Perinatal Outcome of Growth Restricted Fetuses with Abnormal Umbilical Artery Doppler waveform compared to Growth Restricted Fetuses with Normal Umbilical Artery Doppler Wave forms at a tertiary referral hospital in urban Ethiopia

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Abstract

Background: Intrauterine growth restriction is defined as a fetal weight below the 10th percentile for a given gestational age and can be identified using umbilical artery doppler velocimetry which is a non-invasive technique. The objective of this study was to determine the perinatal outcome of growth-restricted fetuses with abnormal umbilical artery doppler study compared to those with normal umbilical artery Doppler waveforms at a tertiary referral hospital in Ethiopia.

Methods: A comparative prospective cohort study was conducted among pregnant mothers complicated with intrauterine growth restriction (IUGR) admitted to labor and delivery room for pregnancy termination during from September 2018-February 2019. Two midwives collected the data using a structured and pretested questionnaire. The data were entered and analyzed using SPSS version 23. After conducting descriptive analysis, exploring the entire data and checking for, statistical associations between abnormal umbilical artery doppler and outcome variables, binary logistic regression was conducted to control for confounders.

Results: A total of 170 pregnant mothers complicated with growth-restricted fetuses were included in the study, among which 133 were with normal umbilical artery doppler studies and 37 were with abnormal umbilical artery doppler studies. On the 7th neonatal day, 129(97%) of normal and 29(78.4%) of abnormal umbilical artery doppler were alive whereas 4(3%) of normal and 9(24.3%) of abnormal umbilical artery Doppler studies ended in early neonatal death. Twenty (15%) of normal and 24(64.9%) of abnormal umbilical artery doppler study neonates required neonatal intensive care admission. Growth restricted fetuses complicated with abnormal doppler were two times more likely to require neonatal intensive care unit admissions compared to growth-restricted fetuses with normal umbilical artery doppler flow, P-value 0.002, (OR=2.059,95%CI 1.449-2.926). Growth restricted fetuses complicated with abnormal doppler were four times more likely to end in early neonatal death compared to growth-restricted fetuses with normal umbilical artery doppler flow, P-value 0.001, (OR=4.136, 95%CI 3.423-4.998).

Conclusion: The abnormal umbilical artery doppler waveform is associated with cesarean section delivery, neonatal intensive care unit admission, respiratory distress syndrome, neonatal sepsis, neonatal hyperbilirubinemia and early neonatal death. Growth restricted fetus with abnormal umbilical artery born at gestational age less than 34 weeks were more likely to require NICU admission, develop respiratory distress syndrome and end in early neonatal death. Growth restricted fetuses complicated with abnormal umbilical artery doppler waveform should undergo umbilical vein and ductus venous doppler studies to prevent preterm delivery based on umbilical artery doppler study finding alone.

Background

Intrauterine growth restriction (IUGR) is defined as a fetal weight below the 10th percentile for a given gestational age. About half of preterm births stillbirths and a quarter of term stillbirths are growth

restricted. IUGR fetuses are frequently described as symmetric or asymmetric in terms of their body proportion. Symmetrically small fetuses are usually associated with factors that directly impair the intrauterine growth potential of the fetus (for example, Chromosomal abnormalities, viral infections, etc.) while asymmetric growth restriction is classically associated with uteroplacental insufficiency. The most common cause of uteroplacental insufficiency is pregnancy-induced hypertension(1-3).

The preferred examination for the diagnosis of IUGR is the ultrasonography examination. These include greyscale assessment of parameters of fetal biometry and doppler study of the artery and vein. The sonographic biometric criteria for diagnosing IUGR include a high ratio of femoral length (FL) to abdominal circumference, (AC), a high ratio of head circumference (HC) to AC, and small abdominal circumference (less than 95th centile) with unexplained oligohydramnios. The AC measurement is the best single measurement to assess fetal growth because, in growth curtailment, the liver is virtually always affected (2, 4).

