Original Article

Umbilical Artery Doppler Velocimetry as A Diagnostic Tool for Foetal Growth Restriction Among Women with High-Risk Pregnancy in Jos, North Central Nigeria.

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Abstract

Background: Foetal growth is a common challenge among high-risk pregnancies as a result of placental insufficiency. Current evidence shows that umbilical artery Doppler velocimetry is the clinical standard for distinguish between IUGR and SGA. **Objective**-To determine the prevalence of IUGR among SGA foetuses in women with high-risk pregnancies using umbilical artery Doppler velocimetry. **Design:** It was a hospital based prospective study. **Methods and Materials**: This was a prospective study conducted from 1st February 2021 to 31st January 2022. A total of 161 women with high-risk pregnancies between 28 weeks and 38 weeks of gestation were recruited. A convenience sampling method was used, and interviewer-administered semi-structured questionnaire was administered. Data on socio demographic characteristics, obstetric history, LMP, gestational age, previous history of contraceptive use, irregular menstrual periods, and co-morbidities were obtained. The ultrasound was performed by a single investigator using 3.5MHz convex probe of GE Voluson P8 4D ultrasound machine. The foetal biometric parameters were measured in 2D mode before the Doppler mode was activated for the velocimetry of the umbilical artery. foetuses with EFW below the 10th percentile for their GA were adjudged SGA, while those with abnormal umbilical Doppler in addition were tagged growth restricted (IUGR). The data was analysed using SPSS software version 20. **Results:** The prevalence of SGA and IUGR in this study was 19.9% (32) and 17.4% (28) respectively. All the 28 IUGR foetuses were among SGA foetuses, giving a prevalence of 87.5%. This was statistically significant (p ≤ 0.0001). Majority (69.2%) of the IUGR were among women with pre-eclampsia. This was also statistically significant (p ≤ 0.0001). Majority (89.3%) of the IUGR foetuses had reduced umbilical artery Doppler velocimetry. **Conclusion:** Umbilical artery Doppler is a useful antenatal surveillance tool in women with high-risk pregnancies. Majority of SGA foetuses in women with high-risk pregnancies are growth restricted. Umbilical artery Doppler should be a routine practice in high-risk pregnancies complicated by foetal growth challenges.

Keywords: Umbilical artery Doppler Velocimetry, Foetal surveillance, SGA, IUGR, High-risk pregnancy

INTRODUCTION

High-risk pregnancies account for approximately 20% of the global perinatal mortality.[1] 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.[2] Foetal growth is a common

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challenge among high-risk pregnancies as a result of placental insufficiency. This causes nutritional and respiratory deficits leading to poor growth. SGA and IUGR are often used interchangeably but they are not synonymous. SGA describe fetuses that are constitutionally small for date but are otherwise normal, and often achieve their expected growth potential without any risk of adverse perinatal outcome.[3],[4] The diagnosis of SGA in utero is most often made based on serial biometric measures like the most

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sensitive EFW below the 10th percentile or use of elevated HC/AC which has the highest positive predictive value. This approach is limited by the fact that it may overlook those fetuses with both impaired growth and increased risk of adverse outcome in which their abdominal circumference and EFW remain above the 10th percentile for gestation.[5] On the other hand, intrauterine growth restriction (IUGR) is a pathological condition in which the foetuses failed to achieve their genetic growth potential regardless of foetal size. Fetuses with impaired growth are at an increased risk of adverse outcome despite abdominal circumference and EFW that is above the 10th percentile for gestation.[6]

Research showed that foetal growth restriction accounts for approximately 30% of stillbirths globally.[7] The high frequency of perinatal mortality among IUGR is the result of germinal matrix haemorrhage, cystic periventricular leukomalacia, and neonatal complications including cognitive dysfunction and poorer neurodevelopmental scores associated with poorer school performance as a consequence of premature births and fetal programing that leads to metabolic syndrome later in life.[8]

