■ **Original Research Article**

Umbilical Artery Doppler Velocimetry as a Predictor of Perinatal Outcome Among Antenatal Women with High-Risk Pregnancies

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Abstract

Background: Perinatal morbidity is a huge burden globally, with greater impact in the developing countries. Umbilical artery Doppler velocimetry as an antenatal surveillance tool significantly reduces perinatal morbidity and mortality among high-risk pregnancies, especially those complicated with IUGR. **Objective:** To determine the association between abnormal umbilical artery Doppler velocimetry and perinatal outcome in high-risk pregnancies. **Design:** It was a hospital based prospective cohort study. **Methodology:** The study participants were 161 consenting pregnant women with high-risk pregnancies between 28 weeks and 38 weeks of gestation admitted into the antenatal ward of Jos University Teaching Hospital between 1st February, 2021 and 31st January, 2022. Data on socio demographic characteristics, obstetric history, gestational age, LMP, previous history of contraceptive use, irregular menstrual periods, and co-morbidities were obtained. Ultrasound scan was performed using a 3.5MHz convex probe of GE Voluson P8 4D ultrasound machine. The fetal biometric parameters were measured in 2D mode before the Doppler mode was activated for the velocimetry of the umbilical artery. Reduced end diastolic flow was measured as raised pulsatility index (PI) and resistive index (RI) above the 95th percentile. This procedure was repeated two weekly or more frequently depending on the abnormality noted. They were then followed up till delivery to determine the fetal outcome. Analysis was done using SPSS software version 20. **Results:** The prevalence of high-risk pregnancy was 41.2%. Hypertensive disorders accounted for 53.4% (86) of the study participants. Abnormal umbilical artery waveform pattern was found in 17.4%. The prevalence of IUGR among the study population was 14.9% (24). There were 95.7% (154) live births and 7(4.3%) stillbirths. There was statistically significant association between abnormal umbilical artery velocimetry and IUGR, preterm delivery, stillbirth, low birth weight, low APGAR scores at 5th minute and need for SCBU admission. **Conclusion:** Umbilical artery Doppler study is a useful antenatal surveillance tool for women with high-risk pregnancies. It is significantly associated with perinatal outcomes like IUGR, Preterm delivery, stillbirth, low birth weight, low APGAR scores at 5th minute. The poorer the Doppler indices, the worst the perinatal outcome.

Key Words: Umbilical artery, Doppler velocimetry, High-risk pregnancy, Fetal Surveillance

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Introduction

Perinatal morbidity and mortality are a huge burden globally[1]. About two-thirds of the global 2.6 million stillbirths occur mostly in developing countries.[2,3] In Nigeria, a stillbirth rate of 71/ 1000 deliveries was reported in a Maternal and Perinatal Health Survey.[4] High-risk pregnancy accounted for approximately 20% of the global perinatal mortality.[5] In Nigeria, high-risk pregnancies account for about 50% of perinatal mortality.[6] When a pregnancy is complicated by a factor or factors that compromise the outcome of the mother or baby or both is considered high-risk.[7] Hypertensive disorders in pregnancy, which include chronic hypertension, gestational hypertension, preeclampsia and preeclampsia superimposed on chronic hypertension are the major cause of placental insufficiency. Other high-risk conditions include pregestational diabetes, chronic renal disease, sickle cell disease, antiphospholipid syndrome.

