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EVALUATION OF HEMODYNAMIC CHANGES IN THE UMBILICAL ARTERY, UTERINE ARTERY, MIDDLE CEREBRAL ARTERY DOPPLER INDICES ON NEONATAL OUTCOME AND MODE OF DELIVERY: A PROSPECTIVE STUDY

Obstetrics & Gynaecology

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ABSTRACT

Background: Doppler ultrasonography is a valuable non-invasive tool to assess fetoplacental and fetal cerebral hemodynamics. Abnormal doppler indices and biophysical profile (BPP) scores can predict fetal compromise, mode of delivery, and neonatal outcomes. **Aim:** To evaluate the hemodynamic changes in the umbilical artery, uterine artery, and middle cerebral artery (MCA) doppler indices, and to study their correlation with mode of delivery and neonatal outcomes. **Methods:** This is a prospective study conducted on 80 pregnant women >28 weeks of gestation with oligoamnios. Demographic, maternal, obstetric, and clinical data were collected. Doppler assessment of the umbilical artery, uterine arteries, and MCA, along with cerebroplacental ratio (CPR) and BPP were performed. Correlations of doppler parameters, amniotic fluid index (AFI), CPR, and BPP with mode of delivery and NICU admission were assessed. Statistical analysis was done using IBM Statistical Software for Social Sciences (SPSS) version 20 with $p \leq 0.05$ considered statistically significant**. Results:** The majority of participants were aged ≤25 years (49%), primigravida (60%), and from lower socio-economic strata (72%). Umbilical artery doppler was normal in 75%; while 10% showed reduced diastolic flow, 10% absent end-diastolic flow, and 5% reversed end-diastolic flow. Both abnormal doppler patterns and AFI <5 cm were significantly ($p<0.05$) correlated with lower segment caesarean section (LSCS). Furthermore, BPP score correlated with mode of delivery ($p=0.004$); whereas CPR, showed no significant correlation. In addition, normal umbilical artery flow was correlated with lower NICU admission, although not statistically significant. **Conclusion:** An integrated evaluation using doppler studies and BPP represents a practical, non-invasive strategy for optimizing delivery planning and neonatal management, thereby contributing to improved perinatal outcomes in both high-risk and general obstetric populations.

KEYWORDS

Doppler ultrasonography, Umbilical artery, Biophysical profile, LSCS, NICU

INTRODUCTION

Doppler ultrasonography is now a vital, non-invasive modality in obstetric care for assessing fetoplacental and fetal cerebral hemodynamics, providing valuable information on fetal well-being and the risk of adverse perinatal outcomes. Doppler indices of the umbilical artery, uterine arteries, and middle cerebral artery (MCA) represent vascular resistance and blood flow redistribution within the fetoplacental circulation and have been linked to perinatal morbidity and delivery outcomes in both high-risk and low-risk obstetric populations.[1,2]

Abnormal umbilical artery doppler parameters, including elevated pulsatility and resistance indices, have been associated with fetal compromise, low birth weight, and increased rates of neonatal intensive care admissions, underscoring their prognostic significance.[1,3] In a similar manner, MCA doppler findings and calculated indices such as the cerebroplacental ratio (CPR) reflect fetal adaptive mechanisms, including the brain-sparing phenomenon in compromised pregnancies, and have been explored as predictors of perinatal outcomes.[1,4,5]

Although individual doppler parameters have been widely studied, the combined influence of umbilical, uterine, and MCA doppler indices on mode of delivery and neonatal outcomes-particularly with the inclusion of uterine artery hemodynamics-remains an area of continued clinical investigation. Against this background, the present study was undertaken to assess hemodynamic changes in umbilical, uterine, and MCA doppler indices and to evaluate their correlation with neonatal outcomes and mode of delivery.

MATERIALS AND METHODS

Ethical Approval

The study was initiated after due permission from Institutional Ethical Committee and Review Board of Hassan Institute of Medical Sciences (HIMS), Hassan, Karnataka. A written informed consent was obtained from all the patients participated in the study.

