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The Correlation Between Cerebroplacental Ratio and Body Mass Index in Third Trimester

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HIGHLIGHTS

1. Cerebroplacental ratio decreases with higher BMI.
2. Elevated BMI may affect fetal circulation.
3. BMI influences cerebroplacental ratio variations.
4. Third trimester BMI impacts fetal health.
5. Lower cerebroplacental ratio in obese pregnancies

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ABSTRACT

This retrospective study investigates the correlation between cerebroplacental ratio (CPR) and body mass index (BMI) in pregnant women during their third trimester. A total of 150 pregnant women, aged 28 to 40 weeks, undergoing routine antenatal Doppler scans at KIMS Hospital, Bangalore, between January and October 2023, were included in the study. The study aimed to determine whether maternal BMI impacts the cerebroplacental ratio, a key indicator of fetal well-being, by assessing the pulsatility indices (PI) of the middle cerebral artery (MCA) and umbilical artery. Doppler ultrasonography was utilized to measure blood flow in the uterine, umbilical, and middle cerebral arteries, with the CPR calculated as the ratio of the MCA PI to the umbilical artery PI. Fetal Doppler was done for 150 pregnant women presenting for antenatal scan in third trimester. The participants were classified into four BMI categories: underweight, normal weight, overweight, and obese. The results showed no significant negative association between BMI and cerebroplacental ratio. However, a significant negative correlation was observed between BMI and both the MCA PI and umbilical artery PI. This suggests that although CPR itself may not be directly affected by BMI, other Doppler parameters such as the PI of key vessels are influenced by maternal weight during pregnancies.The study concludes that while BMI does not appear to directly alter the cerebroplacental ratio, maternal obesity remains a critical factor in pregnancy outcomes due to its association with complications such as gestational hypertension, preeclampsia, and gestational diabetes mellitus. These findings emphasize the importance of monitoring pregnant women with high BMI for potential risks and providing early dietary and medical interventions to improve maternal and fetal health outcomes.

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INTRODUCTION

Doppler ultrasonography is a crucial noninvasive tool used to monitor pregnancy hemodynamics and assess both fetal and placental circulation. By evaluating blood flow in the maternal and fetal circulatory systems, Doppler ultrasound plays a significant role in predicting adverse pregnancy outcomes. The primary vessels assessed in Doppler studies include the uterine artery, umbilical artery, middle cerebral artery, and ductus venosus. These evaluations help in monitoring the health of the placenta and fetus, allowing clinicians to detect early signs of complications such as fetal growth restriction and preeclampsia. The ability of Doppler ultrasound to forecast adverse perinatal outcomes has made it a valuable asset in modern obstetric care[1].

The uterine artery Doppler is typically used to assess placental function. Abnormal blood flow in the uterine arteries can be an early indicator of preeclampsia or placental insufficiency, conditions that can have serious implications for both mother and baby. The umbilical artery Doppler is critical for assessing the resistance of blood flow from the placenta to the fetus. Increased resistance or abnormal blood flow in this artery may signal placental dysfunction and fetal growth restriction. The middle cerebral artery Doppler is often used to assess the redistribution of fetal blood flow in response to stress, a condition known as the "brain-sparing effect." This is often seen in fetuses experiencing hypoxia or growth restriction, where blood is preferentially directed toward the brain to preserve its function. Lastly, the ductus venosus Doppler evaluates fetal venous circulation, particularly the blood flow returning to the fetal heart. Abnormalities in this vessel can suggest heart failure or severe fetal compromise[2-3].

Collectively, these Doppler measurements provide a comprehensive picture of both maternal and fetal well-being and can help predict the likelihood of complications such as preeclampsia, fetal growth restriction, preterm birth, and even perinatal mortality. Given their accuracy in predicting adverse perinatal outcomes, Doppler ultrasonography is widely used as part of routine prenatal care in high-risk pregnancies[3].