Placental insufficiency is the common pathway for most of these high-risk pregnancies.[8] Placental insufficiency cause nutritional and respiratory deficit leading to fetal growth restriction. Early-onset IUGR leads to vascular changes in the fetoplacental unit. The end diastolic flow in the umbilical artery is of clinical importance as it reflects the status of the placental circulation. The end diastolic flow shows continuous increase throughout gestation because of decline in the feto-placental impedance. The decrease in impedance with advancing gestation is a direct result of an increase in the number of tertiary stem villi that takes place with placental maturation.[9,10] High-risk pregnancies affect either the number or obliterate the small muscular arteries in the tertiary stem villi of the placenta leading to increasing resistance. There is an inverse relationship between placental vascular resistance and end-diastolic flow. In other words, the end diastolic flow decrease progressively with increase in placental resistance as a result of the obliteration of these placental tertiary stems villi.[11,12] These Doppler changes begin when villous damage is >30%.[8] and progressively increase to the ominous absent or reversed end diastolic flow when over 70 % of placental tertiary villi are obstructed.[13]

The human fetus is an efficient physiologic oximeter machine. When it encounters unfavourable circumstances as a result of situations like placental insufficiency, it mobilizes a spectrum of adaptive/compensatory responses. With worsening symptoms, the compensatory response gives way to the decompensatory responses. These adaptive responses can be detected by close antenatal fetal surveillance.

Antenatal fetal surveillance remains a major challenge in modern obstetrics. The current clinical standard is the use of biophysical profile (BPP). The BPP is a dynamic test of fetal wellbeing that combines ultrasonographic evaluation and non-stress test (NST) otherwise called antenatal cardiotocograph (CTG). It suffers from important limitations, key of which is waiting for the impact of the insult on the fetus before intervention. In addition, the ultrasound scoring is flawed as it assigns equal scores to parameters of varying significance.[14] Furthermore, when the decrease in fetal activity is acute, amniotic fluid volume may not decrease. Similarly, CTG has a low sensitivity and high specificity. In other words, it is very good at telling which fetuses are well but are poor at identifying which ones are unwell. While a tracing with good variability provides strong reassurance of good fetal oxygenation, abnormal tracings poorly correlate with fetal status and has a high false-positive rate. Again, the loss of fetal heart rate variability in itself, may not necessarily be an ominous observation but normal fetal physiologic adjustments to a number of medications, illicit substances, or simply behavioural state.[2] In addition, CTG has high intra and inter-observer errors. Furthermore, reactivity is not expected in early IUGR (<30 weeks). While 80% of fetuses beyond 32 weeks have a reactive NST, the rate of reactivity is lower in IUGR fetuses since CNS maturation is delayed, but centrally regulated responses to hypoxia remain preserved.[15] Therefore, non-stress testing must be considered a secondary test and should ideally not be used by itself for IUGR monitoring.[14,16] Other subjective fetal surveillance methods still in use in many institutions in developing countries include clinical symphysio-fundal height measurement and fetal heart rate monitoring, Cardiff and Sadovsky fetal kick count which relies on maternal perception of fetal movement, serial measurement of biometric parameters using 2D ultrasound scan.[2]

Current evidences show that umbilical artery Doppler velocimetry is a superior surveillance tool for predicting perinatal outcome in high-risk pregnancies particularly those complicated by fetal growth restriction.[17,18,19,20] It reduces the risk of perinatal death by approximately one third, without increasing interventions such as iatrogenic preterm delivery.[2, 21] In addition, it is the clinical standard for distinguishing between SGA and IUGR, as well as for clinical staging of IUGR.[22] Umbilical artery Doppler (UmAD) velocimetry assessment can be both qualitative and quantitative. Qualitatively, it can be described as reduced end diastolic flow, absent end diastolic flow (AEDF) or reversed end diastolic flow (REDF). Although

there are other quantitative indices, the systolic to diastolic ratio (S/D), resistive index (RI) and pulsatility index (PI) represent those most used. Absent and reversed end diastolic flow (AREDF) which represents an extreme abnormality in waveform, is the only measure that provides both diagnostic and prognostic information for the management of IUGR. While AEDF is associated with an 80-fold increase in perinatal mortality, presence of REDF, has been related to a higher incidence of long-term permanent neurologic damage compared to IUGR fetuses with positive EDF.[23] In the same vein, research shows that in IUGR, the degree of neurodevelopmental abnormality in childhood is proportionally related to the impedance within the umbilical artery Doppler velocimetry.[24] It is worth noting that only in pregnancies with suspected FGR does the use of umbilical artery Doppler sonography reduce the number of perinatal deaths and unnecessary obstetric interventions,[25] as routine use of umbilical artery Doppler in low-risk pregnancies had shown no benefits.[18]