Doppler ultrasound in IUGR fetuses is used for diagnosis and in-utero monitoring of the progression of the disease(3). Doppler study in IUGR is important to identify early changes in the fetoplacental or uteroplacental circulation of growth-restricted fetuses. The commonly studied and used vessels are umbilical artery(UA) and vein(UV) followed by the middle cerebral artery(MCA). The systolic/diastolic (S/D) ratio, the resistance index (RI), and the pulsatility index (PI) are the three Doppler indices most widely used to analyze arterial blood flow resistance and diagnose IUGR. An S/D ratio is the most important among these and an S/D ratio of greater than 3 after 30 weeks of gestation is abnormal. Decreased fetal weight with decreased amniotic fluid volume and presence of maternal hypertension are good predictors of IUGR (2, 4, 5).

Perinatal mortality rates in growth-restricted neonates are 6 to 10 times that of those with normal growth; perinatal mortality rates as high as 120 per 1000 for all cases of IUGR have been reported. In survivors, the incidence of intrapartum asphyxia may be as high as 50% (2). Many studies reported that respiratory distress syndrome(RDS), Necrotizing enterocolitis (NEC), Intraventricular hemorrhage (IVH), clotting disorders, and multi-organ failure are significantly more likely to occur in growth-restricted neonates. High perinatal mortality has been reported in association with absent and reversed end-diastolic flow velocities in the umbilical arteries (1-3, 6-11).

The high perinatal morbidity and mortality associated with growth-restricted fetuses mandate monitoring and evaluation using different parameters. Appropriate prenatal identification and management are very important to prevent some perinatal complications that lead to adverse outcomes in growth-restricted fetuses. It has been reported that UA Doppler significantly reduces perinatal mortality and iatrogenic premature interventions by differentiating pathologic growth restriction from constitutionally small fetuses. A metanalysis of randomized controlled studies has shown that UA Doppler in combination with standard antepartum testing, was associated with a decrease of up to 38% in perinatal mortality (12).

Saint pau's Hospital Millennium Medical College(SPHMMC) is a tertiary hospital in which almost all growth-restricted fetuses are being diagnosed and monitored using the umbilical artery(UA) Doppler flow study. However, there is limited information regarding the role of UA Doppler study and the impact of abnormal UA Doppler studies on perinatal outcomes of IUGR fetuses in Ethiopia. The aim of the study is, therefore, to determine the perinatal outcome of growth-restricted fetuses with abnormal umbilical artery Doppler waveforms compared to normal umbilical artery Doppler waveforms at Saint Paul's Hospital Millennium Medical College.

Methods And Materials

Study area, period and design.

The study was conducted at Saint Paul's Hospital Millennium Medical College(SPHMMC), Addis Ababa, Ethiopia from September 2018-February 2019. SPHMMC is a tertiary teaching referral hospital under Federal Ministry of Health (FMOH). According to the statistics office of the hospital, nearly 50,000 attended antenatal care and around 10,000 deliveries were attended in 2018,35 % of deliveries being by cesarean section. In this hospital OBGYN specialists and 3rd and 4th year, OBGYN residents perform ultrasound including UA Doppler for diagnosis and monitoring of IUGR fetuses. This was a hospital-based comparative prospective cohort study to determine the perinatal outcome of growth-restricted fetuses with abnormal umbilical artery Doppler waveforms compared to growth-restricted fetuses with normal umbilical artery Doppler waveforms among pregnant mothers complicated with IUGR and admitted to labor and delivery room for pregnancy termination during the study period.

Inclusion criteria considered for the study were: singleton intrauterine pregnancy having Antenatal care (ANC) follow up, delivery and neonatal care at SPHMMC whose gestational age was $\geq$28 completed weeks by reliable last normal menstrual period (LNMP) or by early ultrasound of less than 24 weeks, diagnosed to have IUGR by ultrasound with UA Doppler study done by OBGYN specialists, and/or 3rd and 4th-year OBGYN residents. Patients with lethal congenital anomalies, Intrauterine fetal death before having Doppler studies and unknown last normal menstrual period and no ultrasound before 24 weeks were excluded.

