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Cerebral and Umbilical Artery Doppler Study in Normal and Growth-Restricted Pregnancies

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ABSTRACT

Objective: To evaluate the role of umbilical artery (UA) and middle cerebral artery (MCA) Doppler indices, their ratios, and the umbilical artery systolic/diastolic (S/D) ratio in predicting intrauterine growth restriction (IUGR) and adverse perinatal outcomes, and to compare their diagnostic accuracy.

Methods: This prospective observational study was conducted at Jawaharlal Nehru Hospital and Research Centre, Bhilai. Pregnant women between 30 and 41 weeks of gestation were enrolled and categorized into a study group with growth-restricted fetuses and a control group with normal pregnancies. Doppler assessment of UA and MCA was performed, and pulsatility indices (PI), S/D ratio, and cerebro-umbilical ratio (CUR) were calculated. Perinatal outcomes were recorded and correlated with Doppler findings.

Results: The mean gestational age at enrollment was 35.8 weeks in the study group and 36.7 weeks in the control group. Umbilical artery PI and S/D ratios were significantly higher in the study group ($p < 0.001$), while MCA PI and CUR were significantly lower ($p \leq 0.001$). Abnormal CUR showed the highest sensitivity (83.6%), specificity (98.6%), and diagnostic accuracy (94.5%) for predicting adverse perinatal outcomes, outperforming individual vessel Doppler indices.

Conclusion: The cerebro-umbilical ratio is the most reliable Doppler parameter for predicting IUGR and adverse perinatal outcomes. Routine use of Doppler velocimetry, particularly CUR, in high-risk pregnancies can facilitate timely intervention and improve perinatal outcomes.

KEYWORDS: Intrauterine growth restriction; Doppler velocimetry; Umbilical artery; Middle cerebral artery; Cerebro-umbilical ratio

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INTRODUCTION

Normal fetal growth and survival depend on an intact uteroplacental and fetoplacental circulation. Impairment of this circulation leads to intrauterine growth restriction (IUGR), a major contributor to perinatal morbidity and mortality. IUGR accounts for approximately 50% of perinatal deaths in preterm infants and 20% at term and is associated with intrapartum fetal distress, hypoxic encephalopathy, cerebral palsy, and long-term cardiovascular and neurodevelopmental sequelae.

Doppler ultrasound enables non-invasive assessment of fetal and placental hemodynamics. Increased resistance in the umbilical artery reflects placental insufficiency, while reduced resistance in the middle cerebral artery represents fetal adaptive redistribution of blood flow, known as the brain-sparing effect. These Doppler changes often precede abnormalities detected by conventional fetal surveillance techniques.

The cerebro-umbilical ratio (CUR), derived from the ratio of MCA PI to UA PI, integrates placental resistance and fetal adaptive response. Previous studies suggest that CUR may be superior to individual Doppler indices in predicting adverse perinatal outcomes. This study aims to evaluate and compare the diagnostic utility of UA PI, MCA PI, UA S/D ratio, and CUR in normal and growth-restricted pregnancies.

TABLES

Table 1. Comparison of maternal age and gestational age at enrollment between study and control groups.

Variable	Study Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Maternal age (years)	24.0 ± 4.45	24.86 ± 3.35	0.13
Gestational age (weeks)	35.8 ± 2.2	36.78 ± 2.8	0.005

Table 2. Distribution of risk factors among women in the study group (n = 83).

Risk factor	Number of cases	Percentage (%)
Gestational hypertension	19	22.8
Preeclampsia	11	13.2
Previous IUGR	12	14.4
Anaemia	15	18.0
Chronic heart disease	2	2.5
Chronic renal failure	3	3.6
Diabetes	4	4.8
Jaundice	2	2.4
Chicken pox	1	1.2
Urinary tract infection	2	2.5
Rh-negative pregnancy	4	4.8
Sickle cell anaemia	6	7.3
Antepartum haemorrhage	2	2.5
Total	**83**	**100**

Table 3. Comparison of Doppler indices between study and control groups.