Despite the emerging evidence showing umbilical artery Doppler velocimetry as a superior surveillance tool in reducing perinatal morbidity and mortality in high-risk pregnancies, this benefit is yet to be fully maximized in our environment. This study aims to assess the use of umbilical artery Doppler velocimetry as a predictor of perinatal outcome among antenatal women with high-risk pregnancies in Jos University Teaching Hospital.

Methods and Materials

The study was conducted in the feto-maternal unit of the department of Obstetrics and Gynaecology of Jos University Teaching Hospital over a period of one year from 1st February 2021 to 31st January 2022. It was a hospital based prospective cohort study. The participants were one hundred and sixty-one (161) antenatal women with high-risk pregnancies between 28 weeks and 38 weeks of gestation. Participants who met the inclusion criteria were recruited from either the antenatal clinic or antenatal ward. Inclusion criteria include Pre-existing medical disorders like pre-gestational diabetes, Chronic Hypertension, Renal disease, Sickle cell disease, previous history of IUFD / stillbirth and previous history of recurrent pregnancy losses. Exclusion criteria include women with multiple gestation, congenital anomaly of the fetus, unreliable to follow up, high-risk pregnant women who did not consent for the study. A convenience sampling method was used, an interviewer-administered semi-structured questionnaire was used to obtain data on socio demographic characteristics, obstetric history, gestational age, LMP, previous history of contraceptive use, irregular menstrual periods, and co-morbidities.

Ultrasound scan results were also obtained. The ultrasound scan was done by the investigator using a GE Voluson P8 4D ultrasound machine. A 3.5MHz convex probe was selected for both fetal biometric parameters which were measured in 2D mode before the colour flow mapping was activated to identify the vessel and defining the direction of blood flow followed by the pulse wave Doppler velocimetry of the umbilical artery was performed at the free loop as the site of insonation. The accuracy of Doppler measurements was optimized out according to the International Society of Ultrasound in Obstetrics and Gynaecology (ISUOG) Practice Guidelines: use of Doppler ultrasonography in obstetrics.[26] A minimum of three waveforms in the original upright position were obtained. We ensure correct position by watching the 2D image and listening to the audible representation of the Doppler shift over the loudspeaker. Gain was adjusted to see clearly the Doppler velocity waveform.

Fetuses with EFW below the 10th percentile for their GA were adjudged SGA, while those SGA with abnormal umbilical Doppler in addition were tagged growth restricted (IUGR). Reduced end diastolic flow was measured as raised pulsatility index (PI) and resistive index (PI) above the 95th percentile. This procedure was repeated two weekly or more frequently depending on the abnormality noted. They were then followed up till delivery to determine the fetal outcome. The findings of the Doppler velocimetry were reported to the managing team if any abnormality was detected. Management of those with abnormal velocimetry followed the management protocol of attending Consultants. They were admitted for further evaluation and decision taken on timing and mode of delivery. Termination of the pregnancy was considered in the presence of any of the following: absent or reversal of end diastolic flow in the umbilical artery, non-reassuring test of fetal wellbeing (biophysical profile) and worsening maternal condition. Fetal/neonatal outcomes (gestational age at delivery, birth weight, live birth or stillbirth, Apgar score at 5 minutes, SCBU admission) were assessed after delivery. Analysis of the data was done using SPSS software version 20. Ethical approval was obtained from the ethical committee of the Jos University Teaching Hospital.

