Section: Radiodiagnosis

Original Research Article

ROLE OF MIDDLE CEREBRAL ARTERY PULSATILITY INDEX VALUES IN GESTATIONAL HYPERTENSIVE PATIENTS – ANALYTICAL STUDY

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ABSTRACT

Background: Evaluation of Middle cerebral artery Pulsatility index values in gestational hypertensive patients.
Materials and Methods: It is an Analytical study in Department of Radio diagnosis over a period of 6 months in 40 pregnant women in II and III rd trimester with gestational hypertension as high risk factor referred from Department of Obstetrics and Gynaecology to Department of Radiodiagnosis.
Results: Abnormal MCA/UA PI (Cerebroplacental ratio) Doppler ratio strongly correlated with worse fetal prognosis. Fetuses with abnormal Doppler Velocimetry had a significantly higher incidence of low birth weight, and admission to NICU. Late onset FGR fetuses with normal Doppler Velocimetry on diagnosis show progression from 37 weeks gestation with worsening uteroplacental ratio followed by a decrease in MCA pulsating index (PI).
Conclusion: Umbilical artery Doppler may be normal, but fetuses may react with decreased middle cerebral artery (MCA) impedance in response to hypoxemia. This leads to late development of complications in fetus and ultimately leads to perinatal mortality.
Keywords: Pulsatility index, Resistive index, Cerebroplacental ratio, Neonatal intensive care unit.

INTRODUCTION

Any unexpected or unanticipated medical or obstetric condition associated with a pregnancy with an actual or potential hazard to the health or well-being of the mother or fetus is considered a high-risk pregnancy. Doppler provides a safe, non-invasive, relatively cheap, readily available, and very effective method in feto-maternal surveillance in high-risk pregnancies and improves feto-maternal outcomes in high-risk pregnancies. Abnormal blood flow patterns in fetal circulation detected by Doppler ultrasound may indicate poor fetal prognosis.

Fetal growth restriction is commonly defined as an estimated fetal weight (EFW) that is below the 10th percentile for gestational age. It is associated with an increased risk of intrauterine demise, neonatal morbidity and neonatal death; therefore, antenatal detection and surveillance with the optimization of delivery timing are necessary to improve pregnancy outcomes. The pathologic causes of fetal growth restriction can be categorized as maternal (e.g., chronic conditions associated with vascular disease), fetal (e.g., chromosomal abnormalities), and placental (e.g., abnormal placentation). All these entities lead to a final common pathway of suboptimal uterine-placental perfusion and fetal nutrition.[1,2]

IUGR fetus identification is one of the main objectives of prenatal care, since proper prenatal diagnosis and management reduces perinatal morbidity and mortality. A fetus with severe growth restriction first demonstrates changes in the umbilical artery as decreased end-diastolic flow and then in the middle cerebral artery as increased end-diastolic flow. This is followed by alterations in the venosus circulation, including the ductus venosus (decreased forward flow during atrial systole) and the umbilical vein (pulsatile flow). Doppler ultrasound of the umbilical artery and MCA provides information about the hemodynamic status of a growth-restricted fetus.[3] Doppler is effective in reducing fetal

mortality and significant morbidity in high-risk pregnancies. Once fetal growth restriction has been diagnosed, serial ultrasound is used for the evaluation of fetal growth and Doppler Velocimetry and to guide pregnancy management, including the timing of delivery.

MATERIALS AND METHODS

It is an Analytical study in Department of Radio diagnosis, Sri venkateswara medical college, Tirupati, over a period of 6 months, from November 2024 to April 2025, in 40 pregnant women in II and III rd trimester with gestational hypertension as high risk factor referred from Department of Obstetrics and Gynaecology to Department of Radiodiagnosis.

Inclusion Criteria

Mothers presenting with gestational hypertension as high risk factor.

Exclusion Criteria

Other high-risk pregnancies. Multiple pregnancies.

Procedure for data Collection

Pregnant women with gestational hypertension in II & III trimesters, referred to the Radiodiagnosis department for an obstetric scan will be included in the study. After taking informed written consent considering the inclusion and exclusion criteria, an obstetric scan will be performed. All findings are statistically analyzed.

Ethical Issues

Clearance from Institutional Ethical committee was obtained before the study was started.

All the examinations were made with the patient lying in a semi-recumbent position with a lateral tilt. Doppler transducer was placed on the abdominal wall over the uterus and carefully manipulated till identified Doppler signals appropriate for that particular vessel. All the examinations were done only during fetal apnea and fetal inactivity. The signal was recorded for a minimum of 5 to 8 cycles with blood flow velocity waveforms of equal shape and amplitude and satisfactory quality.

