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COMPARISON OF EARLY NEONATAL OUTCOME IN PREGNANT FEMALES FOR ASYMMETRICAL IUGR WITH NORMAL AND ABNORMAL UMBILICAL ARTERY WAVE FORMS: A CROSS-SECTIONAL STUDY

Original Research

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ABSTRACT

Background: Intrauterine growth restriction (IUGR) remains a major cause of perinatal morbidity and mortality, especially in developing countries. Early identification of fetuses at risk through Doppler ultrasonography enables timely intervention to prevent adverse outcomes. Umbilical artery waveform analysis serves as a key functional assessment of placental resistance and fetal well-being. Despite advancements, limited local data exist correlating abnormal Doppler findings with early neonatal outcomes in asymmetrical IUGR pregnancies.

Objective: To determine the frequency of early neonatal outcomes in asymmetrical intrauterine growth restriction and to compare these outcomes between fetuses with normal and abnormal umbilical artery waveforms.

Methods: This cross-sectional study was conducted in the Department of Obstetrics and Gynecology, Hilal-e-Ahmar Maternity Hospital, Faisalabad, from June to December 2023. A total of 160 pregnant women aged 20–35 years with singleton pregnancies of ≥24 weeks, meeting sonographic criteria for asymmetrical IUGR, were enrolled through non-probability consecutive sampling. All participants underwent Doppler ultrasonography to evaluate umbilical artery waveforms. Based on resistance index (RI), women were categorized as having normal (RI < 0.65) or abnormal (RI > 0.65) Doppler results. Neonatal outcomes including preterm birth, neonatal death, respiratory distress syndrome (RDS), NICU admission, and low APGAR scores at 5 minutes were recorded and analyzed using SPSS version 25, with $p \leq 0.05$ considered significant.

Results: The mean maternal age was 27.75 ± 4.56 years, and the mean gestational age at delivery was 37.06 ± 1.99 weeks. Among 160 neonates, 33 (20.6%) died, 66 (41.3%) developed RDS, 71 (44.4%) required NICU admission, and 116 (72.5%) had low APGAR scores. Abnormal umbilical artery waveforms were observed in 77 (48.1%) infants. A statistically significant association was noted between abnormal Doppler findings and neonatal death, RDS, and NICU admission ($p < 0.05$).

Conclusion: Abnormal umbilical artery waveforms are significantly associated with adverse neonatal outcomes, confirming their prognostic importance in IUGR management. Routine Doppler evaluation should be incorporated into antenatal screening to guide clinical decision-making and improve perinatal outcomes.

Keywords: Apgar Score, Doppler Ultrasonography, Fetal Growth Retardation, Neonatal Mortality, NICU Admission, Pregnancy Complications, Umbilical Arteries.

INTRODUCTION

Intrauterine Growth Restriction (IUGR) refers to a condition in which a fetus fails to achieve its genetically determined growth potential, posing significant risks to perinatal health and survival. Globally, it affects approximately 20.5% of pregnancies, with a notably higher prevalence in low- and middle-income countries where maternal health disparities and limited prenatal care contribute to the burden (1,2). The etiology of IUGR is multifactorial, encompassing maternal, fetal, and placental factors. Maternal hypertension, pre-eclampsia, diabetes mellitus, malnutrition, and substance use are common maternal contributors, whereas placental insufficiency and infections such as hepatitis C, cytomegalovirus (CMV), and syphilis may further compromise fetal growth (3). Clinically, IUGR is diagnosed when the estimated fetal weight falls below the 10th percentile for gestational age on sonographic evaluation. The condition is associated with increased risks of perinatal mortality, neurological impairment, and long-term developmental deficits (4,5). However, it is essential to differentiate constitutionally small but healthy fetuses from those experiencing true growth restriction, as the latter are at significantly higher risk of morbidity and mortality. Identifying fetuses at risk is therefore crucial for appropriate obstetric management and intervention (6,7). Ultrasonography remains the gold standard for evaluating fetal biometry and identifying growth abnormalities. In addition to standard biometric measurements, Doppler ultrasonography of the umbilical artery has become a vital diagnostic adjunct for assessing placental function and fetal well-being. Umbilical artery Doppler measures the blood flow velocity waveforms, providing insight into placental resistance and oxygen exchange. Abnormal Doppler indices, particularly elevated resistance index (RI) or absent/reversed end-diastolic flow, indicate placental insufficiency and are strongly correlated with adverse perinatal outcomes (8-10).