Results

A total of 2,506 pregnant women booked for antenatal care at JUTH during the study period out of which 1,032 were high-risk pregnancies giving a 41.2% prevalence for high-risk pregnancies. Table 1 shows the demographic characteristics. The mean age of the participants was 31.6 ± 5.8 years with an age range of 20-45 years. Majority 48(29.8%) were in the age range 35-39 years. Ethnic distribution showed 61(37.9%) of the participants were Hausa while 58(36.0%) were Plateau Indigenous tribes, Yoruba 13 (8.1%) and Igbos 5 (3.1%). The study further revealed that 60(37.3%) of the participants were housewives and 74(46.0%) had tertiary level of education.

Table 1: Maternal Demographic Characteristics (n = 161)

Characteristics	Frequency (f)	Percentage (%)
Maternal age (years)		
20-24	18	11.2
25-29	39	24.2
30-34	44	27.3
35-39	48	29.8
≥ 40	12	7.5
Mean age ±SD	31.6 ± 5.8 years	
Religion		
Christianity	87	54.0
Islam	74	46.0
Ethnicity		
Hausa	61	37.9
Igbo	5	3.1
Yoruba	13	8.1
Plateau Indigenous tribes	58	36.0
Others	24	14.9
Level of Education		
None	1	0.6
Primary	18	11.2
Secondary	68	42.2
Tertiary	74	46.0
Occupation		
Housewife	60	37.3
Business	28	17.4
Professional/Executive	6	3.7
Artisan	23	14.3
Student	14	8.7
Civil servant	16	9.9
Trader	14	8.7

Table 2: Maternal Reproductive History (n = 161)

History	Frequency (f)	Percentage (%)
Gravidity		
Primigravida	28	17.4
Gravida 2-4	74	46.0
Gravida 5 & above	59	36.6
Parity		
Nulliparous	37	23.0
Para 1	30	18.6
Para 2-4	70	43.5
Para 5 & above	24	14.9
Number of Children alive		
0-4	147	91.3
≥ 5	14	8.7
Gestational age at recruitment		
28-34	68	42.2
35-41	93	57.8
Gestational age (weeks) at booking		
< 20	102	63.4
≥ 20	59	36.6

Table 2 shows the maternal reproductive history. Primigravidas were 28(17.4%), while 24(14.9%) were grandmultiparous. The average gravidity in this study was 4.1±2.7 pregnancies and the mean parity was 2.3±2.1 births. Majority of the participants (91.3%) had 0-4 number of living children while only 14(8.7%) had 5 and above living children. All the participants were booked for antenatal care. The average gestational age at booking was 17.4±6.4 weeks with 102(63.4%) booking at gestational age below 20 weeks.

Figure 1 shows the distribution of risk factors. Overall, hypertensive disorder in pregnancy was the commonest risk 86 (53.4%) with Chronic hypertension being 40(24.8%), PIH 28 (17.4%), preeclampsia 13 (8.1%), and chronic hypertension with superimposed pre-eclampsia 5 (3.1%). Previous IUFD was 36(22.4%).
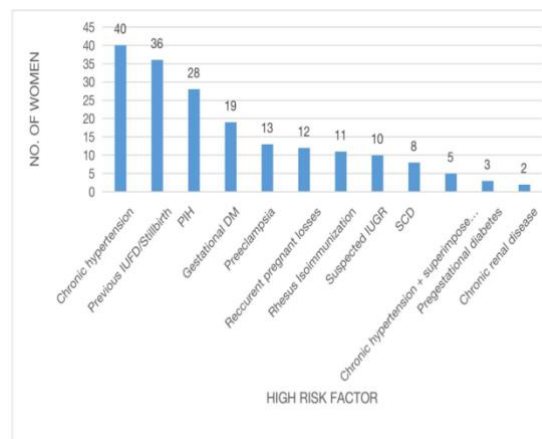

Figure 1: Risk for High-Risk Pregnancy

Table 3 Showing umbilical artery Doppler waveform pattern and indices

Waveform pattern /Indices	f	%
WAVEFORM PATTERN		
Normal pattern	111	68.9
High RI	14	8.7
High PI	11	6.8
AEDF	2	1.2
REDF	1	0.6

The prevalence of IUGR among the study population was 24 (14.9%). Table 3 shows umbilical artery Doppler waveform pattern and indices. Normal umbilical artery waveform pattern was seen in majority 111(68.9%) of the study group. The prevalence of abnormal umbilical artery waveform pattern in this study

group was 17.4 % (n=28). Fourteen (8.7 %), 11 (6.9%), 2 (1.2%) and 1 (0.6%) participant demonstrated high RI, high PI, AEDF and REDF values respectively.