An important factor that has been increasingly associated with adverse pregnancy outcomes is maternal body mass index (BMI). BMI is a measure of body fat based on weight in relation to height and is calculated using the formula: weight (kg) / height² (m²). It is a simple and widely accepted method for classifying individuals into weight categories, which include underweight, normal weight, overweight, and obese. According to the Institute of Medicine, a BMI below 18.5 is classified as underweight, a BMI between 18.5 and 24.9 is considered normal or healthy, a BMI between 25.0 and 29.9 is categorized as overweight, and a BMI of 30 or above is classified as obese[4-5].

Maternal obesity is increasingly recognized as a significant risk factor for a range of adverse pregnancy outcomes. Studies have consistently shown that women with higher BMIs are at greater risk for complications such as gestational diabetes, preeclampsia, postpartum hemorrhage, stillbirth, and cesarean delivery. One of the most notable risks associated with obesity during pregnancy is the increased likelihood of developing preeclampsia, a hypertensive disorder characterized by high blood pressure and damage to organs such as the liver or kidneys. The risk of preeclampsia has been found to rise in proportion to BMI, with obese women being several times more likely to develop this condition than women of normal weight[4].

The relationship between obesity and pregnancy outcomes is complex, as excess body weight can affect both maternal and fetal health through various mechanisms. In obese pregnant women, excess adipose tissue can lead to chronic inflammation and insulin resistance, both of which contribute to the development of gestational diabetes and preeclampsia. Obesity can also impair placental function, potentially leading to fetal growth restriction and increased perinatal morbidity and mortality[6].

Given these risks, we hypothesized that maternal obesity may negatively impact feto-maternal blood flow as measured by Doppler ultrasonography. Specifically, we aimed to investigate the relationship between maternal BMI and the cerebroplacental ratio (CPR) in the third trimester of pregnancy. The CPR is a Doppler-derived measurement that compares blood flow in the fetal middle cerebral artery to blood flow in the umbilical artery. A low CPR indicates preferential blood flow to the brain, often signaling fetal distress or growth restriction. A normal or high CPR suggests that the placenta is functioning well, providing adequate oxygen and nutrients to the fetus[7].

The rationale behind this study is that obesity, through its association with placental dysfunction, could potentially alter blood flow patterns in the fetus, leading to an abnormal CPR. Obesity-related placental dysfunction could manifest as increased resistance in the umbilical artery, decreased blood flow to the fetus, and a redistribution of blood toward the brain, all of which are indicative of fetal compromise. By examining the association between BMI and CPR, we hoped to uncover whether maternal obesity contributes to abnormal feto-maternal circulation, potentially increasing the risk of adverse perinatal outcomes[7-8].

Doppler ultrasonography is an essential tool for assessing feto-maternal blood flow and predicting adverse pregnancy outcomes. With maternal obesity on the rise globally, it is important to understand how increased BMI may influence Doppler parameters such as the CPR, which is a key indicator of fetal well-being. Our study aims to explore the potential relationship between maternal BMI and cerebroplacental ratio, contributing to the growing body of knowledge on how maternal health influences fetal outcomes. By identifying such associations, healthcare providers can better manage high-risk pregnancies and improve both maternal and fetal health outcomes.

MATERIALS AND METHODS

This is a retrospective study which included 150 pregnant women undergoing routine third trimester scan from 28 to 40 weeks in KIMS hospital and research centre, Bangalore between

Jan 2023 and October 2023.

INCLUSION AND EXCLUSION CRITERIA

INCLUSION CRITERIA

All pregnant woman in third trimester undergoing routine third trimester scan. **Evaluation by ultrasound, Doppler study and calculating the body mass index.** Height and weight measurements of all women undergoing scan were recorded B.M.I. was calculated and the women were grouped into 4 categories -underweight (< 18.5 kg/m2), normal weight (18.5–24.9 kg/m2), overweight (25-29.9 kg/m2) and obese (≥30 kg/m2)]. The scans are done using PHILLIPS AFFINITI 70 using C5-1 probe. According to the established protocols, the uterine artery, umbilical artery, and middle cerebral artery (MCA) were all evaluated using color Doppler. The values of Uterine arteries, Umbilical Arteries, and Middle Cerebral Artery's systole/diastole (S/D) ratio, pulsatility index (PI), and resistance index (RI) were noted. For our study the cerebro-placental ratio was calculated using Middle cerebral artery and umbilical artery PI.