Sample size and sampling procedure.

The sample size was calculated with using info stat calc version 7, for cohort study. Pregnant mothers complicated with IUGR which had abnormal UA Doppler studies were labeled as an exposed group, and pregnant mothers complicated with IUGR which had normal UA Doppler studies were labeled as a non-exposed group. Considering perinatal mortality of 28% in the exposed group and 6% in non-exposed groups(10), using the power of 80% and confidence interval (CI) of 95%, the calculated sample size was 150, adding a 10% loss to follow up gave a total sample size of 170. The ratio of non-exposed to exposed was taken as 3.6:1. So 37 cases of the exposed group and 133 cases of the non-exposed group were collected consecutively for comparison for six months.

Study variables: -

Exposure variable.

Abnormal umbilical artery doppler waveform.

Confounding variables.

Confounding variables considered were: Age, place of residence, level of education, occupation, marital status, parity, gestational age, mode of delivery and hypertension

Outcome variables.

Perinatal outcomes (prematurity, Birth weight, APGAR score, the need for resuscitation, NICU admission, RDS, neonatal sepsis, perinatal mortality).

Operational definitions.

Normal UA Doppler waveform: Normal Doppler indices (between 10th and 95th centile) and positive end-diastolic velocities.

Abnormal UA Doppler waveform: Raised (above 95th centile) indices (S/D ratio, RI, and or PI) or absent or reversed UA doppler flow.

Prematurity: delivery after 28 weeks but before 37 weeks of gestational age.

Non-Reassuring Fetal Heart Rate Pattern (NRFHRP): abnormal fetal heart rate is considered as a non-reassuring fetal heart rate pattern in this study.

Low 5th Apgar score: 5th minute Apgar score of < 7.

Neonatal Intensive Care Unit(NICU) admission: those neonates admitted to NICU.

Respiratory Distress Syndrome(RDS): also known as hyaline membrane disease (HMD), is a respiratory disorder of premature babies, in this study is a clinical diagnosis considered by the neonatal care team.

Neonatal sepsis: is a type of neonatal infection and the diagnosis of which is considered by the neonatal care team clinically or confirmed microbiologically as the presence of bacterial bloodstream infections such as meningitis, pneumonia, urinary tract infection, or gastroenteritis, in the setting of fever.

Perinatal mortality: in this study its intrapartum fetal death plus the death of neonates in the first seven days (early neonatal deaths) per 1000 live Birth.

Intrauterine growth restriction: birth weight below the 10th percentile for a given gestational age.

Data collection procedure and instrument.

A structured and pretested English questionnaire were used to assess sociodemographic characteristics, obstetric factors, umbilical artery Doppler waveforms, and the neonatal outcomes Two trained midwives working at labor and delivery room collected data by interviewing the mother and reviewing the maternal and neonatal chart. The phone number of mothers and their card numbers were recorded for the latter tracing of neonatal outcomes.

Data collection was started at the time the women were admitted to the labor and delivery room and were continued through the intrapartum course until delivery. The neonates who were not referred to Neonatal Intensive Care Unit (NICU) were followed until mothers discharged and those neonates which were referred to NICU were followed in the NICU. The status of all neonates was checked at the seventh neonatal day. Those admitted to NICU were checked at NICU for the outcome and all those discharged home before the 7th day was checked during follow up visits. Those who didn't appear on follow up were reminded by cell phone call. Principal investigator supervised data collection and checked for completeness, accuracy, and consistency of all questionnaires.

Data processing and analysis.

Data cleaning was performed to check for outliers, missed values, and any inconsistencies before the data were analyzed using the software. Data were entered and analyzed using SPSS version 23. A chi-square test was used to check statistical associations between abnormal UA Doppler and outcome variables and covariates. Outcome variables with P value less than 0.05 were selected, and cross-tabulation was done to determine the strength and direction of the association between abnormal UA Doppler and each outcome variable. All covariates with P value less than 0.05 (covariates associated with exposure variable) were selected for binary logistic regression to determine their association with each outcome variable. Statistical significance of the association between exposure and outcome variables were determined by a 95% confidence interval and p-value set at 0.05. Adjusted Odds Ratio (OR) was used to determine the strength and direction of the association between exposure and outcome variables.