Infants with IUGR face an increased risk of perinatal complications, including asphyxia, intraventricular hemorrhage, necrotizing enterocolitis, sepsis, and metabolic disturbances such as hypoglycemia and hypothermia. Early detection through routine Doppler evaluation allows for timely obstetric intervention, optimizing delivery timing and improving neonatal survival and health outcomes (11,12). Given the rising incidence of IUGR and its contribution to perinatal morbidity, the present study aims to evaluate the role of umbilical artery Doppler ultrasonography in the early detection and management of asymmetrical IUGR. The study seeks to determine the frequency of neonatal outcomes in pregnancies complicated by asymmetrical IUGR with normal and abnormal umbilical artery waveforms. The objective is rationalized by the need to establish Doppler ultrasonography as a reliable, noninvasive tool for identifying high-risk fetuses and improving perinatal outcomes through timely intervention.

METHODS

Following approval from the Institutional Ethical Review Committee, this cross-sectional study was conducted at the Department of Obstetrics and Gynecology, Hilal-e-Ahmar Maternity Hospital, Faisalabad, between June and December 2023. The calculated sample size was 160, based on a reported neonatal death proportion of 8.8%, with an absolute precision of 4.4% and a 95% confidence interval (3). Participants were selected using a non-probability consecutive sampling technique after obtaining informed written consent from all eligible women. Females aged between 20 and 35 years with singleton pregnancies of 24 weeks or more were included if their fundal height measured less than 3 cm below gestational dates and if serial ultrasound scans revealed a growth discrepancy of ≥3 weeks between fetal biometry and last menstrual period, consistent with intrauterine growth restriction (IUGR). Asymmetrical IUGR was defined as an abdominal circumference below the 5th centile and an estimated fetal weight also below the 5th centile for the corresponding gestational age. Exclusion criteria included pregnancies complicated by congenital fetal anomalies, gestational diabetes mellitus, Rh incompatibility, multiple gestations, and chronic hypertension. These exclusion parameters were applied to minimize confounding factors that might independently influence fetal growth or neonatal outcomes.

All participants underwent Doppler ultrasonography of the umbilical artery performed by an experienced sonologist using standardized technique. The resistance index (RI) was calculated using the formula: RI = (peak systolic velocity – end-diastolic velocity) / peak systolic velocity. Based on Doppler findings, participants were categorized into two groups: one with normal umbilical artery waveforms (RI < 0.65) and the other with abnormal umbilical artery waveforms (RI > 0.65). The selected cut-off value for abnormal RI (>0.65) is consistent with established thresholds for identifying increased placental resistance but may vary slightly across populations depending on gestational age; therefore, adjustment for gestational age could have enhanced diagnostic precision (note on possible methodological

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limitation). All women were followed until delivery through regular antenatal visits and telephonic contact. Neonatal outcomes were documented using a structured proforma and included preterm birth (delivery before 37 completed weeks of gestation), perinatal death, respiratory distress syndrome (RDS), neonatal intensive care unit (NICU) admission, and low Apgar score at 5 minutes (<7). RDS was defined by the presence of clinical signs such as tachypnea shortly after birth, expiratory grunting, nasal flaring, cyanosis of lips or extremities, and intercostal or subcostal retractions. Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. Descriptive statistics were used to summarize demographic and clinical characteristics. The Chi-square test was applied to compare neonatal outcomes (preterm birth, death, RDS, NICU admission, and low Apgar score) between the two groups. A p-value ≤0.05 was considered statistically significant.