STATISTICAL ANALYSIS

Pearson Chi Square tests was used to find the correlation between cerebroplacental ratio and body mass index,[P-Value] was set at $P<0.05$.

Statistical Package for Social Sciences [SPSS] for Windows, Version.22.0. Released 2013. Armonk, NY: IBM Corp. was used to perform statistical analyses.

RESULTS

Table 1: Age Groups of Pregnant Woman Included in Our Study.

Age Group	Count	Column N %
Less than 25	49	32.70%
Between 26 to 30	57	38.00%
More than 31 years	44	29.30%

Chi Square = 6.833 p=0.337

The table presents the age distribution of pregnant women in the study, with 38% being between 26 to 30 years, 32.7% under 25 years, and 29.3% over 31 years. The Chi-square value (6.83 3) and p-value (0.337) indicate no statistically significant difference in the age group distribution.

Table 2: Gestational Weeks of the Subjects Included in Our Study

Gestational Weeks	Count	Column N %
Between 32 to 36 Weeks	63	42.00%
Less than 32 weeks	56	37.30%
More than 36 Weeks	31	20.70%

The table shows the gestational age distribution of the subjects, with 42% being between 32 to 36 weeks, 37.3% less than 32 weeks, and 20.7% more than 36 weeks. The majority of subje--cts . are in the 32 to 36-week range, representing a significant portion of the study population

Table 3: Distribution of Pregnant Woman With BMI Category

BMI Category	Count	%
Normal	50	33.30%
Obese	26	17.30%
Overweight	65	43.30%
Underweight	9	6.00%

The table shows the BMI distribution among pregnant women in the study. The majority of participants are overweight (43.3%), followed by those with normal BMI (33.3%), and a smaller percentage are obese (17.3%) or underweight (6%). This indicates a higher prevalence of overweight and obese categories among the participants.

Table 4: Correlation of BMI Category with the Age Group

BMI Category	Age Group					
	Less than 25		Between 26 to 30		More than 31 years	
	N	%	N	%	N	%
Normal	22	44.90%	16	28.10%	12	27.30%
Obese	5	10.20%	8	14.00%	13	29.50%
Overweight	15	30.60%	32	56.10%	18	40.90%
Underweight	7	14.30%	1	1.80%	1	2.30%

Chi-Square = 20.89, p = 0.002

From this, we can conclude that as age increases, the percentage of individuals in the overweight and obese categories also increases.

The table illustrates the correlation between BMI categories and age groups among pregnant women. Overweight individuals are more prevalent in the 26-30 and over 31 age groups (56.1% and 40.9%, respectively), while the normal BMI category is most common in women under 25 (44.9%). The Chi-square value (20.89) with a p-value of 0.002 indicates a statistically significant correlation between BMI and age.

Table 5: BMI Category Correlations with Gestational Weeks

BMI Category	Gestational Weeks					
	Between 32 to 36 Weeks		Less than 32 weeks		More than 36 Weeks	
	N	%	N	%	N	%
Normal	20	31.70%	20	35.70%	10	32.30%
Obese	11	17.50%	6	10.70%	9	29.00%
Overweight	30	47.60%	25	44.60%	10	32.30%
Underweight	2	3.20%	5	8.90%	2	6.50%

Chi Square = 6.833 p=0.337

The table shows the correlation between BMI categories and gestational weeks. Overweight women are more common across all gestational periods, particularly between 32 to 36 weeks (47.6%). Normal BMI is also prevalent, with a significant number of women falling under less than 32 weeks and between 32 to 36 weeks. The Chi-square value (6.833) and p-value (0.337) indicate no significant association between BMI and gestational age