Ethical consideration.

Ethical approval was obtained from Saint Paul's Hospital Millennium Medical College ethical review committee. Written informed consent to conduct the study and publish the outcome was obtained from each patient and confidentiality was maintained during data collection, analysis, and interpretation. All the datasets used and/or analyzed during the current study are included in the manuscript and available from the corresponding author on reasonable request.

Results

Maternal socio-demographic characteristics of the study participants.

A total of 170 pregnant mothers complicated with IUGR were included in the study, among which 133 were with normal UA Doppler studies and 37 were with abnormal UA Doppler studies. From abnormal UA Doppler studies, 14 of them are AED, and or REDF while 23 of them were affected doppler indices (raised indices). About 64(48.1%) of patients in the normal UA doppler were in the age group of 20-25 compared to 9(24.3%) of abnormal UA doppler in the group. About 130(97.7%) of patients in the normal UA doppler were married compared to 35(94.6%) of the abnormal UA Doppler. There is no statistically significant difference in socio-demographic characteristics in terms of maternal age, ethnicity, religion, level of education, occupation, marital status and place of residence (Table 1).

Table 1: Socio-demographic characteristics of mothers complicated with IUGR at SPHMMC, Addis Ababa, Ethiopia from September 2018-February 2019 (n= 133 for normal UA Doppler group, n=37 for abnormal UA Doppler group).

Variable	Category	Normal UA Doppler, N (%)	Abnormal UA Doppler, N (%)	Chi-square (p-value)
Maternal age	<20	2(1.5)	2(5.4)	2.802(0.241)
	20-25	64(48.1)	9(24.3)	
	26-30	30(22.6)	13(35.1)	
	31-35	19(14.3)	9(24.3)	
	>35	9(6.8)	1(2.7)	
Ethnicity	Oromo	56(42.1)	11(29.7)	0.281(0.962)
	Amhara	34(25.6)	12(32.4)	
	Tigre	3(0.2)	4(10.8)	
	Gurage	32(24.1)	8(21.6)	
	Others	8(6)	2(5.4)	
Religion	Orthodox	69(51.9)	23(62.2)	6.405(0.063)
	Muslim	34(25.6)	9(24.3)	
	Protestant	30(22.6)	5(13.5)	
Level of education	Illiterate	9(6.8)	3(8.1)	2.065(0.721)
	Elementary	49(36.8)	15(40.5)	
	High school	59(44.4)	13(35.1)	
	College/university.	16(12)	6(16.2)	
Occupation	Housewife	92(69.2)	26(70.3)	4.663(0.193)
	Government employee	14(10.5)	5(13.5)	
	Private employee	16(12)	6(16.2)	
	Merchant	6(4.5)	0	
	Daily laborer	4(3)	0	
	Student.	1(0.8)	0	

Marital status	Married.	130(97.7)	35(94.6)	3.402(0.431)
	Single.	2(1.5)	0	
	Divorced.	0	1(2.7)	
	Widowed.	1(0.8)	1(2.7)	
Place of residence.	Rural	11(8.3)	4(10.8)	1.281(0.762)
	Urban	122(91.7)	33(89.2)	

Maternal reproductive and obstetric characteristics of the study participants.

About 37(27.8%) of participants with normal UA doppler were para I compared to 10(27%) of those with abnormal UA Doppler but the difference is not statistically significant. The two groups were statistically different in terms of gestational age, mode of delivery, indications for cesarean section and hypertension. About 26(70.3%) of abnormal UA Doppler patients gave birth by cesarean section compared to 43(32.3%) of patients in the normal UA Doppler. In the abnormal UA group around 11(29.7%) of the cesarean section were done for absent and or reversed end-diastolic velocity (AEDV/REDV), while 8(21.6%) of them were done for NRFHR compared to 24(18.02%) of cesarean section for NRFHR in those with normal UA. Eleven (29.7%) of the abnormal UA group had hypertension compared to 15(11.3%) of IUGR with normal UA Doppler (Table 2).

