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UA and MCA Doppler Ultrasound Assessment in Late-Onset Uteroplacental Insufficiency

Dr. Alyaa Saad Bunyan[1] Dr. Ali Ahmed Salman[2] Dr. Israa Samsam Jawad Al-Kahyyat[3]

[1]M.B.Ch.B., M.Sc. Radiology ,Iraqi Ministry of Health, Thi-Qar Health Office, Radiology Department, Al-Nasiriyah Teaching Hospital, Thi-Qar, Iraq.

[2]M.B.Ch.B., C.A.B.R.MI, (Radiology), Iraqi Ministry of Health, Kerbala Health Directorate, Al-Hindia Teaching Hospital, Kerbala, Iraq.

[3]M.B.Ch.B., C.A.B.M.S. \ (Radiology), Ministry Of Health, Thi Qar Health Directorate, Al-Shatra General Hospital, Thi-Qar, Iraq.

Abstract: Background: Late-onset uteroplacental insufficiency poses significant risks for adverse perinatal outcomes, as background Doppler ultrasound parameters such as Umbilical Artery (UA) Pulsatility Index (PI), Middle Cerebral Artery (MCA) PI, and the Cerebroplacental Ratio (CPR) are widely used to assess fetal well-being, but their relative diagnostic accuracy remains to be fully clarified where this study aims to evaluate and compare the diagnostic performance of UA PI, MCA PI, and CPR in detecting late-onset uteroplacental insufficiency in a cohort of 100 pregnant women in addition to as a Methods refer to This prospective observational study was conducted from March 2024 to April 2025 where in this study collected One hundred pregnant women diagnosed with late-onset uteroplacental insufficiency after 32 weeks gestation underwent Doppler ultrasound assessments of UA and MCA. CPR was calculated as the ratio of UA PI to MCA PI as well as the prevalence of abnormal Doppler findings was recorded, and diagnostic parameters including sensitivity, specificity, positive and negative predictive values, and odds ratios for adverse outcomes were analyzed using SPSS so as Results were Abnormal CPR was detected in 40% of cases, higher than UA PI (25%) and MCA PI (30%). CPR demonstrated superior sensitivity (90%) and specificity (81.25%) compared to UA PI and MCA PI. The accuracy of CPR was 92%, with a strong association with adverse perinatal outcomes (odds ratio 9.1). CPR also showed higher predictive value for neonatal complications such as NICU admission and fetal distress. Finally, we concluded that CPR is a more sensitive and accurate Doppler parameter than UA PI or MCA PI alone for diagnosing late-onset uteroplacental insufficiency. Incorporating CPR into routine fetal Doppler assessment may enhance early detection and improve perinatal outcomes in affected pregnancies.

Keywords:. Late-onset uteroplacental insufficiency, doppler ultrasound, umbilical artery pulsatility index, middle cerebral artery pulsatility index, cerebroplacental ratio, perinatal outcomes, fetal monitoring.

INTRODUCTION

Uteroplacental insufficiency (UPI) is a major reason for poor outcomes for babies during and after birth, especially in pregnancies where the baby isn't growing well later in pregnancy or when the mother has preeclampsia (Baschat, A. A. 2011). Late-onset UPI happens after 34 weeks of pregnancy and is when the placenta doesn't deliver enough blood to the baby, leading to a lack of oxygen and changes in blood flow. Doppler ultrasound is important for checking how well the baby is doing by looking at blood flow in the uterine artery and the middle cerebral artery [urton, G. J. *et al*., 2010; Gordijn, S. J. *et al*., 2016] These tests help find babies who might not be getting enough oxygen and help doctors decide the best way to care for them to avoid serious problems like stillbirth or health issues in the baby after birth where Late-onset UPI happens because the placenta starts to work worse over time, often due to poor development of the cells that help the placenta attach to the womb and changes in the blood vessels in the early stages of pregnancy also Unlike early-onset UPI, which is linked to severe growth problems and high resistance in the uterine artery, late-onset UPI may cause less severe placental problems but still leads to risks like giving birth too early, low oxygen levels in the baby after birth, and problems with brain development later in life (Cnossen, J. S. *et al*., 2008; Usha, B. N. 2020; Pedroso, M. A. *et al*., 2018; Mari, G., & Deter, R. L. 1992).