Table 6: BMI Category correlation with MCA PI Mean

BMI Category	MCAPI Mean	Standard Deviation	P Value (ANOVA TEST)
Normal	1.89	0.36	F = 2.050, p = 0.109
Obese	1.7	0.36	
Overweight	1.79	0.4	
Underweight	1.68	0.33	

The table shows the correlation between BMI categories and the MCAPI (Middle Cerebral Artery Pulsatility Index) mean. The highest MCA PI mean is observed in the normal BMI group (1.89), and the lowest is in the underweight group (1.68).

The ANOVA test results (F = 2.050, p = 0.109) suggest that there is no statistically significant difference in MCA PI across different BMI categories.

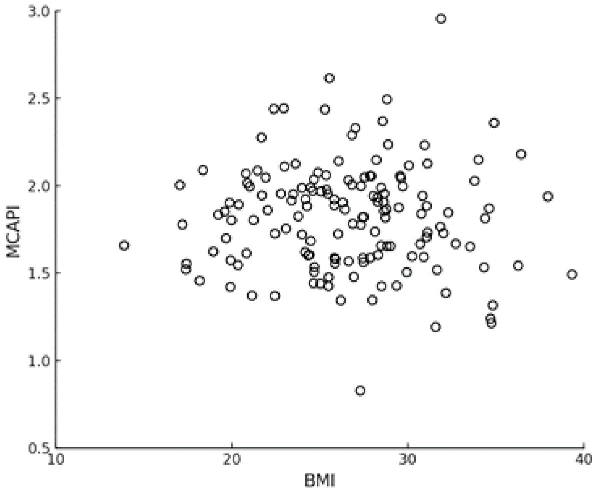

Figure 1: Scatter Plot of BMI Category Correlation With MCA PI

Table 7: BMI Category Correlation with CPR Mean

BMI Category	CPR Mean	Standard Deviation	P Value (ANOVA TEST)
Normal	1.96	0.39	
Obese	1.97	0.54	
Overweight	2.01	0.51	
Underweight	1.66	0.3	F = 1.510, p = 0.214

The table presents the correlation between BMI categories and CPR (Cerebroplacental Ratio) mean. The overweight group has the highest CPR mean (2.01), while the underweight group has the lowest (1.66). The ANOVA test result (F = 1.510, p = 0.214) indicates no statistically significant difference in CPR across different BMI categories.

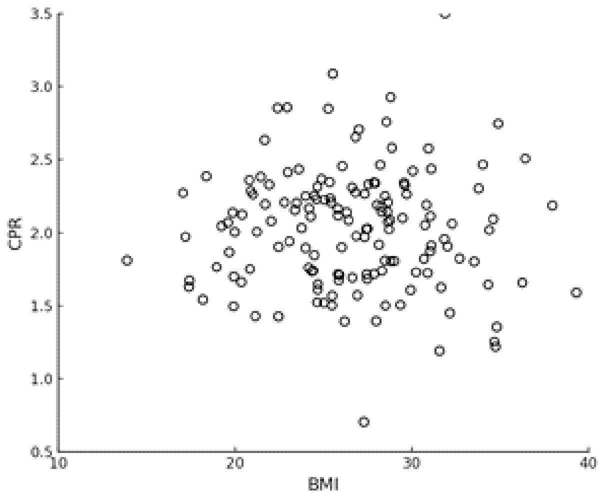

Figure 2: Scatter Plot Represents Correlation of BMI Category With CPR

Tabe 8: BMI Category correlation With CPR Percentile Mean

BMI Category	CPR Percentile Mean	Standard Deviation	P Value (ANOVA TEST)
Normal	41.01	27.18	F = 1.887 p = 0.134
Obese	37.59	28.21	
Overweight	43.94	29.35	
Underweight	21.08	16.73	