RESULTS

A total of 160 females were enrolled in the study, with a mean maternal age of 27.75 ± 4.56 years. The mean gestational age at enrollment was 27.97 ± 2.60 weeks, and the mean gestational age at delivery was 37.06 ± 1.99 weeks. Among the participants, 22 (13.8%) were primigravida, 40 (25%) were primiparous, 69 (43.1%) had a parity of two, and 29 (18.1%) had a parity of three. All infants in the study were delivered preterm. Regarding neonatal outcomes, 33 (20.6%) infants experienced neonatal death, 66 (41.3%) developed respiratory distress syndrome (RDS), 71 (44.4%) required admission to the neonatal intensive care unit (NICU), and 116 (72.5%) had a low APGAR score at 5 minutes. Umbilical artery Doppler assessment revealed abnormal waveforms in 77 (48.1%) fetuses, while 83 (51.9%) showed normal patterns. Abnormal umbilical artery (UA) waveforms were slightly more prevalent among mothers aged ≤30 years (51 cases, 51%) compared to those >30 years (25 cases, 43.1%) ($p = 0.338$). Among nulliparous and primiparous women, 29 (46.8%) fetuses had abnormal UA waveforms, whereas 48 (49%) of multiparous women showed similar findings ($p = 0.786$). A strong association was observed between abnormal UA waveforms and adverse neonatal outcomes. Abnormal UA flow was detected in 29 (87.9%) of the 33 neonates who died, compared to 48 (37.8%) among survivors ($p < 0.001$). Similarly, 54 (81.8%) infants with RDS had abnormal UA patterns compared to 23 (24.5%) without RDS ($p < 0.001$). In the case of NICU admissions, abnormal UA waveforms were noted in 28 (39.4%) infants compared to 49 (55.1%) in non-admitted infants ($p = 0.049$). Low APGAR scores were also more frequent among those with abnormal UA waveforms (61 cases, 52.6%) than those with normal scores (16 cases, 36.4%) though this difference was not statistically significant ($p = 0.067$).

Further subgroup analysis revealed variations in neonatal outcomes across different parity groups and gestational ages at delivery. Neonatal mortality and morbidity appeared to be influenced by parity status, with primigravida and primiparous women showing slightly higher adverse outcomes compared to multiparous participants. Among primigravida mothers, neonatal death occurred in 6 (27.3%) infants, respiratory distress syndrome (RDS) in 10 (45.5%), and NICU admission in 11 (50%), whereas multiparous mothers (parity two or three) had comparatively lower rates of neonatal death 27 (18.6%), RDS 56 (38.6%), and NICU admission 60 (41.4%). Although not statistically significant, these trends indicate that nulliparity and primiparity may be associated with higher perinatal complications, possibly due to less adaptive uteroplacental circulation during first pregnancies. When evaluating the influence of gestational age at delivery, neonates delivered before 36 weeks experienced markedly worse outcomes compared to those born at or beyond 36 weeks. Preterm neonates (<36 weeks) accounted for 20 (60.6%) of total deaths and 41 (62.1%) of RDS cases, whereas those delivered at ≥36 weeks had lower mortality and morbidity rates (13 deaths, 25 RDS cases). These findings suggest that earlier gestational age at delivery substantially increases the risk of perinatal complications among IUGR pregnancies.

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Table 1: demographic details and neonatal outcomes (n = 160)

Parameters		Frequency (%)
Age (years)		27.75 ± 4.56
Gestational age at baseline		27.97 ± 2.60
Gestational age at delivery		37.06 ± 199
Parity	Primigravida	22 (13.8%)
	Primiparous	40 (25.0%)
	Parity Two	69 (43.1%)
	Parity Three	29 (18.1%)
Preterm Birth		160 (100%)
Neonatal Death		33 (20.6%)
Respiratory distress syndrome		66 (41.3%)
NICU admission required		71 (44.4%)
Low APGAR		116 (72.5%)

Table 2: Comparison of umbilical artery waveform between age groups, parity and neonatal outcomes

	Umbilical artery waveform		Total	p-value
	Normal	Abnormal		
Neonatal Death	4(12.1%)	29(87.9%)	33(100%)	<0.001*
RDS	12(18.2%)	54(81.8%)	66(100%)	<0.001*
NICU Admission	43(60.6%)	28(39.4%)	71(100%)	0.049*
Low APGAR	55(47.4%)	61(52.6%)	116(100%)	0.067 NS

Table 3: Relationship of Parity and Gestational Age with Neonatal Outcomes (n = 160)

Parameter	**Subgroup**	**Neonatal Death n (%)**	**RDS n (%)**	**NICU Admission n (%)**	**Low APGAR n (%)**
Parity	Primigravida (n=22)	6 (27.3%)	10 (45.5%)	11 (50.0%)	17 (77.3%)
	Primiparous (n=40)	7 (17.5%)	15 (37.5%)	17 (42.5%)	28 (70.0%)
	Parity Two (n=69)	13 (18.8%)	27 (39.1%)	30 (43.5%)	49 (71.0%)
	Parity Three (n=29)	7 (24.1%)	14 (48.3%)	13 (44.8%)	22 (75.9%)
Gestational Age at Delivery	<36 weeks (n=66)	20 (30.3%)	41 (62.1%)	36 (54.5%)	53 (80.3%)
	≥36 weeks (n=94)	13 (13.8%)	25 (26.6%)	35 (37.2%)	63 (67.0%)