Study Design And Patients

This is a prospective cohort study conducted with total of 80 pregnant women with oligoamnios in the Department of Obstetrics and Gynaecology at Sri Chamarajendra Maternity Hospital, Hassan Institute of Medical Sciences, Hassan, over a period of 18 months.

Inclusion Criteria

1. Pregnant women >28 weeks of gestation with oligoamnios

Exclusion Criteria

Pregnant women with
1. Multiple gestation
2. Intrauterine death at admission
3. Hemodynamic instability
4. Chorioamnionitis
5. Antepartum haemorrhage
6. Diagnosed with anomalous foetus
7. Need of emergency intervention in pregnancy

Data Collection

Demographic, maternal, and clinical data were recorded. All participants underwent detailed general and obstetric examination, including measurement of symphysis fundal height (SFH) and abdominal circumference along with routine haematological investigations. High-risk pregnancies with associated comorbidities were assessed in detail. Ultrasound evaluation included assessment of amniotic fluid index (AFI), biophysical profile (BPP), and obstetric doppler studies to evaluate fetal hemodynamic status, which were subsequently correlated with neonatal outcomes.

Doppler examinations were performed using a Mindray 35C50EA duplex Doppler scanner with a 2.5 MHz convex transducer. Umbilical artery doppler indices were obtained from a free-floating loop of the umbilical cord during fetal apnoea, with the average of three readings recorded. MCA doppler assessment was carried out at the level of the cerebral peduncles using colour doppler to identify the circle of Willis, and the sample volume was placed within 1 cm of the artery's origin.

Uterine artery doppler indices were assessed near the internal cervical os using colour flow mapping. Pulsatility index (PI) and resistance index (RI) values of all three vessels were documented, and the CPR was calculated as the ratio of MCA PI to umbilical artery PI, with a cut-off value of <1.08 considered abnormal.

Management and timing of delivery were guided by AFI, BPP,

gestational age, and doppler findings. Women with AFI between 5 and 8 cm were managed conservatively and monitored with serial ultrasonography; while the induction of labour was planned after 37 weeks when appropriate. In cases with AFI less than 5 cm, weekly non-stress test (NST) and modified BPP were performed, and delivery was decided based on obstetric indications. Immediate lower segment caesarean section (LSCS) was undertaken irrespective of gestational age in the presence of non-reassuring NST and abnormal doppler findings.

Study Outcomes

The correlation between obstetric doppler parameters and BPP with neonatal outcomes, including birth weight, gestational age, NICU admission, and neonatal morbidity were assessed.

Statistical Analysis

Data were entered in Microsoft Excel 2021 and statistical analysis was done using IBM Statistical Software for Social Sciences (SPSS) version 20. Categorical variables were represented in the form of percentages, and frequencies. Continuous variables were presented as descriptive statistics (Mean and Standard deviation). Categorical variables were analysed using the Chi-square test. $p \leq 0.05$ was considered statistically significant.

RESULTS

Among 80 participants, nearly half of the participants were aged ≤25 years (49%) followed by those aged 26–30 years (31%) and >30 years (20%). Most participants belonged to the lower socio-economic strata, with 37% from the lower class and 35% from the lower middle class. Majority of the participants were primigravida (60%). Almost half of the participants (47.5%) had no comorbidities; among those with comorbid conditions, preeclampsia (24%) and anaemia (15%) were the most common. Most pregnancies i.e., 71% were at term (>37 weeks), followed by 34–37 weeks (17%) and <34 weeks of gestation (12%). Regarding birth weight, over half of the neonates weighed between 1.5–2.5 kg (51.2%), while 37.5% weighed >2.5 kg and 13% weight <1.5 kg. In terms of BMI, the majority of participants were overweight or obese, with 45% classified as obesity class I and 13% as obesity class II (Table 1).