The primary aim of antepartum surveillance is to assess the risk of foetal death in pregnancies complicated by maternal medical problems or foetal compromise. Research findings showed that better assessment of risk factors and fetal surveillance potentially avoid stillbirth risk and improve fetal outcome through appropriate timely delivery. [3, 6, 9]

In 1997, the American College of Obstetricians and Gynecologists reported that the use of umbilical artery Doppler in conjunction with standard antepartum testing (e.g., NST) reduced mortality.[10] Currently, the use of umbilical artery Doppler velocimetry is the standard for managing high risk pregnancies complicated by pre-eclampsia and IUGR (level A recommendation).[11] In addition, umbilical artery Doppler velocimetry is the clinical standard for both distinguishing between IUGR and SGA as well as for clinical staging of IUGR.[12],[13] The umbilical artery Doppler provides clinical information about the foetal placental unit and its waveforms provide estimates of downstream placental vascular resistance and placental blood flow.[14] Usually, the fetoplacental bed is a low impedance system associated with minimal wave reflection. This is because the umbilical arteries are not innervated beyond the proximal 1-2cms and contains less collagen and elastin than the systemic arteries. This lack of innervations made the umbilical circulation to be considered as passive in which the flow rates are determined mainly by the mean effective perfusion pressure. The inverse relationship between placental vascular resistance and end-diastolic flow has longed been established.[15] As placental vascular resistance decreases as a result of increase in the number of tertiary stem villi, the end diastolic flow progressively increases with advancing GA.

Umbilical artery Doppler (UmAD) velocimetry assessment can be both qualitative and quantitatively. 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 commonly used. Absent and reversed end diastolic flow (AREDF) are mostly found in early IUGR and have been reported to be present on average 1 week before computerized CTG changes. Another advantage of umbilical artery Doppler is that AREDF which represents an extreme abnormality in waveform, is the only measure that provides both diagnostic and prognostic information for the management of IUGR.[12] 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 end diastolic flow.[8]

Despite several studies worldwide that showed significant role of umbilical artery Doppler ultrasound in the management of high-risk pregnancies[,3,9,11,12] it has not been incorporated as part of the routine surveillance for high-risk pregnancies in most institution, especially in the developing Countries. This study aims to assess the usefulness of umbilical Doppler velocimetry in distinguishing between IUGR and SGA in women with high-risk pregnancies at Jos University Teaching Hospital.

METHODS AND MATERIALS

The study was conducted in the foeto-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. 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 pregestational diabetes, Chronic Hypertension, Renal disease, Sickle cell disease, Previous history of IUFD / stillbirth and previous history of recurrent pregnancy

losses. women with multiple gestation, congenital anomaly of the foetus, unreliable to follow up, High risk pregnant women who did not consent for the study were excluded from 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, LMP, gestational age, previous history of contraceptive use, irregular menstrual periods, and co-morbidities. The ultrasound scan was performed by one of the researchers using GE Voluson P8 4D ultrasound machine. A 3.5MHz convex probe was selected for both foetal biometric and the Doppler study. The foetal biometric parameters were measured in 2D mode before the Doppler study. Doppler velocimetry was performed by first activating the colour flow (CF) mode to identify the direction of flow of the selected free loop of the umbilicus. The pulse wave (PW) mode was then activated, and the sampling gate was adjusted along the path of the transmitted beam to the appropriate location and size of the Doppler sample volume of the target area to be interrogated. This provides the precise spatial velocity information.

The accuracy of Doppler measurements was optimized according to the International Society of Ultrasound in Obstetrics and Gynaecology (ISUOG) Practice Guidelines: use of Doppler ultrasonography in obstetrics.[16] A minimum of three waveforms in the original upright position were obtained. Foetuses with EFW below the 10th percentile for their GA were adjudged SGA, while those with abnormal umbilical Doppler in addition were tagged growth restricted (IUGR). Reduced end diastolic flow was defined as raised pulsatility index (PI) or resistive index (RI) above the 95th percentile. This procedure was repeated two weekly or more frequently depending on the abnormality noted. 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, non-reassuring test of foetal wellbeing (biophysical profile) and worsening maternal condition. The data was analysed using SPSS software version 20. Ethical approval was obtained from the ethical committee of the Jos University Teaching Hospital.