Doppler velocity waveforms of umbilical and middle cerebral arteries were taken. Then the image and measurements were taken. After delivery, follow up of these cases has been done and outcome is correlated with Doppler findings.

Cut off values for abnormal Doppler Velocimetry:

Umbilical artery PI and RI: Values are taken from waveform with low impedence flow and are compared with reference values of gestational age specific standardised reference chart centiles.

Middle cerebral artery PI and RI: Values obtained are compared with reference values of gestational age specific standardised reference chart centiles.

Cerebroplacental Ratio: Ratio of Middle Cerebral Artery PI / Umbilical Artery PI < 1.

Abnormal perinatal outcome: The perinatal outcome was considered abnormal when any one or a combination of the following was present.

1. APGAR < 8 at 5 minutes
2. NICU admission within 72 hours of birth due to perinatal asphyxia and respiratory distress.

Statistical Analysis of data: The data is entered into MS excel and further analyzed using SPSS version 21. The categorical data were analyzed using percentage.

RESULTS

The present study includes 40 gestational hypertensive patients in the second and third trimesters, referred to the Department of Radiodiagnosis from November 2024 to April 2025. Umbilical and middle cerebral arteries flow velocity waveforms (FVW) were analyzed, and the pulsatility index (PI), resistive index (RI), and cerebroplacental ratio (CPR) were measured. On the basis of flow velocity waveforms (FVW), the uteroplacentofetal blood flow was classified as normal, with increased resistance to flow, absent end-diastolic flow (AEDF), and reversed end-diastolic flow (REDF). In case of reversed and absent end-diastolic flow, the decision to terminate pregnancy irrespective of gestational age was taken. The delivery and outcome of the pregnancy is analyzed as below.

Fetal growth restriction (FGR) is defined as an estimated fetal weight (EFW) / abdominal circumference (AC) at one point in time during pregnancy being below 3rd percentile or EFW below the 10th percentile for gestational age with deranged Doppler parameters (ACOG).

Fetal growth restriction (FGR) diagnosed before 32 weeks is termed as Early FGR, identified by fetal smallness associated with Doppler abnormalities with significant perinatal morbidity and mortality.

Fetal growth restriction (FGR) diagnosed after 32 weeks of gestation is termed as Late FGR, had less growth potential associated with little Doppler abnormalities leads to significant morbidity.

Table 1: Comparison of the umbilical artery PI and Middle cerebral artery PI with fetal outcome

Umbilical artery PI	Abnormal fetal outcome	Normal fetal outcome
Abnormal PI	7 (TP)	3 (FP)
Normal PI	20(FN)	10 (TN)
Middle cerebral artery PI		
Abnormal PI	12 (TP)	3 (FP)
Normal PI	5 (FN)	20 (TN)

Table 2: Test performance values for PI of umbilical artery and Middle cerebral artery PI

PI of umbilical artery	Number of cases	Statistical performances	Percentages
True positives	7	Sensitivity	26%
True negatives	10	Specificity	77%
False positives	3	Positive predictive value	70%

False negatives	20	Negative predictive value	33%
PI of Middle cerebral artery			
True positives	12	Sensitivity	70%
True negatives	20	Specificity	87%
False positives	3	Positive predictive value	80%
False negative	5	Negative predictive value	80%

The pulsatility index of the umbilical artery was about 77%. So, the umbilical artery pulsatility index had more specificity in predicting adverse fetal outcomes in high-risk pregnancies. The middle cerebral artery pulsatility index had the most specificity 87% and maximum false positive (80%) values in predicting adverse fetal outcomes in high-risk pregnancies.

Table 3: Comparison of the CPR with fetal outcome

	Abnormal fetal outcome	Normal fetal outcome
Abnormal CPR	10 (TP)	5 (FP)
Normal CPR	7 (FN)	18(TN)

Table 4: Test performance values for CPR

Values for CPR	Number of cases	Statistical performances	Percentages
True positives	10	Sensitivity	45 %
True negatives	18	Specificity	83 %
False positives	5	Positive predictive value	77%
False negatives	7	Negative predictive value	55%

Cerebroplacental ratio is the more specific (83%) and positive predictive (77%) value in predicting adverse fetal outcomes in gestational hypertensive patients and more than the middle cerebral artery pulsatility index and umbilical artery pulsality index. So, from both the above index, it was clear that the umbilical artery pulsatility index had more specificity (77%) in predicting adverse fetal outcomes in high-risk pregnancies but not more than that of the middle cerebral artery pulsatility index (87%). The difference between the PI value of umbilical and middle cerebral artery was about 10%.