Table 1. Demographic, Maternal, And Obstetric Characteristics

Variable	n (%)
Age (years)	
≤25	39 (49.0)
26–30	25 (31.0)
>30	16 (20.0)
Socio-economic status (SES)	
Upper class	1 (1.0)
Upper middle class	1 (1.0)
Middle class	21 (26.0)
Lower middle class	28 (35.0)
Lower class	29 (37.0)
Obstetric score	
Primi	48 (60.0)
Multi	32 (40.0)
Comorbidities	
Preeclampsia	19 (24.0)
Anaemia	12 (15.0)
Antepartum eclampsia	4 (5.0)
Hypothyroidism	4 (5.0)
Hyperthyroidism	2 (2.5)
Gestational diabetes mellitus (GDM)	1 (1.3)
No comorbidities	38 (47.5)
Period of gestation (weeks)	
>37	57 (71.0)
34–37	13 (17.0)
<34	10 (12.0)
Birth weight (kg)	
<1.5	9 (13.0)
1.5–2.5	41 (51.2)
>2.5	30 (37.5)
BMI (kg/m²)	
Underweight	3 (4.0)
Normal	10 (12.0)
Overweight	21 (26.0)
Obesity class I	36 (45.0)
Obesity class II	10 (13.0)

The majority of participants had MCA PI >1.5 (68%). MCA RI was in the range of 1-1.5 in majority of participants (60%). Regarding the umbilical artery PI, 64% of participants had values >1.5, whereas 26% had values <1. Similarly, umbilical artery RI values were predominantly between 1–1.5 (68%). Uterine artery PI was >1.5 in major proportion of participants (66%) followed by values between 1–1.5 (55%). The systolic/diastolic (S/D) ratio was >2.5 in two-thirds of participants (66%) (Table 2).

Table 2. Distribution Of Participants According To Obstetric Doppler Parameters

Doppler parameter	Category	n (%)
MCA PI	< 1	15 (19.0)
	1 – 1.5	10 (13.0)
	> 1.5	55 (68.0)
MCA RI	< 1	24 (30.0)
	1 – 1.5	48 (60.0)
	> 1.5	8 (10.0)
Umbilical Artery PI	< 1	21 (26.0)
	1 – 1.5	8 (10.0)
	> 1.5	51 (64.0)
Umbilical Artery RI	< 1	25 (31.0)
	1 – 1.5	46 (68.0)
	> 1.5	9 (11.0)
Uterine Artery PI	< 1	16 (20.0)
	1 – 1.5	11 (14.0)
	> 1.5	53 (66.0)
Uterine Artery RI	< 1	28 (35.0)
	1 – 1.5	44 (55.0)
	> 1.5	8 (10.0)
S/D Ratio	1.5 – 2	10 (12.0)
	2 – 2.5	17 (22.0)
	> 2.5	53 (66.0)

PI, Pulsatility index; MCA, Middle cerebral artery; S/D ratio; Systolic/Diastolic ratio

Umbilical artery doppler was normal in 75% of participants, while 10% showed reduced diastolic flow, another 10% had absent end-diastolic flow (AEDF), and 5% exhibited reversed end-diastolic flow (REDF). The CPR was <1.08 in 49% of participants and >1.08 in 51%. Most deliveries were performed via LSCS (73%), whereas full-term vaginal delivery (FTVD) accounted for 15%, preterm vaginal delivery (PTVD) for 8%, and instrumental delivery for 4%. Among the 59 LSCS cases, the most common indications were oligohydramnios with fetal doppler changes (35.5%) followed by severe oligohydramnios with acute fetal distress (25.4%), and previous LSCS with oligohydramnios (15.3%). Less frequent indications included breech presentation with comorbidities (6.7%), non-progression of labor (6.7%), failed induction of labor (4.3%), and 4.3% accounted for other causes (Table 3).