Table 4 shows the association between abnormal umbilical artery velocimetry and maternal/fetal outcome among women with high-risk pregnancy.

Table 4: Association between umbilical artery velocimetry (Doppler indices and waveform pattern) and Maternal/ fetal outcome among the study participants (n= 161).

Variable	Doppler study			χ^2	df	p-value
	Normal F (%)	Abnormal F (%)	Total F (%)			
IUGR						
Yes	7 (29.2)	17 (70.8)	24 (100.0)	51.783	1	<0.0001*
No	126 (92.0)	11 (8.0)	137 (100.0)			
GA at delivery						
< 37 weeks	16 (64.0)	9 (36.0)	25 (100.0)	7.133	1	0.008*
≥ 37 weeks	117 (86.0)	19 (14.0)	136 (100.0)			
Fetal outcome						
Live	131 (85.1)	23 (14.9)	154 (100.0)			
Stillbirth	2 (28.6)	5 (71.4)	7 (100.0)		1	0.002f*
Mode of delivery						
Vaginal	80 (87.0)	12 (13.0)	92 (100.0)	2.825	1	0.093
C-section	53 (76.8)	16 (23.2)	69 (100.0)			
Vaginal						
Spontaneous	60 (88.2)	8 (11.8)	68 (100.0)		1	0.504f
Induce	20 (83.3)	4 (16.7)	24 (100.0)			
Caesarean						
Emergency	34 (72.3)	13 (27.7)	37 (100.0)	1.655	1	0.198
Elective	19 (86.4)	3 (13.6)	22 (100.0)			
Birth weight (kg)						
< 2.5	12 (37.5)	20 (62.5)	32 (100.0)	56.565	1	<0.0001*
≥ 2.5	121 (93.8)	8 (6.2)	129 (100.0)			
APGAR score						
< 7	9 (52.9)	8 (47.1)	17 (100.0)			
≥ 7	124 (86.1)	20 (13.9)	144 (100.0)	11.644	1	0.001*
Sex of baby						
Male	68 (80.0)	17 (20.0)	85 (100)	0.853	1	0.356
Female	65 (85.5)	11 (14.5)	66 (100)			
SCBU admission						
Yes	14 (56.0)	11 (44.0)	25 (100.0)	19.845	1	<0.0001*
No	117 (90.7)	12 (9.3)	129 (100.0)			
Early neonatal death						
Yes	1 (33.3)	2 (66.7)	3 (100.0)		1	0.058f
No	130 (86.1)	21 (13.9)	151 (100.0)			

*Statistically significant   f= Fisher's exact test.

Majority 17(70.8%) of the fetuses with IUGR had abnormal umbilical artery velocimetry compared to 7(29.2%) who had normal umbilical artery velocimetry. This was statistically significant (p ≤ 0.0001). There was also statistically significant association between abnormal umbilical artery velocimetry and gestational age at delivery (p = 0.008), Stillbirth (p = 0.002), birth weight (p ≤ 0.0001), APGAR score at 5th minutes (p = 0.001) and SCBU admission (p ≤ 0.0001). There was however no statistically significant association between abnormal umbilical velocimetry and mode of delivery, sex of baby and early neonatal death.

Table 5 shows the relationship between Doppler Waveform pattern and fetal outcomes. There was statistically significant association between abnormal umbilical artery velocimetry and IUGR, preterm delivery, stillbirth, low birth weight, low APGAR scores at 5th minute and need for SCBU admission.