Table 5: Comparison of the umbilical artery RI with fetal outcome

Umbilical artery RI	Abnormal fetal outcome	Normal fetal outcome
Abnormal RI	11 (TP)	4 (FP)
Normal RI	6 (FN)	19 (TN)
Middle cerebral artery RI		
Abnormal RI	5 (TP)	10 (FP)
Normal RI	10 (FN)	15 (TN)

Table 6: Test performance values for RI of umbilical artery

Umbilical artery RI	Number of cases	Statistical performances	Percentages
True positives	11	Sensitivity	61%
True negatives	19	Specificity	86.3%
False positives	4	Positive predictive value	73.3%
False negatives	6	Negative predictive value	76%
Middle cerebral artery RI			
True positives	5	Sensitivity	33.3%
True negatives	15	Specificity	60%
False positives	10	Positive predictive value	33.3%
False negatives	10	Negative predictive value	60%

The umbilical artery resistance index had a more negative predicting value (76%) in predicting adverse fetal outcomes in high-risk pregnancies. But not more than that of the ratio of middle cerebral artery/ umbilical artery resistance index. The middle cerebral artery resistance index had a more negative predictive value (60%) for adverse fetal outcomes in high-risk pregnancies but not more than that of the umbilical artery and the ratio of middle cerebral artery/ umbilical artery resistance index.

Table 7: Distribution of Adverse Perinatal Outcomes

Adverse perinatal outcomes	No. of cases
NICU admissions	31 (86 %)
Low Apgar scores	31 (86%)
RDS	29 (80%)
Fever	5 (13%)
Vomiting	3 (8%)

RDS- respiratory distress syndrome NICU – neonatal intensive care unit

In 40 cases of suspected FGR fetuses, 36 cases show FGR fetuses associated with abnormal Doppler findings, which warranted early intervention among these cases. Using birth weight below the 10th percentile was to define small for gestational age baby or fetal growth retardation. 90% of cases were FGR i.e., 22.2% are early FGR and 77.7% are late FGR. Among these fetuses' adverse perinatal outcomes as described above like low APGAR scores, Respiratory distress syndrome needs NICU admissions.

DISCUSSION

In this study, we evaluated role of Doppler in high-risk pregnancies and studied the predictive value of Doppler findings in gestational hypertensive cases (high-risk pregnancies) and determined its importance in the management of fetal outcome.

Katherine W. Fong et al,[4] compared the diagnostic performance of fetal middle cerebral (MCA) and umbilical (UA) arterial Doppler ultrasonography (US) for prediction of adverse perinatal outcome in suspected intrauterine growth restriction (IUGR) and noted sensitivity 44.7% and specificity 86.6% and concluded that in suspected IUGR, while an abnormal UA PI is a better predictor of adverse perinatal outcome than an abnormal MCA, a normal MCA PI may help to identify fetuses without major adverse perinatal outcome, especially before 32 weeks gestational age. In the present study, the sensitivity, specificity, positive predictive value, and negative predictive value are 26%, 77%, 70%, and 33%. The present study's specificity was almost comparable with the Katherine W Fong et al,[4] while the sensitivity was invariable.

Table 8: Statistical comparison of umbilical artery PI values

Umbilical artery PI values	Sensitivity	Specificity	PPV	NPV
Katherine W. Fong et al,[4]	44.7%	86.6%	-	-
Maulik D et al,[5]	79 %	93 %	83%	91%
Present study	26%	77%	80%	80%

Maulik D et al,[5] did a study in 350 high risk patients with umbilical artery Doppler and fetal outcome were correlated with values of; sensitivity 79%, specificity 93%, Positive Predictive Value 83% and Negative Predictive Value 91%. In the present study, the sensitivity, specificity, positive predictive value, and negative predictive value are 26%, 77%, 70%, and 33%. The present study's specificity was almost comparable with the Katherine W Fong et al,[4] while the sensitivity was invariable.

Mulders et al,[6] study, found a sensitivity of 53.3 % and a specificity of 87.9 % for the UA PI at around 32–34 weeks of pregnancy. In the present study, the sensitivity, specificity, positive predictive value, and negative predictive value are 26%, 77%, 70%, and 33%. The present study's specificity was almost comparable with the Mulders et al et al,[6] while the sensitivity was invariable.