Table 3. Umbilical Artery Doppler Findings, CPR, Mode Of Delivery, And Indications For LSCS

Category	n (%)
Umbilical artery Doppler	
Normal	60 (75.0)
Reduced diastolic flow	8 (10.0)
AEDF	8 (10.0)
REDF	4 (5.0)
Cerebroplacental ratio (CPR)	
<1.08	39 (49.0)
>1.08	41 (51.0)
Mode of delivery	
LSCS	59 (73.0)
FTVD	12 (15.0)
PTVD	6 (8.0)
Instrumental delivery	3 (4.0)
Indications for LSCS (n = 59)	
Oligohydramnios with fetal doppler changes	21 (35.5)
Severe oligohydramnios with acute fetal distress	15 (25.4)
Previous LSCS with oligohydramnios	9 (15.2)
Breech with comorbidities	4 (6.7)

Non-progression of labour	4 (6.7)
Failed induction of labour	3 (4.3)
Others	3 (4.3)

AEDF, Absent end-diastolic flow; REDF, Reversed end-diastolic flow; LSCS, Lower segment caesarean section; FTVD, Full-term vaginal delivery; PTVD, Preterm vaginal delivery

The results on correlation of doppler parameters, AFI and CPR with mode of delivery were represented in Table 4. Results showed statistically significant correlation between mode of delivery with doppler findings (p = 0.004) and AFI (p = 0.008).

Table 4. Correlation Of Doppler Parameters, AFI And CPR With Mode Of Delivery

Correlation between umbilical artery doppler findings and mode of delivery					
Mode of Delivery	**AEDF**	**Normal**	**REDF**	**Reduced Diastolic Flow**	**p-value**
FTVD	4 (50.0)	8 (13.3)	0 (0.0)	0 (0.0)	0.004
Instrumental	0 (0.0)	2 (3.3)	0 (0.0)	1 (12.5)	
LSCS	4 (50.0)	48 (80.0)	1 (25.0)	6 (75.0)	
PTVD	0 (0.0)	2 (3.3)	3 (75.0)	1 (12.5)	
Correlation between AFI and mode of delivery					
AFI (cm)	**FTVD**	**Instrumental**	**LSCS**	**PTVD**	**p-value**
< 5	8 (12.9)	1 (1.6)	51 (82.3)	2 (3.2)	0.008
5 – 8	4 (22.2)	2 (11.1)	8 (44.4)	4 (22.2)	
Total	12 (15.0)	3 (3.8)	59 (73.8)	6 (7.5)	
Correlation between CPR and mode of delivery					
CPR	**FTVD**	**Instrumental**	**LSCS**	**PTVD**	**p-value**
<1.08	6 (15.4)	1 (2.6)	30 (76.9)	2 (5.1)	0.805
>1.08	6 (14.6)	2 (4.9)	29 (70.7)	4 (9.8)	
Total	12 (15.0)	3 (3.8)	59 (73.8)	6 (7.5)	

Values expressed as n (%) unless otherwise stated

AEDF, Absent end-diastolic flow; REDF, Reversed end-diastolic flow; CPR, Cerebroplacental ratio; LSCS, Lower segment caesarean section; FTVD, Full-term vaginal delivery; PTVD, Preterm vaginal delivery; AFI, Amniotic fluid index

The results on correlation between BPP score and mode of delivery were represented in Table 5. Results depicted that participants with low BPP scores (<4) predominantly had PTVD (75%), while those with intermediate scores (4–6) mainly underwent LSCS (86.7%). Participants with higher BPP scores (6–8) were also majorly delivered via LSCS (75.4%), with a smaller proportion having FTVD (14.8%) or instrumental delivery (4.9%). The correlation between BPP score and mode of delivery was statistically significant (p = 0.004).