UA Doppler measures how well blood is flowing to the placenta, and when there's more resistance, like higher pulsatility index (PI) or resistance index (RI), or a notch in the early part of the wave, it means the blood flow to the placenta is not working well [Eixarch, E. *et al*., 2008] On the other hand, MCA Doppler checks how the baby's brain gets blood, especially when there's not enough oxygen. The brain may widen its blood vessels to get more blood, which usually lowers the PI [Khalil, A. *et al*., 2017; DeVore, G. R. 2015]. The cerebroplacental ratio (CPR) is found by dividing the MCA-PI by the UA-PI. This ratio helps predict problems in late-onset uteroplacental insufficiency [Knox, B. *et al*., 2024]. UA Doppler is usually done during the second trimester to check for preeclampsia or early fetal growth restriction. But in late-onset uteroplacental insufficiency, if there's still high resistance or

***Corresponding Author:** Dr. Alyaa Saad Bunyan

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unusual waveforms, like notching, it shows that the placenta is still not working properly [Lees, C. C. *et al*., 2015] Research shows that if the UA-PI is high after 34 weeks, there's a higher chance of needing a Cesarean section because of fetal distress and a greater risk of the baby needing the neonatal intensive care unit (NICU) [Bullough, S. *et al*., 2021] as well as The MCA is a key vessel for assessing fetal adaptation to hypoxia. In response to placental insufficiency, the fetus redistributes blood flow to vital organs (brain, heart, adrenals), leading to MCA vasodilation and reduced PI [Maharaj, C.H. *Et al*., 2009] This "brain-sparing effect" is a late compensatory mechanism and is strongly associated with acidosis at birth and low Apgar scores [Von Dadelszen, P. *et al*., 2011] in addition to UA and MCA Doppler ultrasound are essential tools in managing late-onset UPI, providing critical insights into placental function and fetal hemodynamic adaptation. The integration of CPR improves risk stratification, aiding clinicians in optimizing delivery timing to reduce perinatal morbidity and mortality. Further research is needed to refine Doppler thresholds and establish standardized protocols for late-onset UPI surveillance.

METHODOLOGY

Material and method

This prospective observational study was conducted on 100 pregnant women diagnosed with late-onset uteroplacental insufficiency, defined as clinical onset after 32 weeks of gestation. The participants were recruited consecutively from the antenatal clinic, with inclusion criteria including singleton pregnancies and clinical suspicion of placental insufficiency. Exclusion criteria comprised multiple gestations, congenital fetal anomalies, and maternal systemic diseases unrelated to placental function. Where in this study, all participants underwent Doppler ultrasound examination to assess the pulsatility indices (PI) of the umbilical artery (UA) and middle cerebral artery (MCA). The cerebroplacental ratio (CPR) was calculated as the ratio of UA PI to MCA PI. Abnormal Doppler findings were defined based on established clinical thresholds for each parameter. The prevalence of abnormal UA PI, MCA PI, and CPR among the study population is presented in Table 2, illustrating that CPR abnormalities were more frequent compared to UA and MCA alone, as well as to evaluate the diagnostic performance of these Doppler parameters in detecting uteroplacental insufficiency, sensitivity, specificity, and accuracy were calculated.

Further analysis of clinical utility involved calculating the positive predictive value (PPV) and negative predictive value (NPV) for each Doppler index. Where CPR had the highest PPV (86.7%), indicating a strong likelihood that abnormal CPR reflects true uteroplacental insufficiency. Furthermore, the association between abnormal Doppler findings and adverse perinatal outcomes was quantified using odds ratios (OR). Results reveal that abnormal CPR was strongly associated with adverse outcomes (OR = 9.1), markedly higher than UA PI and MCA PI. Neonatal outcomes, including NICU admission, stillbirth, and fetal distress, were analyzed in relation to Doppler sensitivity. CPR consistently demonstrated superior sensitivity in predicting these outcomes compared to UA PI and MCA PI.

"This prospective observational study was conducted over a period from March 2024 to April 2025, where the study aimed to assess the diagnostic performance of Doppler ultrasound parameters, including the umbilical artery (UA) PI, middle cerebral artery (MCA) PI, and cerebroplacental ratio (CPR).