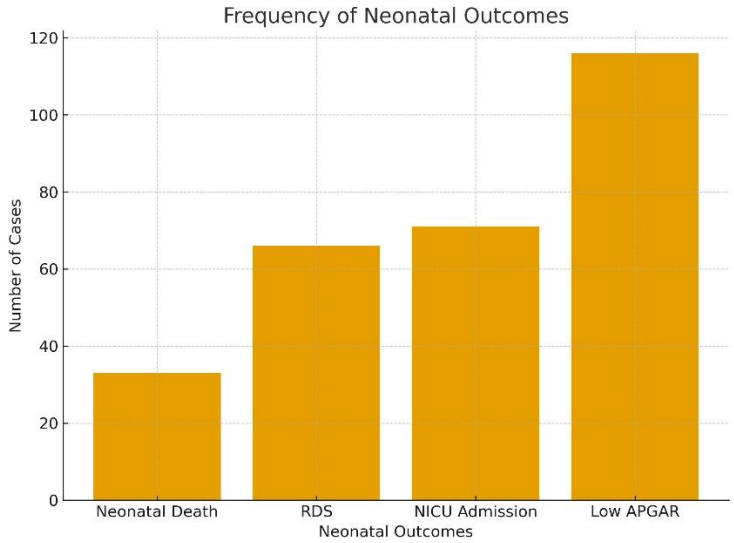

Figure 2 Frequency of Neonatal Outcomes

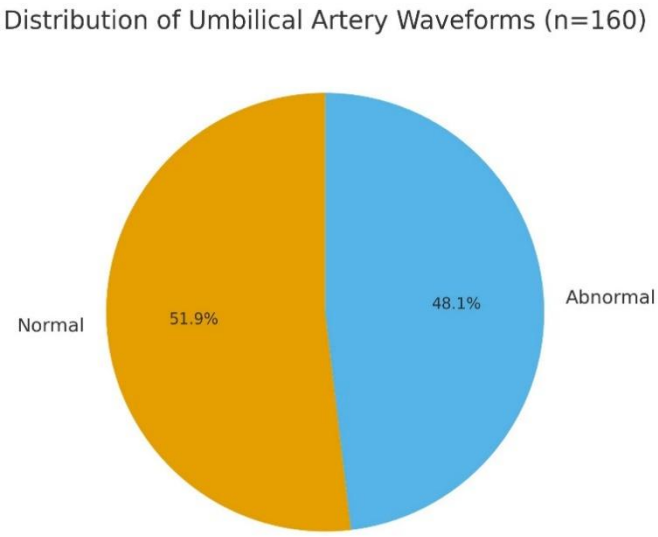

Figure 2 Distribution of Umbilical Artery Waveforms (n=160)

DISCUSSION

The present study evaluated the role of umbilical artery Doppler ultrasonography in predicting adverse neonatal outcomes among pregnancies complicated by intrauterine growth restriction (IUGR). The findings demonstrated that nearly half of the fetuses (48.1%) exhibited abnormal umbilical artery (UA) waveforms, and this abnormality was significantly associated with adverse outcomes, including neonatal death, respiratory distress syndrome (RDS), and the need for neonatal intensive care unit (NICU) admission. These results emphasize the diagnostic and prognostic importance of UA Doppler assessment in detecting placental insufficiency and guiding timely clinical intervention in IUGR pregnancies. IUGR remains a critical obstetric challenge, particularly in differentiating growth-restricted fetuses from those that are constitutionally small but healthy. While small-for-gestational-age (SGA) fetuses generally have a favorable prognosis, those with true growth restriction are at an increased risk of perinatal morbidity and mortality (13,14). Functional assessment through Doppler ultrasonography offers a dynamic evaluation of placental perfusion and fetal adaptation, complementing conventional biometric measurements that may lag behind the onset of placental dysfunction (15-17). In this study, abnormal Doppler indices corresponded with a significantly higher rate of neonatal mortality (87.9%), RDS (81.8%), and NICU admissions (39.4%) compared to those with normal Doppler findings, aligning with global evidence that impaired UA flow strongly predicts poor perinatal outcomes.