Table 5: Relationship between Doppler Waveform Pattern and Fetal Outcome

Pregnancy/Fetal Outcome	Doppler Pattern Waveform				χ^2 (f)	p
	Normal F (%)	ReDF F (%)	AEDF F (%)	REDF F (%)		
IUGR					49.707	<0.0001
Yes	8(33.3)	14(58.3)	1(4.2)	1(4.2)		
No	131(95.6)	5(3.6)	1(0.7)	0(0.0)		
Gestational age (weeks) at delivery					13.776	0.001*
< 37	17(12.2)	5(26.3)	2(100.0)	1(100.0)		
≥ 37	122(87.8)	14(73.7)	0(0.0)	0(0.0)		
Mode of Delivery					5.125	0.090
Vaginal	82(59.0)	7(36.8)	2(100.0)	1(100.0)		
Caesarean	57(41.0)	12(63.2)	0(0.0)	0(0.0)		
Vaginal (Spontaneous/ Induced)					3.768	0.272
Spontaneous	62(75.6)	5(71.4)	1(50.0)	0(0.0)		
Induced	20(24.4)	2(8.6)	1(50.0)	1(100.0)		
C/S (Emergency/ Elective)					1.549	0.313
Emergency	37(64.9)	10(83.3)	0(0.0)	0(0.0)		
Elective	20(35.1)	2(16.7)	0(0.0)	0(0.0)		
Fetal Outcome					25.740	<0.000*
Live birth	137(98.6)	17(89.5)	0(0.0)	0(0.0)		
Stillbirth	2(1.4)	2(10.5)	2(100.0)	1(100.0)		
Birth weight (kg)					42.602	0.0001*
< 2.5	15(10.8)	14(73.7)	2(100.0)	1(100.0)		
≥ 2.5	124(89.2)	5(26.3)	0(0.0)	0.(0.0)		
Sex of Baby					3.277	0.304
Male	71(51.1)	13(68.4)	1(50.0)	0(0.0)		
Female	68(48.9)	6(31.6)	1(50.0)	1(100.0)		
APGAR Score at 5th minutes					20.672	0.0001*
< 7	9(6.5)	5(26.3)	2(100.0)	1(100.0)		
≥ 7	130(93.5)	14(73.7)	0(0.0)	0(0.0)		
SCBU Admission					25.490	0.0001*
No	122(89.1)	7(41.2)	0(0.0)	0(0.0)		
Yes	15(10.9)	10(58.8)	0(0.0)	0(0.0)		
Early Neonatal Death					9.641	0.032*
No	136(99.3)	15(88.2)	0(0.0)	0(0.0)		
Yes	1(0.7)	2(11.8)	0(0.0)	0(0.0)		

f = *Fisher's Exact Test*
* = Statistically Significant
ReDF = Reduced End Diastolic Flow (RI and PI), AEDF = Absent End Diastolic Flow, REDF = Reversed End Diastolic Flow

Discussion

The prevalence of high-risk pregnancy in this study was 41.2%. This was like the prevalence of 40.1% found in a study done in Enugu, Nigeria.[6]

It is however higher than the prevalence of 20% found in other studies.[5, 27] The higher prevalence in this study could be because our facility serves as a referral centre. Most of the women in the study belong to the age range 35-39 years which is expected as advanced maternal age (35 years of age and older) is a known risk factor for most of the high-risk factors recruited in this study such as hypertensive disorders in pregnancy, gestational diabetes, recurrent miscarriages and IUGR. Majority of the women with high-risk pregnancy were multigravidas making up to 82.6% of the study population which was similar to study findings of Ahmed et al and Komuhangi et al.[28] Hypertensive disorder in pregnancy was the commonest risk for high-risk pregnancy in this study which is similar to findings in other studies.[29,30] This was not surprising as hypertensive disorders in pregnancy are the most common medical complications encountered in developing world.[29, 31] The prevalence of abnormal umbilical artery velocimetry in this study was 17.4%. The prevalence of 1.8% for AEDF/REDF was similar to the prevalence of 2% for AEDF/REDF reported in a study in India.[32] However, the overall prevalence of abnormal Doppler velocimetry was slightly higher than previous study from Uganda where they reported a prevalence of abnormal flow pattern to be 10.95% with AEDF and REDF reported as 4.2% and 0.6% respectively.**Error! Bookmark not defined.** It was however lower than studies by Suryavanshi et al and Ahmed et al who reported a prevalence of 38.7% and 40% respectively. The difference could be as a result of variations in the defined risk factors for high-risk pregnancy in the various studies.