Data collected from Doppler ultrasound measurements, including Umbilical Artery (UA) Pulsatility Index (PI), Middle Cerebral Artery (MCA) PI, and Cerebroplacental Ratio (CPR), were analyzed using IBM SPSS Statistics software. The analysis aimed to evaluate the diagnostic performance of these parameters in detecting late-onset uteroplacental insufficiency furthermore Initially, all continuous variables were assessed for normality using histograms and the Shapiro-Wilk test to determine distribution characteristics in addition to normally distributed data, descriptive statistics were reported as mean ± standard deviation (SD); for non-normal data, medians and interquartile ranges were used, which in second step was Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each Doppler parameter, considering clinical thresholds for abnormality and as above To evaluate the association between abnormal Doppler indices and adverse perinatal outcomes, odds ratios (OR) with 95% confidence intervals (CI) were estimated using binary logistic regression with A p-value of less than 0.05 was considered statistically significant throughout the analysis.

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RESULTS

As shown in Table 1, the study group was comprised of 100 pregnant women with a diagnosis of late-onset uteroplacental insufficiency, as evidenced by clinical presentation after 32 weeks' gestation. This well-defined sample ensures that our findings specifically regard uteroplacental compromise in the later stages of gestation. The homogeneity in the population characteristics adds to the reliability of the following Doppler results and clinical interpretations.

Table 1 Presents the basic characteristics of the study population, confirming the relevance of the sample.

Parameter	Value
Number of pregnant women	100
Gestational age range	Late onset (after 32 weeks)
Condition	Uteroplacental insufficiency

Table 2 discloses the incidence of abnormal Doppler results in our study population. In this, 25% of women had abnormal UA PI results, 30% had abnormal MCA PI, whereas 40% had abnormal CPR. The greater proportion of abnormal CPR shows that this ratio can identify fetal hemodynamic alteration, which is not always manifest by looking at UA or MCA separately. This implies that CPR is more sensitive to subtle circulatory adjustments in uteroplacental insufficiency.

Table 2 Summarizes the proportion of abnormal results for each Doppler parameter, highlighting the frequency of abnormal findings.

Doppler Parameter	% Abnormal
Umbilical Artery (UA) PI abnormal	25
Middle Cerebral Artery (MCA) PI abnormal	30
Cerebroplacental Ratio (CPR) abnormal	40

If one examines diagnostic sensitivity in Table 3, CPR is outstanding with 90% sensitivity, far above that of UA PI (44%) and MCA PI (71%). Sensitivity indicates how well a test can identify affected patients, and thus, the high CPR sensitivity indicates that it can more effectively detect actual cases of late-onset uteroplacental insufficiency. This is a validation of the clinical usefulness of CPR as a good screening parameter.

Table 3 Shows the sensitivity of each Doppler parameter, with CPR demonstrating the highest sensitivity.

Doppler Parameter	Sensitivity (%)
UA PI	44
MCA PI	71
CPR	90

Table 4 presents specificity, which measures the test's ability to correctly identify those without the condition. CPR again shows strong performance with 81.25% specificity, slightly better than MCA PI at 80% and superior to UA PI at 70%. This balance between sensitivity and specificity indicates CPR's robust diagnostic capability, with fewer false positives compared to UA PI.

Table 4 Displays the specificity, indicating that CPR is highly specific in this context.

Doppler Parameter	Specificity (%)
UA PI	70
MCA PI	80
CPR	81.25

In terms of overall accuracy (Table 5), both MCA PI and CPR performed well, with accuracy rates of 94% and 92%, respectively, while UA PI lagged somewhat behind at 83%. Accuracy incorporates both true positive and true negative results, demonstrating how well the test performs overall. The high accuracy of both CPR and MCA PI underlines their practical utility in clinical settings.

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Table 5 Lists the overall diagnostic accuracy, where both CPR and MCA PI perform well.

Doppler Parameter	Accuracy (%)
UA PI	83
MCA PI	94
CPR	92

Tables 6 and 7 explore the clinical predictive values. The positive predictive value (PPV) shown in Table 6 indicates that 86.7% of abnormal CPR readings truly reflected uteroplacental insufficiency, outperforming MCA PI (80%) and UA PI (60%). Similarly, Table 7 highlights the negative predictive value (NPV), with CPR at 97%, well above MCA PI (90%) and UA PI (80%). The high NPV is especially important, as it reassures clinicians when Doppler results are normal, suggesting a low risk of missed diagnosis.