RESULTS

During the study period, a total of 2,506 pregnant women booked for antenatal care at JUTH out of which 1,032 were high risk pregnancies. The prevalence of high-risk pregnancy was 41.2%. A total of 170 high risk pregnant women were recruited for the study out of which 9 were lost to follow up giving a completion rate of 94.7% (161 participants). The mean age of the participants was 31.6 ± 5.8 years with an age range of 20-45 years. All (100.0%) of the participants were married. Ethnic distribution showed 61(37.9%) of the participants were Hausa while 58(36.0%) were Plateau Indigenous people. The study further revealed that 60(37.3%) out 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
⬜ ⬜	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 people	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

Twenty-eight (17.4%) of the participants were primigravids while 24(14.9%) were grand multiparous. 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 or more living children. The average

gestational age at recruitment into the study was 34.8±3.3 weeks with more than half 93(57.8%) being recruited at gestation age of 35-38 weeks. 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.

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
⬜ ▦	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
⬜ ▥	59	36.6

Figure 1 Overall, 86 (53.4%) of the study participants had hypertensive disorder in pregnancy with Chronic hypertension being the commonest risk for high-risk pregnancy amongst the participants 40(24.8%) followed by previous IUFD/Still birth 36(22.4%).
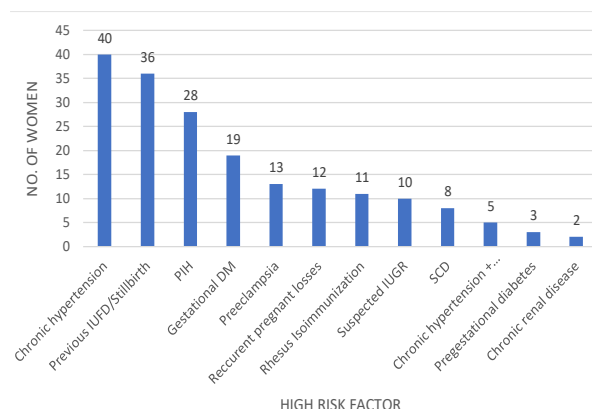

Figure 1: Risk Factors for High-Risk Pregnancy

Table 3. Normal umbilical artery waveform pattern was seen in majority 111(68.9%) of the study group. The prevalence of SGA and IUGR in this study was 19.9% (32) and 17.4% (28) respectively. All the 28 IUGR foetuses were among SGA foetuses, given a prevalence of 87.5%. This was statistically significant (p ≤ 0.0001). Majority (69.2%) of the IUGR were among women with hypertensive disorders. This was also statistically significant (p ≤ 0.0001). Reduced umbilical artery Doppler velocimetry was the major (89.3%) abnormality observed in the umbilical Doppler of the IUGR fetuses.
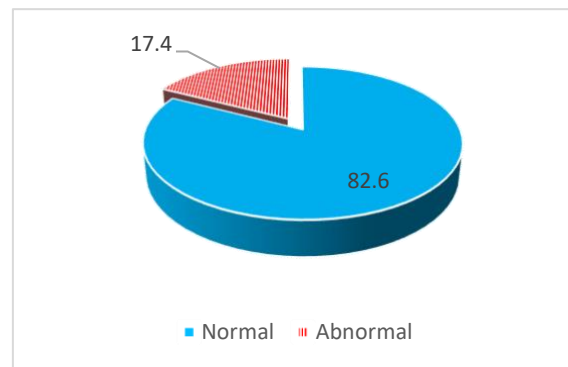

Fig 2 The prevalence of abnormal umbilical artery velocimetry.

The prevalence of abnormal umbilical artery velocimetry in this study was 17.4% (n=28). The prevalence of IUGR among the study population was 24 (14.9%).