Table 5: Correlation Between BPP Score And Mode Of Delivery

Mode of Delivery	**BPP <4**	**BPP 4–6**	**BPP 6–8**	**p-value**
FTVD	1 (25.0)	2 (13.3)	9 (14.8)	0.004
Instrumental	0 (0.0)	0 (0.0)	3 (4.9)	
LSCS	0 (0.0)	13 (86.7)	46 (75.4)	
PTVD	3 (75.0)	0 (0.0)	3 (4.9)	

Values expressed as n (%) unless otherwise stated

FTVD, Full-term vaginal delivery; PTVD, Preterm vaginal delivery; LSCS, Lower segment caesarean section

Table 6: Correlation Of Umbilical Artery Doppler And CPR With Need For NICU Admission

Umbilical Artery Doppler	**NICU Not Required**	**NICU Required**	**p-value**
AEDF	2 (8.7)	5 (10.2)	0.597
Normal	20 (86.9)	37 (75.5)	
REDF	0 (0.0)	2 (4.1)	
Reduced diastolic flow	1 (4.3)	5 (10.2)	
CPR	**NICU Not Required**	**NICU Required**	**p-value**
< 1.08	12 (52.0)	22 (45.0)	0.564
> 1.08	11 (48.0)	27 (55.0)	

Values expressed as n (%) unless otherwise stated

AEDF, Absent end-diastolic flow; REDF, Reversed end-diastolic flow; CPR, Cerebroplacental ratio; NICU, Neonatal intensive care unit

The results on correlation of umbilical artery doppler and CPR with need for NICU admission were represented in Table 6. Results implied that smaller proportions of participants with AEDF & reduced diastolic flow, and REDF, required NICU admission in 10.2% each and 4.1% respectively. With regards to CPR, participants with having CPR values <1.08 and >1.08 required NICU admission in 45% and 55% respectively. However, there was no statistically significant correlation exist between umbilical artery doppler (p = 0.597) and CPR (p = 0.564) with NICU admission.

DISCUSSION

The present study examined demographic factors, maternal characteristics, obstetric variables, and doppler parameters, and evaluated their association with mode of delivery and neonatal outcomes among 80 pregnant women beyond 28 weeks of gestation with oligohydramnios. Nearly half of the participants were aged ≤25 years, the majority belonged to lower socio-economic groups (72% from lower and lower-middle classes), and most were primigravida (60%). These observations are comparable to earlier studies from developing regions, where younger maternal age and primigravidity are commonly reported in obstetric populations.[6,7] Slightly over half of the participants in our study had associated maternal comorbidities, with preeclampsia (24%) and anemia (15%) being the most prevalent, findings that are in agreement with Fareed et al., who identified hypertensive disorders and maternal anemia as frequent contributors to adverse perinatal outcomes in similar cohorts.[8]

Regarding fetal outcomes, 71% of pregnancies in the present study reached term, and most neonates had birth weights ranging between 1.5 - 2.5 kg, indicating a predominance of term deliveries with normal or mildly restricted fetal growth. The BMI distribution revealed a substantial proportion of overweight and obese women (45% class I and 13% class II). These findings were consistent with recent literature highlighting the increasing prevalence of maternal obesity and its influence on pregnancy outcomes.[9-11] These findings suggest that maternal BMI and socio-economic status may affect fetal growth, placental function, and doppler indices, emphasizing the need for a holistic maternal evaluation.

Doppler assessment showed that most participants demonstrated normal or mildly elevated indices of the MCA, umbilical artery, and uterine artery, suggesting relatively preserved fetoplacental circulation. In the present study, MCA PI exceeded 1.5 in 68% of cases, while MCA RI values between 1 - 1.5 were observed in 60%, indicating normal to mildly increased cerebral vascular resistance. Elevated umbilical artery PI (>1.5) was noted in 64% of participants, with RI values predominantly between 1 - 1.5 (68%). Uterine artery PI and RI values were similarly found to be largely within normal or mildly raised ranges. These findings are in concordance with earlier reports suggesting that mild increase in Doppler indices may reflect physiological adaptation in low- to moderate-risk pregnancies, whereas significantly abnormal values are more closely associated with fetal compromise.[12,13]