Table 2: -Maternal reproductive and obstetric characteristics of the pregnant mothers complicated with IUGR with normal and abnormal Doppler studies at SPHMMC, Addis Ababa, Ethiopia from September 2018-February 2019.

Variable	Category	Normal UA Doppler, N (%) N (%)	Abnormal UA Doppler, N (%) N (%)	Chi-square (P-value)
Parity.	I	37(27.8)	10(27.0)	2.870(0.238)
	II	6(4.5)	4(10.8)	
	III	6(4.5)	0	
	IV	2(1.5)	1(2.7)	
	V and above	2(1.5)	0	
Gestational age.	(28-32)	2(1.5)	2(5.4)	7.283(0.007)
	(32-34)	5(3.8)	6(16.2)	
	(34-37)	21(15.8)	10(27.0)	
	37 and above	105(78.9)	19(51.4)	
Mode of delivery.	Vaginal	90(67.7)	11(29.7)	14.682(0.005)
	Cesarean delivery	43(32.3)	26(70.3)	
Indications for cesarean delivery.	NRFHRP	24(18.0)	8(21.6)	4.532(0.023)
	AEDF/REDF	0	11(29.7)	
	Mal-presentation	7(5.3)	0	
	Dystocia.	14(10.5)	5(13.5).	
Hypertension.	No	118(88.7)	26(70.3)	8.237(0.044)
	Yes	15(11.3)	11(29.7)	

Comparison of perinatal outcome of neonates with normal and abnormal UA Doppler waveform.

All the abnormal UA doppler waveform groups were born alive compared to one (0.75) intrapartum (stillbirth) in those with normal UA Doppler, but the result was not statistically different. On the 7th neonatal day, 129(97%) of normal and 29(78.4%) of abnormal UA Doppler were alive whereas 4(3%) of normal and 9(24.3%) of abnormal UA Doppler studies ended in END. Apgar scores of 9(6.8%) of normal and 11(29.7% of abnormal Doppler groups was less than seven. About 22(16.5%) of neonates with normal UA Doppler required resuscitation compared to 25(67.6%) of abnormal UA Doppler neonates. Two (5.4%) neonates with abnormal UA doppler studies developed meconium aspiration syndrome compared to six (4.5%) of normal UA doppler waveforms and the difference is not statistically different with P-value of 0.431.

Twenty (15%) of normal and 24(64.9%) of abnormal UA Doppler study neonates required NICU admission. Fetuses complicated with IUGR with abnormal doppler were two times more likely to require neonatal NICU admissions compared to IUGR fetuses with normal UA Doppler flow, P-value 0.002, (OR=2.059,95%CI 1.449-2.926). Fetuses complicated with IUGR with abnormal doppler were four times more likely to end in END compared to IUGR fetuses with normal UA Doppler flow, P-value 0.001, (OR=4.136, 95%CI 3.423-4.998) (Table 3).

Table 3: Perinatal outcome of fetuses complicated with IUGR with normal and abnormal Doppler studies at SPHMMC, Addis Ababa, Ethiopia from September 2018-February 2019 ((n= 133 for normal UA Doppler group, n=37 for abnormal UA Doppler group).

iable	Normal UA Doppler	Abnormal UA Doppler	Chi square (P-value)	RR (95% CI)
l birth.	1 (0.75%)	0	2.802(0.241)	-
5th minute APGAR score.	11 (8.3%)	11(29.7%)	30.475(0.001)	2.142(1.669-2.748)
ed of resuscitation.	22 (16.5%)	25 (67.6%)	9.782(0.002)	2.350(1.648-3.352)
CU admission.	20 (15%)	24 (64.9%)	9.631(0.002)	2.059(1.449-2.926)
piratory distress syndrome.	17 (12.8%)	19 (51.4%)	8.001(0.005)	2.267(1.539-3.340)
conium aspiration syndrome.	6 (4.5%)	2 (5.4%)	3.402(0.431)	-
onatal sepsis.	12 (9.0%)	9 (24.3%)	17.388(0.001)	2.598(1.972-3.424)
onatal hyperbilirubinemia	2 (1.5%)	2 (5.4%)	22.685(0.001)	2.161(1.660-2.813)
ly neonatal death(END). d(END)	6 (3%)	9 (24.3%)	21.657(0.001)	4.136(3.423-4.998)

