ROC curve analysis showed that that MCA PI and CPR had significantly higher diagnostic accuracy than other indices in predicting outcome of pregnancy. Also, MCA-PI had significantly diagnostic accuracy in predicting adverse outcome of pregnancy. Moreover MCA/UA RI was found better predictor for adverse outcome of pregnancy with an area under the curve. However MCA-RI was non-significant in predicting pregnancy outcome [Fig. 5].

4. DISCUSSION

This study showed that 9 out of 15 anemic patients had CPR <1.08. There was statistically significant difference in number of cases who had anemia in both cases who had CPR<1.08 or ≥1.08 (P<0.003). The mean CPR in anemic patients was 1.13 with a standard deviation 0.39. There was significant decrease in the mean of CPR among patients who had anemia (1.13± 0.39) compared to those without anemia (1.53±0.48) with a p-value 0.01. In addition, there was no significant association seen between low CPR and having previous history of abortion or IUGR as well as being smoking (P>0.05). These results were in accordance to a prior result that was conducted via Moiety and Ahmed, 2012 [9] as for the CPR ratio, in moderate and severe anemia were below the normal range (<1.1), which confirms that the fetus had to adapt by increasing its blood flow redistribution towards the brain. Such adaptation was confirmed by the increase of the CPR ratio after maternal red blood cell transfusion and parenteral iron supplementation. The increase in cerebral resistance after the transfusion without significant change in umbilical or uterine resistance confirms that maternal anemia does not create placental dysfunction and that the situation can be restored quickly by two units of red blood transfusion to the patient or intravenous iron. In addition, the mean gestational age in cases with CPR<1.08 was 37.67±0.65 that was lower than that in cases with CPR≥1.08 (38.1±1.07). There was no significant difference between cases who had normal and abnormal CPR regarding gestational age at delivery (P=0.194). Novac et al., 2017 [10] reported that gestational age at birth was lower for CPR <1.08 (36.3±0.80 w) versus fetuses with CPR>1.08 (38±0.96 w). In agreement with our result Ghosh et al., 2018 [11] and Askar et al., 2018 [12] found that there was no statistically significant difference in Doppler parameter as regard gestational age. Gruettner et al., 2019 [13] found that the mean gestational week of delivery was 37 in the group of patients with pathological CPR and 39 in the group of patients with normal CPR. According to their studies, there was a significant difference between the two CPR groups, according to the gestational week at birth (p<0.001). This has also been described by Flood and his colleagues, 2014 that must be stressed that patients with low CPR delivered significantly at an earlier stage, which could also explain the lower birth weights. In addition, the current study indicated that 58.3% of cases who had cerebroplacental ratio <1.08 delivered by CS compared to 50% of cases who had cerebroplacental ratio > 1.08. There was no difference between cases who had normal and abnormal cerebroplacental ratio regarding mode of delivery (P=0.629). Novac and his co-workers, 2017 [10] found an increased percentage of cesarean section for fetal distress in fetuses with CPR <1.08, which was 44.44% of all cesarean section, compared to 15.46% in fetuses with CPR>1.08. This was comparable to the 46% caesareans for fetal distress noted by Geetha and Prasad, 2016 [14] and Cruz- Martinez et al., 2015 [15] also reported that an abnormal CPR was significantly associated with an emergent caesarean delivery for fetal distress in labor (37.8%). Parra-Saavedra et al., 2013 [16] reported 27% of the caesarean sections for fetal distress. Askar et al., 2018 [12] found that mean maternal age was 32.02 years, mean parity 1.72 and mean gestational age at delivery was 37.98weeks, mean birth weight was 2825.1 and 54% of patients had cesarean section,46% had vaginal delivery. In agreement with our results, Malik and Saxena, 2012 [17] didn’t note a significant relation between abnormal CPR and mode of delivery. This finding was comparable to the statistically significant relation noted by Singh et al., 2013 [18] with 61.5% caesarean deliveries in their study though. Furthermore, Ganju, 2020 [19] reported that abnormal CPR is significantly associated with caesarean delivery (p value=0.001). Gruettner and his co-workers, 2019 [13] found that in their cases 41.2% of the patients had a spontaneous delivery, whereas 9.6% had a vaginal operative delivery and 49.3% underwent a cesarean section. When they compared all three types of delivery mode of patients with pathological and normal CPR the difference was significant (p<0.001).