Alatas C et al,[7] conducted a study on 75 high-risk pregnancies, and it was found that the Middle Cerebral Artery PI value had a high specificity (96.4%) and negative predictive value (80.6%). This study concluded that Doppler flow measurement of MCA provides useful information about the perinatal outcome, especially in high-risk pregnancies. Similarly to this study, the present study showed a low Sensitivity of 70% and a high specificity of 87%. However, the positive and negative predictive value is reasonably similar in both the studies, which was equally comparable.

Table 9: Statistical comparison of MCA PI values

Comparison of MCA PI values	Sensitivity	Specificity	PPV	NPV
Alatas C and co- workers,[7]	31.6%	96.4%	75%	80.6%
Morris RK et al,[8]	85%	56%	-	-
Present study	70%	87%	80%	80%

Morris RK et al,[8] systemic review and meta-analysis of middle cerebral artery Doppler to predict perinatal well-being. Abnormal MCA Doppler showed limited predictive accuracy for compromise of fetal wellbeing having results of high sensitivity of 85 % and low specificity 56%. Contrast to this his study, the present study showed a low Sensitivity of 70% and a high specificity of 87%.

Guerrero Casillas MA et al,[9] concluded that in relation to perinatal death, the MCA/UA PI had a sensitivity of 100% and specificity of 91%. Similarly to this study, the present study showed a high sensitivity (83%) and high specificity of (87%).

Table 10: Statistical comparison of CPR values

Study	Sensitivity	Specificity	PPV	NPV
Guerrero casillar MA et al,[9]	100 %	91 %	-	-
Oros et al,[1]	86%	89 %	-	-
Ebrashy A, Azmy,[10]	64.1%	72.7%	89.2%	36.3%
Present study	83%	87%	80%	80%

In a study conducted by D. Oros et al,[1] reference ranges of UA and MCA Doppler indices and CPR, and the resulting references have important implications for clinical practice having results of 86 % of sensitivity and 89 % specificity. Similarly to this study, the present study showed a high sensitivity (83%) and high specificity of (87%).

According to another similar study done by Ebrashy A, Azmy,[10] co-workers, in relation to neonatal morbidity, MCA/UA PI had 64.1% sensitivity, 72.7% specificity, 89.2% positive predictive value and 36.3% negative predictive value. It was concluded that there was a strong correlation between MCA/UA PI and neonatal outcome in women with gestational hypertension. Similarly to this study, the present study showed a high sensitivity (83%) and high specificity of (87%). In all the below mentioned studies, comparison of CPR in various studies in done where the Guerrero casillar MA et al,[9] study shows highest sensitivity (100%).

According to the study done by Oros et al,[1] fetuses with both umbilical and fetal cerebral waveforms altered at the same time the risk of fetal distress is exceedingly high (86%) compared to those with both vessels having normal waveforms (4%). Similar to this study, the present study shows high NICU admissions in abnormal Doppler findings (96%) and RDS.

Table 11: Comparison of NICU admissions

Study	NICU	RDS
Oros et al,[1]	86 %	89 %
Present study	90 %	80%

CONCLUSION

In Doppler ultrasound study, the best parameter is the cerebroplacental ratio (CPR), which is calculated dividing the middle cerebral artery (MCA) Doppler pulsatility index (PI) (MCA-PI) by the umbilical artery (UA) Doppler pulsatility index PI (UA-PI). This ratio reflects small decreases in fetal cerebral vascular resistance with slight increases in placental resistance in a combined way. This relationship seems to be more sensitive to hypoxia than its individual components, correlating better with a possible adverse outcome.

In cases of FGR, the cerebroplacental ratio is more sensitive (95%) and had got more positive predictive value (83%) than the middle cerebral artery (MCA) and umbilical artery (UA) indices in predicting adverse fetal outcome. In cases of IUGR, the umbilical artery PI was more specific (81%) and has got more positive predictive value (72%) than all other parameters in predicting adverse fetal outcome Early-onset FGR is associated with high impedance utero placental perfusion which in turn leads to elevated umbilical artery blood flow resistance once villous damage exceeds 30%. This leads to early development of complications in fetus ultimately leads to perinatal mortality. Late-onset FGR is more common but less severe with absent or mild placental abnormalities. Umbilical artery Doppler may be normal, but fetuses may react with decreased middle cerebral artery (MCA) impedance in response to hypoxemia. This leads to late development of complications in fetus ultimately leads to perinatal mortality.

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