Previous studies have demonstrated that abnormal umbilical artery doppler flow patterns are strong predictors of operative delivery, preterm birth, and fetal compromise.[14,15] In line with these reports, the present study identified a statistically significant association between doppler findings and mode of delivery (p = 0.004). Additionally, AFI showed a significant correlation with mode of delivery (p = 0.008). A majority of participants with AFI <5 cm underwent LSCS (82.3%), while those with AFI between 5 - 8 cm experienced varied delivery outcomes, including LSCS, FTVD, PTVD, and instrumental deliveries. This observation is consistent with earlier studies indicating that oligohydramnios, particularly when accompanied by abnormal doppler parameters, increases the likelihood of cesarean delivery due to fetal distress or intrapartum complications.[16,17] conversely, CPR did not demonstrate a significant association with mode of delivery (p = 0.805) in the current study, similar to findings reported by Novillo-Del Alamo et al., who suggested that CPR alone may not be a reliable predictor of operative delivery in mixed-risk populations, despite its utility in identifying fetal blood flow redistribution and hypoxemia.[18]

BPP scores in the present study showed a significant association with

mode of delivery (p = 0.004). Lower BPP scores (<4) were mainly associated with PTVD, whereas intermediate score (4–6) and higher score (6–8) were predominantly linked to LSCS. These results further support the role of BPP in evaluating fetal well-being and guiding obstetric decision-making, in agreement with Sujani et al., who emphasized the usefulness of BPP in combining NST and amniotic fluid assessment for early detection of fetal compromise and timely intervention.[19]

Neonatal outcomes, particularly NICU admissions, were influenced by umbilical artery doppler patterns in the present study. A smaller proportion of neonates with AEDF, REDF, or reduced diastolic flow required NICU admission; however, these associations were not statistically significant (p = 0.597). Similarly, CPR did not show a significant correlation with NICU admission (p = 0.564). These findings are consistent with those of Vinodhini and Coumary, who reported that although abnormal doppler flow patterns may indicate fetal compromise, NICU admission is determined by multiple factors, including gestational age, birth weight, and immediate neonatal adaptation.[20]

Overall, this prospective study demonstrates that umbilical artery, uterine artery, and MCA doppler indices, together with AFI and BPP, are valuable in predicting mode of delivery and neonatal outcomes. Abnormal umbilical artery doppler findings and low AFI emerged as significant predictors of LSCS, while BPP scores provided additional insight into fetal condition and optimal timing of delivery. Although CPR was helpful in identifying cerebral redistribution, it did not independently predict mode of delivery or NICU admission in the present cohort. These results highlight the complementary role of doppler studies and BPP in optimizing perinatal management, particularly in populations with a high burden of maternal comorbidities and diverse socio-economic backgrounds.

The strengths of this study include its prospective design, which facilitated systematic and real-time collection of maternal, fetal, and doppler data, thereby reducing recall bias. The inclusion of multiple doppler parameters *viz.* umbilical artery, uterine artery, and MCA indices along with CPR and BPP scores allowed for a comprehensive evaluation of fetal hemodynamics. Correlating these parameters with clinically relevant outcomes such as mode of delivery and NICU admission enhances the clinical applicability of the findings. Additionally, the inclusion of abnormal doppler patterns, including AEDF and REDF, further strengthened the study's relevance by identifying predictors of operative delivery.

Nevertheless, certain limitations should be acknowledged. The relatively small sample size (n = 80) and single-center nature of the study may limit the generalizability of the findings. Only short-term neonatal outcomes were evaluated, with no assessment of long-term neurodevelopmental outcomes. Moreover, potential confounding factors such as maternal comorbidities, BMI, and socio-economic status may have influenced the observed correlations.

CONCLUSIONS

Abnormal umbilical artery Doppler indices and reduced AFI were significantly linked to a higher incidence of LSCS, emphasizing their importance in predicting the need for operative delivery. BPP scores were useful in detecting fetal compromise and facilitating timely obstetric decision-making. Therefore, an integrated evaluation using doppler studies and BPP represents a practical, non-invasive strategy for optimizing delivery planning and neonatal management, thereby contributing to improved perinatal outcomes in both high-risk and general obstetric populations.

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