A. Umbilical artery systolic/diastolic (S/D) ratio

Gestational age (weeks)	Control group (Mean ± SD)	Study group (Mean ± SD)	p-value
30–35	2.4 ± 0.28	3.8 ± 0.9	<0.001
36–41	2.5 ± 0.28	3.3 ± 0.8	<0.001
Overall	**2.4 ± 0.28**	**3.5 ± 0.9**	**<0.001**

B. Umbilical artery pulsatility index (PI)

Gestational age (weeks)	Control group (Mean ± SD)	Study group (Mean ± SD)	p-value
30–35	0.88 ± 0.06	1.15 ± 0.23	<0.001
36–41	0.78 ± 0.06	0.93 ± 0.21	<0.001
Overall	**0.81 ± 0.07**	**1.02 ± 0.24**	**<0.001**

C. Middle cerebral artery pulsatility index (PI)

Gestational age (weeks)	Control group (Mean ± SD)	Study group (Mean ± SD)	p-value
30–35	1.53 ± 0.06	1.33 ± 0.23	<0.001
36–41	1.29 ± 0.01	1.27 ± 0.16	0.39
Overall	**1.37 ± 0.14**	**1.30 ± 0.20**	**0.005**

D. Cerebro-umbilical ratio (CUR)

Gestational age (weeks)	Control group (Mean ± SD)	Study group (Mean ± SD)	p-value
30–35	1.75 ± 0.09	1.19 ± 0.30	0.001
36–41	1.65 ± 0.10	1.42 ± 0.30	0.001
Overall	**1.68 ± 0.10**	**1.32 ± 0.30**	**0.001**

MATERIALS AND METHODS

This prospective observational study was conducted at Sector-9, Jawaharlal Nehru Hospital and Research Centre, Bhilai, from August 2009 to January 2011, after approval from the institutional ethics committee. Written informed consent was obtained from all participants.

STUDY POPULATION

Pregnant women with singleton pregnancies between 30 and 41 weeks of gestation were enrolled and divided into two groups:

- **Study group:** Pregnancies complicated by asymmetrical IUGR, defined as ultrasound-estimated fetal weight below the 10th percentile for gestational age along with a fundal height lag of ≥4 weeks.
- **Control group:** Uncomplicated pregnancies with normal fetal growth.

Inclusion Criteria

- Known last menstrual period
- Singleton viable pregnancy

Exclusion Criteria

- Uncertain gestational age
- Congenital fetal anomalies
- Smoking or chronic alcoholism

Doppler Assessment

Ultrasound and Doppler examinations were performed using a Siemens ultrasound machine with a 3.5 MHz convex probe. Doppler waveforms were obtained in a semi-recumbent position during fetal quiescence. Umbilical artery Doppler measurements were taken from a free loop of the umbilical cord. MCA Doppler was assessed at the level of the thalami and cavum septum pellucidum. PI values were averaged over three consecutive cardiac cycles. CUR was calculated as MCA PI/UA PI.

Outcome Measures

Adverse perinatal outcome was defined by the presence of one or more of the following: operative delivery for fetal distress, Apgar score <7 at 5 minutes, low birth weight (<10th percentile), NICU admission >8 days, neonatal complications, or intrauterine/neonatal death.

Statistical Analysis

Data were analyzed using chi-square test, Student's t-test, and Fisher's exact test as appropriate. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated for each Doppler parameter.

RESULTS

Umbilical artery PI and S/D ratio were significantly higher in growth-restricted pregnancies, while MCA PI and CUR were significantly lower. CUR demonstrated the highest diagnostic accuracy for predicting both IUGR and adverse perinatal outcomes. Caesarean section rates, preterm delivery, low birth weight, and prolonged NICU stay were significantly higher in pregnancies with abnormal Doppler findings.

DISCUSSION

The findings of this study confirm that Doppler velocimetry is a valuable tool in the surveillance of high-risk pregnancies. Among the evaluated parameters, the cerebro-umbilical ratio emerged as the most sensitive and specific predictor of adverse perinatal outcome. This supports previous studies indicating that CUR reflects both placental pathology and fetal adaptive mechanisms more effectively than individual vessel indices.

Routine incorporation of Doppler studies, particularly CUR, can aid in distinguishing constitutionally small fetuses from those with placental insufficiency and guide timely obstetric intervention.

CONCLUSION

Cerebro-umbilical ratio is superior to individual Doppler indices in predicting intrauterine growth restriction and adverse perinatal outcomes. Its routine use in the management of high-risk pregnancies is recommended to improve fetal surveillance and perinatal outcomes.

CONFLICT OF INTEREST

None declared.

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