Table 6 Provides the positive predictive value, reflecting the probability that abnormal results are truly indicative of insufficiency.

Doppler Parameter	PPV (%)
UA PI	60
MCA PI	80
CPR	86.7

Table 7: Shows the negative predictive value, with CPR offering the highest reassurance when results are normal.

Doppler Parameter	NPV (%)
UA PI	80
MCA PI	90
CPR	97

Table 8: Demonstrates that CPR is most strongly associated with adverse perinatal outcomes.

Doppler Parameter	Odds Ratio (OR)
UA PI	1.9
MCA PI	0.1
CPR	9.1

Table 9: Details the predictive performance of each parameter for specific neonatal outcomes, with CPR consistently outperforming the others.

Outcome	CPR Sensitivity (%)	UA PI Sensitivity (%)	MCA PI Sensitivity (%)
NICU admission	83	60	70
Stillbirth	100	60	75
Fetal distress	89	50	65

DISCUSSION

The results of the study on using Doppler ultrasound to assess late-onset uteroplacental insufficiency match up with what has been found in other research, which shows that the cerebroplacental ratio (CPR) is a better predictor of bad outcomes for the baby and women where Our study found that CPR issues were present in 40% of cases, and the test was accurate in detecting these problems 90% of the time and correctly ruling them out 81. 25% of the time, which This is better than other measures like the umbilical artery (UA) and middle cerebral artery (MCA) pulsatility indices (PI). This supports the idea that CPR has a higher accuracy rate (92%) and is more closely linked to worse outcomes, making it a better choice as a Doppler measurement [Elmes, C., & Phillips, R. 2022; Yam J. *et al*., 2000]. In a similar study by Khanjani et al. (2023) on pregnancies with fetal growth restriction (FGR), they also found that CPR and other Doppler ratios were strongly connected to bad perinatal outcomes, including low Apgar scores and needing to stay in the NICU. Their study also showed that the cerebroplacental-uterine ratio (CPUR) was especially good at predicting these outcomes, and that other Doppler measures like UA PI were also higher in cases with bad results. [Karowicz-Bilinska, A. *et al*., 2007] This supports our finding that using more than one Doppler measure can improve how well we predict outcomes, and that lower CPR values

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are linked to worse results as well as In a comprehensive systematic review and meta-analysis by Khalil et al. (2021), the third-trimester CPR showed moderate to high diagnostic accuracy for predicting fetal demise, with pooled sensitivity around 79% and specificity near 78%. Their review spanned large cohorts and highlighted CPR's role in identifying fetuses at risk of adverse outcomes, although predictive performance was lower for operative delivery and NICU admissions compared to fetal demise prediction, as our study higher sensitivity may reflect the focused high-risk late-onset uteroplacental insufficiency population and specific Doppler protocols used in addition to supporting your findings, a prospective cohort study by Macdonald *et al.* (2020) emphasized CPR's utility in predicting fetal growth velocity and adverse outcomes in late-onset FGR and Their data suggested that combining CPR with other Doppler parameters increases prognostic accuracy beyond individual indices. This matches your results showing that CPR had more than a ninefold increased odds ratio for adverse outcomes compared to UA or MCA PI alone, underscoring its clinical importance, and in Another recent analysis highlighted that abnormal CPR correlates with higher rates of cesarean sections due to fetal distress, NICU admissions, and fetal acidosis, which parallels your findings on neonatal complications and Doppler sensitivities. This consistency across studies, including systematic reviews and prospective cohorts, strongly advocates for CPR's incorporation into routine monitoring of pregnancies suspected to have uteroplacental insufficiency.

CONCLUSION

In our study, we concluded that it contributes valuable prospective data confirming CPR's superior sensitivity, specificity, and predictive value compared to UA and MCA Doppler indices, in accord with multiple independent investigations. These findings consolidate CPR's role as a robust, non-invasive marker for the timely identification and management of late-onset uteroplacental insufficiency to improve perinatal outcomes.

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