Mode of delivery, gestational age and hypertension were associated with abnormal UA Doppler studies (table 2). Multiple logistic regression was done to determine the effect of those independent variables on perinatal outcomes in addition to UA doppler abnormality. Mode of delivery and the presence of hypertension were not associated with any of the perinatal outcomes. Gestational age is associated with NICU admission, respiratory distress syndrome(RDS) and early neonatal death. Neonates born between 28 and 32 weeks of gestational age were two times more likely to be admitted to NICU, four times more likely to have respiratory distress syndrome and three times more likely to end up with END (Table 4).

Table 4: Multiple logistic regression of perinatal outcomes with the mode of delivery, gestational age and hypertension among mothers complicated with IUGR with normal and abnormal Doppler studies at SPHMMC, Addis Ababa, Ethiopia from September 2018-February 2019.

Perinatal outcome.	Independent variable.	P-value.	RR (95% CI)
Low 5th minute Apgar score	Mode of delivery Hypertension Gestational age	0.391 0.815 0.773	2.009(0.409-9.878) 0.865(0.090-52.439) 1.023(0.124-3.336)
Early neonatal death.	Mode of delivery Hypertension Gestational age	0.998 0.496 0.025	2.583(0.007-73941) 3.407(0.100-11.590) 2.103(2,048-9.884)
Neonatal hyperbilirubinemia	Mode of delivery Hypertension Gestational age	0.998 0.998 0.921	7.443(0.704-4.951) 2.2730.412-368.583) 0.000(0.219-16.886)
The need for resuscitation.	Mode of delivery Hypertension Gestational age	0.998 0.998 0.921	0.000(0.257-2.917) 0.000(0.090-32.439) 0.000(0.072-63.987)
Neonatal sepsis.	Mode of delivery Hypertension Gestational age	0.200 0.953 0.430	0.200(0.024-1.683) 0.953(0.140-6.483) 0.430(0.063-4.505)
NICU admission.	Mode of delivery Hypertension Gestational age	0.142 0.225 0.035	4.640(0.597-36.061) 2.509(0.568-11.079) 3.425(1.219-5.886)
Respiratory distress syndrome	Mode of delivery Hypertension Gestational age	0.921 0.773 0.012	3.407(0.100-11.590) 2.059(1.449-2.926) 4.136(3.423-4.998)

Discussion

The present study was conducted to compare perinatal outcomes of IUGR with normal and abnormal UA Doppler waveforms. A total of 170 pregnant mothers having a complicated IUGR were included in the study, among which 133 were with normal UA Doppler studies and 37 were with abnormal UA Doppler studies. The two groups were statistically different in terms of gestational age, mode of delivery, indications for cesarean section and presence of hypertension. In this study, 21.1% of the preterm deliveries had normal UA Doppler studies, whereas 48.6% of the preterm deliveries had abnormal UA Doppler studies. Comparing to the previous study, the percentage of preterm deliveries with normal UA Doppler study was higher (21.1% versus 14%), but the percentage of preterm deliveries with abnormal UA Doppler studies was less (48.6% versus 96%)(7).

About 70.3% of abnormal UA Doppler patients gave birth by cesarean section compared to 32.3% of patients in the normal UA Doppler. Most (29.7%) of the cesarean section in abnormal UA group was done for absent and or reversed end-diastolic velocity (AEDV/REDV), while 21.6% of them were done for NRFHR compared to 18.02% of cesarean section for NRFHR in those with normal UA. About 29.7% of the abnormal UA group had hypertension compared to 11.3% of IUGR with normal UA Doppler.