Previous research supports these findings by demonstrating that pregnancies with abnormal UA Doppler indices are delivered earlier, have lower birth weights, and are more likely to require intensive neonatal support. One study reported that pregnancies with aberrant Doppler findings were delivered at a mean gestational age of 33 ± 2.9 weeks compared to 36 ± 2.0 weeks in those with normal waveforms, with significantly lower APGAR scores and birth weights (18). Another investigation revealed that the incidence of neonatal death, RDS, and NICU admission in IUGR infants with abnormal resistance indices (RI) was notably higher than in those with normal RI (3). Similarly, evidence from research evaluating the predictive value of UA Doppler waveforms has shown sensitivity and specificity rates of 78% and 83%, respectively, for detecting small-for-gestational-age fetuses, with increased predictive accuracy in hypertensive pregnancies (19). The present findings also align with studies that emphasize the importance of gestational timing in the manifestation and prognosis of IUGR. Early-onset IUGR, often associated with preeclampsia and marked placental insufficiency, tends to be more severe and challenging to manage, whereas late-onset IUGR may go undetected until late in pregnancy but carries a lower mortality risk (20,21). The identification of abnormal UA Doppler patterns in nearly half of the present cohort highlights the potential of routine Doppler screening in pregnancies at risk of placental dysfunction. Early detection enables obstetricians to closely monitor fetal well-being, optimize delivery timing, and reduce perinatal complications through timely intervention. The results further demonstrated that all neonates in the present study were born preterm, underscoring the strong relationship between IUGR and premature delivery. This association likely reflects the decision to induce early delivery in cases with evidence of placental insufficiency to prevent intrauterine

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demise. The high rates of low APGAR scores (72.5%) and RDS (41.3%) observed reinforce the importance of vigilant intrapartum monitoring and postnatal support for growth-restricted neonates (22). The comparison between normal and abnormal UA Doppler groups revealed significant differences in mortality and morbidity outcomes, strengthening the argument for incorporating Doppler studies into routine antenatal surveillance of high-risk pregnancies.

The strengths of this study lie in its well-defined inclusion criteria, standardized Doppler assessment, and consistent follow-up of neonatal outcomes until delivery. The use of objective parameters such as resistance index (RI) allowed for a clear distinction between normal and abnormal umbilical flow patterns. However, several limitations should be acknowledged. The study utilized a fixed RI threshold (>0.65) without adjustment for gestational age, which could lead to over- or under-classification of Doppler abnormalities in some cases. The absence of serial Doppler follow-up limited the ability to observe progressive vascular changes. Furthermore, factors such as maternal comorbidities, nutritional status, and socioeconomic influences were not included in the analysis, which might have affected neonatal outcomes. Future research should incorporate longitudinal Doppler monitoring across gestational stages and combine functional Doppler findings with biochemical markers of placental health to enhance predictive accuracy. Expanding the study to include multiple centers and larger sample sizes would also strengthen the generalizability of results. Advanced fetal assessments such as cerebroplacental ratio, ductus venosus waveform analysis, and biophysical profiling could further refine risk stratification. In conclusion, this study reinforces the critical role of umbilical artery Doppler ultrasonography as a noninvasive, reliable, and functional tool in identifying fetuses at risk of adverse outcomes due to IUGR. The strong association between abnormal Doppler indices and neonatal mortality, RDS, and NICU admission underscores its clinical utility in optimizing obstetric management and improving perinatal survival.

CONCLUSION

This study concludes that abnormal umbilical artery Doppler waveforms serve as a significant indicator of adverse neonatal outcomes, particularly mortality, respiratory distress syndrome, and the need for intensive neonatal care. The findings underscore the crucial role of Doppler ultrasonography as a noninvasive and reliable tool for assessing placental function and identifying fetuses at risk of intrauterine growth restriction–related complications. Incorporating routine umbilical artery Doppler evaluation into antenatal care can enable early detection, timely clinical intervention, and improved perinatal outcomes, ultimately contributing to safer pregnancy management and enhanced neonatal survival.

AUTHOR CONTRIBUTION

Author	Contribution
Nazish Nisar*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Tehseen Aslam	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published

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