As regard neonatal outcome, our study revealed that there was significant decrease in the prevalence of low birth weight among group who had CPR≥1.08 (P<0.001). Novac et al., 2017 [10] reported that in these cases who had CPR<1.08 they noticed a birth weight of 2405±241.07g compared to a birth weight of 3100±504.09g in fetuses with CPR>1.08. The prevalence of adverse neonatal outcome was higher in the women who had CPR <1.08 compared to that in women who had cerebroplacental ratio ≥1.08. The present study showed that CPR <1.08 was significantly associated with neonatal complication like NICU admissions and neonatal death (P-value<0.05). However, there was no statistically significant relationship between cerebroplacental ratio and neonatal complication like IUFD and neonatal sepsis (P>0.05). There was no statistically significant association between the mean cerebroplacental ratio and IUFD (P=0.358). There was statistically significant association between the mean cerebroplacental ratio and NICU (P<0.001). There was no statistically significant association between the mean cerebroplacental ratio and neonatal sepsis (P=0.303). The mean cerebroplacental ratio of 0.93± 0.22 has a significant association with neonatal death with a p value 0.025.Ktatny et al., 2020 [20] found that changes in CPR were associated with highly statistically significant changes in neonatal outcomes with higher CPR being associated with normal outcomes. Furthermore, abnormality in CPR was associated with a statistically significant abnormality in the outcome as 89.66% of those with normal CPR and 54.55% of those with abnormal CPR had normal outcomes whereas 10.34% of those with normal CPR and 45.45% of those with abnormal CPR had an abnormal neonatal outcome. Changes in CPR were associated with highly statistically significant variations in neonatal outcome with 89.66% of fetuses with normal CPR having normal outcome and 10.34% of them being admitted for more than 24 days whereas 54.55% of fetuses with abnormal CPR had normal outcome, 18.18% of them died and 27.27 % of them were admitted for more than 10 days. Askar et al., 2018 [12] reported that there was significant relation between CPR and mode of delivery, birth weight p-value <0.001. On the other hand, there was insignificant relation between CPR and parity, gestational age at delivery p-value 0.362, 0.097 respectively. Abdallah and Sileem, 2020 [21] found that participants with abnormal CPR had significantly increased incidence of adverse perinatal outcome in terms of the need for urgent CS, lower fetal weight, 5-min Apgar score of less than 7, and neonatal death and NICU admission more than 10 days. Novac et al., 2017 [10] found that admission to NICU was higher by 18.46% vs. 7.69% in fetuses with low CPR compared to those with CPR>1.08. Bano et al., 2010 [22] also present a comparable data where 100% of the neonates with abnormal CPR had a low birth weight, 75% were admitted to NICU. Parra-Saavedra et al., 2013 [16] found that there were 10% perinatal mortalities and was statistically significant. Allam et al., 2015 [23] observed that an abnormal CPR is significantly associated with low birth weight, NICU admissions, and adverse perinatal outcomes. Similarly, our study also shows abnormal CPR and low birth weight to be statistically significant (p-value <0.001). In studies reported by Makhseed et al., 2000 [24] and Ebrashy et al., 2005 [25] CPR has identified more fetuses with adverse outcome than did the biophysical profile showing the significance of CPR.

Ktatny et al., 2020 [20] reported that UA-PI alone in predicting adverse intrapartum and neonatal outcomes, including the need for urgent CS due to intrapartum fetal compromise (IFC), low fetal weight, 5-minute Apgar score ≤ 7, NICU admission, and neonatal death. Therefore, they advocated that CPR should be integrated into the assessment of pregnancies with growth restriction to identify high-risk cases that may benefit from certain timely intervention. A recent meta-analysis Conde-Agudelo et al., 2018 [26] showed that CPR has a moderate-to-high predictive ability for perinatal death with overall sensitivity and specificity of 93% and 76%, respectively. Ktatny et al., 2020 [20] revealed a high diagnostic performance of CPR in predicting a 5-minute Apgar score below 7 with sensitivity and specificity of 100% and 85.37%, respectively. However, Conde-Agudelo et al., 2018 [26] revealed a lower predictive performance with sensitivity and specificity of 54% and 72%, respectively. On the other side, the sensitivity and specificity of CPR in predicting NICU admission were comparable in Ktatny et al., 2020 [20] (50% and 81.3%) and Conde-Agudelo et al., 2018 [26] (45% and 79%). Shahinaj et al., (2010) [27] in their prospective observational study that included 738 singleton pregnancies, that studied The value of the CP ratio in the prediction of neonatal outcome in patient with preeclampsia, found positive correlation and statistically significant between abnormal CP ratio and Neonatal death as P value <0.001, the result showed that CP ratio had 97.7% sensitivity and 66.0% specificity to predict Neonatal death, with positive predictive value 16.5% and negative predictive value 99.7% In this retrospective hospital-based study Gruettner et al., 2019 [13] analyzed 2,270 patients with singleton pregnancies according to their outcome depended on the CPR. The current analysis showed a significant difference between both groups with regards to the mode of delivery (p<0.001). Khalil et al., 2016 [27] suggested that CPR may be a better marker of fetal compromise and adverse outcome than birth weight (BW). In the third trimester, pregnancies with abnormal UtA Doppler or low CPR indices, regardless of fetal size, are at increased risk of stillbirth or adverse outcome. Furthermore, they mentioned that according to studies in normally grown sheep fetuses exposed to acute hypoxia, CPR is the hemodynamic parameter that follows most closely the acute changes in pO2, with similar amplitude of change. Arabin et al., 2016 [28] also found that the CPR is an earlier predictor of adverse outcome than the conventional biophysical profile score. However, the CPR can be part of a biophysical profile (BPS) as already described more than 20 years ago in fetuses with fetal growth restriction or post-term pregnancies when uterine. Therefore, integrating CPR in clinical management may help to better identify fetuses at risk for adverse perinatal events, since abnormal CPR has been associated with an increased risk of perinatal complications.

5. CONCLUSION

A low cerebroplacental ratio reflects redistribution of the cardiac output to the cerebral circulation and has been shown to improve accuracy in predicting adverse outcome compared with Middle cerebral artery (MCA) or Umbilical artery (UA) Doppler alone. Therefore, integrating CPR in clinical management may help to better identify fetuses at risk for adverse perinatal events, since abnormal CPR has been associated with an increased risk of perinatal complications.

CONSENT

Each case participated in the present study was fully informed concerning the nature of the disease and the diagnostic procedures. Verbal consent was taken from all cases before participation in this study.

ETHICAL APPROVAL

This study was approved by the Ethical Committee, faculty of medicine, Tanta University.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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