In the current study newborns with abnormal UA Doppler studies were 2.3 times more likely to develop RDS and require resuscitations respectively compared to those with normal UA Doppler studies. This is comparable with other previous studies(6, 8, 9). Neonates from abnormal UA Doppler studies group were two times more likely to require NICU admission compared to those with normal UA Doppler studies, which is comparable to other study findings(7, 8, 10).

In the current study newborns with abnormal UA Doppler studies were 2,2.5 and 2 times more likely to have low 5th minute APGAR score, neonatal sepsis and neonatal hyperbilirubinemia respectively compared to those with normal UA Doppler studies. This finding is consistent with other similar studies(6-9).

Concerning neonatal mortality in this study, a total of 15(8.8%) neonates died, 24.3% from those with abnormal UA Doppler studies and 4.5% from those with normal UA Doppler studies i.e. neonates from abnormal doppler study were 4 times more likely to end up in END compared to neonates with normal UA Doppler studies. This finding is slightly higher compared to other related studies(7, 9, 10). This might be because of the difference in the level of neonatal care in different countries and institutions as care for preterm babies is poor in our country with high mortality (13-15). There is only one stillbirth from the normal UA Doppler group but there is no stillbirth from abnormal UA group. This difference is not significant and is intrapartum death as patients were recruited in labour which might be related to intrapartum care and the different threshold health professional use for operative intervention for fetuses with normal and abnormal doppler in labour. Mode of delivery and the presence of hypertension were not associated with perinatal outcomes. However, those neonates born at gestational age less than 34 weeks were more likely to require NICU admission, develop respiratory distress syndrome and end in early neonatal death. This is perinatal morbidity and mortality associated with preterm delivery consistent with other study findings(6-9).

The current study has some limitations. The study was limited to short term intrapartum events and neonatal outcomes during the first 7 days of neonatal life. It would have been better if the study was done with antenatal fetal surveillance and looks to outcomes of neonates in the first month of neonatal life.

Conclusions

The abnormal umbilical artery doppler waveform is associated with cesarean section delivery, neonatal intensive care unit admission, respiratory distress syndrome, neonatal sepsis, neonatal hyperbilirubinemia and early neonatal death. Growth restricted fetus with abnormal umbilical artery born at gestational age less than 34 weeks were more likely to require NICU admission, develop respiratory distress syndrome and end in early neonatal death. Growth restricted fetuses complicated with abnormal umbilical artery doppler waveform should undergo umbilical vein and ductus venous doppler studies to prevent preterm delivery based on umbilical artery doppler study finding alone. Further studies to determine long-term outcomes of neonates born with abnormal umbilical artery doppler studies and

perinatal outcome of neonates born with raised doppler indices compared to those with absent or reversed umbilical artery flow is important to stratify management according to the severity of the abnormality.

List Of Abbreviations

AC	Abdominal circumference
AEDF	Absent End Diastolic Flow
ANC	Antenatal Care
FL	Femoral Length
HC	Head Circumference
HMD	Hyaline membrane disease
IUGR	Intra-Uterine Growth Restriction
IVH	Intraventricular hemorrhage
MAS	Meconium aspiration syndrome
MCA	Middle Cerebral Artery
MCH	Maternal and Child Health
NEC	Necrotizing Enterocolitis
NICU	Neonatal Intensive Care Unit
PI	Pulsatility Index
REDF	Reversed End Diastolic Flow
RDS	Respiratory Distress Syndrome
S/D	Systolic diastolic ratio
SGA	Small for Gestational Age
SPHMMC	Saint Paul Hospital Millennium Medical College
SPSS	Statistical Package for Social Sciences
UA	Umbilical Artery

Declarations

Authors contributions.

RA conceived the study, supervised data collection and drafted the manuscript. TW supervised the study and revised statistical analysis. AA, LBT, and GTF revised and edited the manuscript for publication. All authors revised and approved the final manuscript.

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Competing Interests.

The authors declare that they have no competing interests.

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