The table shows the correlation between BMI categories and CPR percentile mean. The overweight group has the highest CPR percentile mean (43.94), while the underweight group has the lowest (21.08). The ANOVA test (F = 1.887, p = 0.134) indicates that there is no statistically significant difference in CPR percentile across the different BMI categories

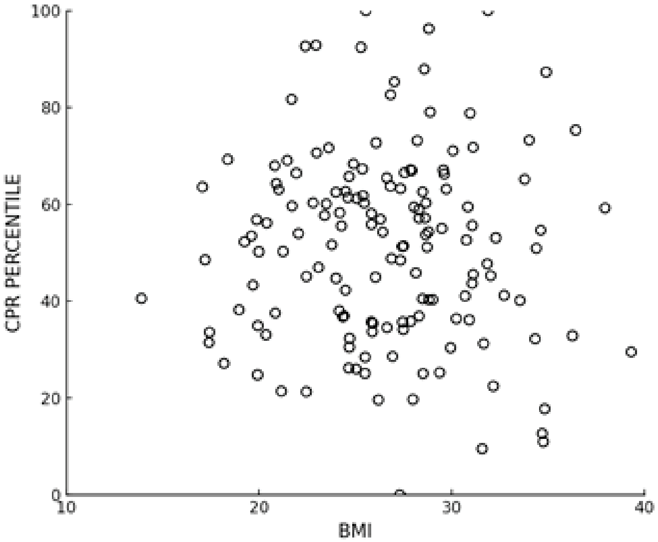

Figure 3: Scatter Plot Represents Correlation of BMI Category With CPR Percentile Mean

The Scatter plot illustrates that as BMI increases, CPR also increases, indicating a positive correlation or, at the very least, no negative correlation between the two variables.

Table 9: BMI Category Correlation With UMBILICAL PI Mean

BMI Category	UMBILICAL PI Mean	Standard Deviation	P Value (ANOVA TEST)
Normal	0.98	0.15	F = 3.744 p = 0.013
Obese	0.89	0.17	
Overweight	0.91	0.16	
Underweight	1.02	0.14	

The table shows the correlation between BMI categories and umbilical PI (Pulsatility Index) mean. The underweight group has the highest umbilical PI mean (1.02), while the obese group has the lowest (0.89). The ANOVA test result (F = 3.744, p = 0.013) indicates a statistically significant difference in umbilical PI across the different BMI categories.

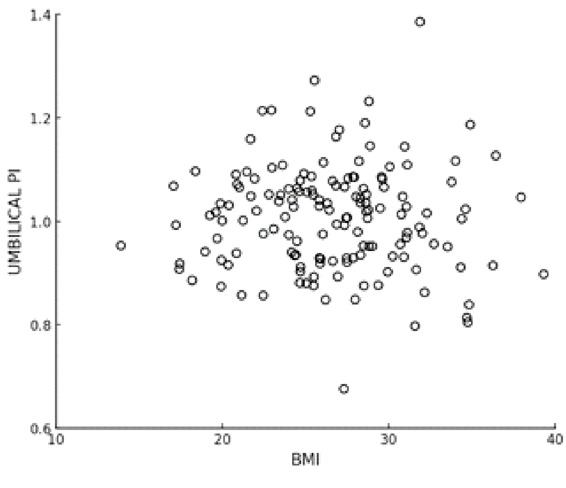

Figure 4: Scatter Plot Between UMBILICAL PI and BMI

The Pearson correlation test revealed that BMI negatively correlates with MCA PI and Umbilical PI, implying that as BMI increases, these two values decrease.

Table 10: Correlation Between MCA PI, UMBILICAL PI and CPR

	MCA PI	UMBILICAL PI	CPR	CPR PERCENTILE
Pearson Correlation	-0.089	-0.260**	0.121	0.097
Sig. (2-tailed)	0.278	0.001	0.139	0.239
N	150	150	150	150

Note: Correlation is significant at the 0.01 level (2-tailed).