There was a statistically significant association between abnormal umbilical artery Doppler velocimetry and preterm birth with 9(32.1%) out of 28 women with abnormal Doppler study delivering at gestational age less than 37 weeks compared to 16(12.0%) out of 117 women with normal Doppler findings. This was similar to findings documented in several previous studies.[25, 32] Another significant observation in this study is that perinatal outcome is poorer in cases with abnormal umbilical artery Doppler velocimetry. Out of the 7 total number of stillbirths found in this study, 5(71.4%) had abnormal Doppler study compared to 2(28.6%) with normal Doppler study. Similarly, 71.4% women with abnormal Doppler velocimetry had low birth weight babies (< 2.5kg) compared to 9.0% with normal Doppler study, 28.6% had babies with APGAR scores less than 7 at 5th minute compared to 6.8% with normal Doppler study and 47.8% were admitted in SCBU compared to 10.7% with normal Doppler study. All these were statistically significant and in keeping with findings in similar studies by Alfervic et al, Komuhangi et al and Ahmed et al,.[21, 28, 29] There was however no statistically

significant association between mode of delivery and early neonatal death in this study which is in contrast with the findings in studies by Ahmed et al, Bhattacharjee et al and Suryavanshi among others.[29, 30, 32]

Factors such as extreme prematurity and unavailability of facilities to cater for such fetuses also tends to affect decision making to effect delivery in our environment. In addition, there is no defined protocol in our facility as regards the optimal timing of delivery during the management of such cases prompting the decision to conduct this study.

Absent end diastolic flow (AEDF) and reversed end diastolic flow (REDF) are generally associated with severe IUGR and high incidence of overall perinatal mortality. In this study, absent end diastolic flow was associated with 100% perinatal mortality (IUFD).

A study by Brar et al reported 50% perinatal mortality in fetuses with reverse end diastolic flow REDF.[33] Similarly, Ahmed et al reported a perinatal mortality rate of 40% in same group.[30] This is supported by previous reports which shows that Absent and reversed end diastolic flow (AREDF) which represents an extreme abnormality in waveform are associated with an 80-fold increase in perinatal mortality, and the presence of REDF is associated with a higher incidence of long-term permanent neurologic damage compared to IUGR fetuses with positive EDF.[23] Reduced end diastolic flow (high PI and RI) on the other hand had a better perinatal outcome with stillbirth occurring in only 2(10.5%) of cases. IUGR was however high in this group 14 (73.7%) with APGAR scores less than 7 at 5th minute found in 5(26.3%), 7(58.8%) required SCBU admission and 2(11.7%) had early neonatal death. These findings were comparable to other documented studies.[30, 33] This study was not without its own limitations. This was a single centre prospective study done in Jos University teaching hospital and thus findings may not be generalized to the whole population of women with high-risk pregnancies in Jos or Nigeria. There is need for a larger multicentre study.

Umbilical artery Doppler velocimetry is a useful tool for fetal surveillance. Abnormal umbilical artery Doppler velocimetry is a common finding in women with high-risk pregnancy. AEDF and REDF are associated with 100% perinatal mortality. It's use in high-risk pregnancy particularly those complicated by utero-placental insufficiency will greatly improve obstetric decision making thereby reducing perinatal morbidity and mortality.

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