Based on the Pearson correlation test, BMI was found to be negatively correlated with MCA PI and Umbilical PI. In other words, as BMI increases, the values of MCA PI and Umbilical PI decrease. Conversely, BMI was positively correlated with CPR and CPR Percentile, meaning that higher BMI is associated with increased CPR values and percentile..

DISCUSSION

In our study, we tried to demonstrate a correlation between body mass index and cerebroplacental ratio in third trimester. Middle cerebral artery PI showed negative correlation and umbilical artery PI showed significant negative correlation. Since there was significant decrease in umbilical artery PI the cerebroplacental ratio which is obtained by the formula MCA PI / umbilical artery PI showed a positive correlation.

Obesity in present time is a significant health concern in the past decade[11,12]. Maternal obesity is associated with higher risk of complications in pregnancy such as gestational hypertension, pre-eclampsia, gestational diabetes mellitus, preterm delivery and increased neonatal morbidity and mortality[9]. Baeten et al. examined the associations between pre-pregnancy weight and the risk of pregnancy complications and adverse outcomes among nulliparous women. They found that compared with lean women, both overweight and obese women had a significantly increased risk for gestational diabetes, preeclampsia, eclampsia, cesarean delivery, and delivery of a macrosomic infant[13].

The prevalence of overweight and obesity has increased in many developing countries over the past twenty years[11,12]. There is evidence showing increased risk of pregnancy complications such as gestational diabetes, preeclampsia and infections among obese women[9,13].

Maternal health and microenvironment have direct and significant impacts on the fetal development[16]. The maternal microenvironment is influenced by a number of factors including maternal metabolic status, amount of body fat, hormones, cytokines, endothelial cell function and adipokines. Increasing BMI correlates with increased adipose tissue mass[19].

Adipose tissue secretes prothrombotic and proinflammatory substances e.g. leptin, endothelin-1, tumour necrosis factor, plasminogen activator inhibitor, interleukins and adiponectin[17]. These substances may affect homeostatic regulation of uteroplacental vascular tone. Maternal obesity leads to the endothelial cell dysfunction increasing fat-derived metabolic products and cytokines[18].

There are many studies in the literature evaluating the relationship between obesity and pregnancy outcomes. Monaghan et al. reported that high uterine artery PI at term is independently associated with increased risk of adverse perinatal outcome regardless of fetal size[14]. In another study, Sebire et al. investigated the pregnancy outcomes in obese women compared to those of normal weight by reviewing a large number of singleton pregnancies. They reported that gestational diabetes mellitus, proteinuric pre-eclampsia, induction of labour, delivery by emergency cesarean section, postpartum haemorrhage, genital tract infection, urinary tract infection, wound infection, birthweight above the 90th centile and intrauterine death were significantly more common in obese pregnant women compared to women with normal BMI[10].

In our study similarly tried to find a correlation between body mass index and cerebroplacental ratio which involves the evaluation of umbilical artery and middle cerebral artery Doppler parameters. Fetal Doppler was done for 150 pregnant women presenting for antenatal scan in third trimester. The age of the patients, height, weight and fetal doppler parameters were recorded. Body mass index and cerebroplacental ratio were considered to look for any correlation between these two parameters in third trimester. According to body mass index the pregnant woman were categorized into underweight, normal, overweight and obese to assess the correlation with cerebroplacental ratio [20].

CONCLUSION

The findings in the study show that irrespective of BMI, the cerebro-placental ratio has similar values and shows no negative association. But there was a negative association with MCA PI and umbilical artery PI. However, we need to keep the women informed about the risks associated with obesity in pregnancy like gestational hypertension, pre-eclampsia, gestational diabetes mellitus, delivery of large for gestational age infant and hence take necessary dietary advice if required early in pregnancy.

LIMITATIONS OF STUDY

US is an operator dependent examination and the results are much affected by patient body habitus.

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