Table 3: Umbilical Artery Waveform Pattern and Doppler indices

Waveform pattern /Indices	f	%
WAVEFORM PATTERN		
Normal pattern	133	82.6
High RI	14	8.7
High PI	11	6.8
AEDF	2	1.2
REDF	1	0.6

REDF = Reversed End Diastolic Flow, AEDF = Absent End Diastolic Flow; PI= Pulsatility index, RI= Resistance index.

Discussion

The prevalence of high-risk pregnancy in this study was 41.2%. This was similar to the prevalence of 40.1% found in a study done in Enugu, Nigeria.[17] It is however higher than the global prevalence of 20% and that reported from India.[1,18] The reason for 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 is a known risk factor for most medical disorders like hypertensive disorders and gestational diabetes. Therefore, it is not surprising that 86 (53.4%) of the study participants had hypertensive disorder in pregnancy, which is similar to previous reports.[19,20,21]

This also agrees with previous reports which show that hypertensive disorders in pregnancy are the most common medical complications encountered in developing world.[19, 22] The prevalence of SGA in this study was 19.9% (32), and all the 28 IUGR foetuses with abnormal Doppler velocimetry were among the SGA foetuses, given a prevalence of 87.5%. This was statistically significant (p ≤ 0.0001). This agrees with previous finding which showed that majority of IUGR foetuses are SGA.[23] In addition, since IUGR foetuses are at risk of poor perinatal outcome this agrees with the report showing that high-risk pregnancy account for approximately 20% of the global perinatal mortality.[1] It was however lower than the prevalence of 42. 3% and 50.9% found in other studies.[20, 24] The wide variation in the prevalences may be due to the differences in the risk categories and the fact that our study was in a referral centre where most high-risk women are referred.

Majority (69.2%) of the IUGR were among women with hypertensive disorders. This was also statistically significant (p ≤ 0.0001), and this agrees with previous studies from the region which shows that high-risk pregnancies account for about 50% of perinatal mortality with hypertension as the commonest medical disorder.[17]

Foetal adaptation in the face of hypoxia occurs in a sequence of events. Umbilical arterial Doppler waveforms reflect the status of the placental circulation, and the increase in end-diastolic flow that is seen with advancing gestation is a direct result of an increase in the number of tertiary stem villi that takes place with placental maturation. Diseases that obliterate small muscular arteries in the placental tertiary stem villi result in a progressive decrease in end-diastolic flow in the umbilical arterial Doppler waveforms. The pathophysiology of PIH and other hypertensive disorders has long been shown to affect either the number or obliterate the small muscular arteries in the tertiary stem villi of the placental leading to Placental insufficiency.[25,26] There is a strong relationship between reduced end-diastolic umbilical artery blood flow velocity and increased vascular resistance in the umbilical placental microcirculation. Progressive decrease in the end diastolic flow in umbilical Doppler reflects the increasing placental resistance from the obliteration of the placental tertiary stems villi. Early vascular changes that reflect as abnormal umbilical artery Doppler resistance (increased PI and RI) begins when the villous damage is >30%,[25] and as absent or reversed end diastolic flow when over 70 % of placental tertiary villi are obstructed.[27] Similarly, studies showed that the pattern of changes in the umbilical artery.

Doppler velocimetry can further predict the foetal outcome.[28] In this study, reduced umbilical artery Doppler velocimetry was the major (89.3%) abnormality observed in the umbilical Doppler of the IUGR foetuses. The 100% mortality observed in foetuses with AEDF and REDF is in keeping with previous findings which showed that they represent advanced stages of placental compromise and extremes of intrauterine decompensation which is associated with adverse pregnancy outcome including long-term neurological outcome, and a wide range of intellectual problems at school age.[29,30]

As a limitation, this study was a single centre and therefore cannot be extrapolated to the general population. A multicentre study is required among our population. Umbilical artery Doppler is a useful antenatal surveillance tool in women with high-risk pregnancies. Majority of SGA foetuses in women with high-risk pregnancies are growth restricted. Umbilical artery Doppler should be a routine practice in high-risk pregnancies complicated by foetal growth challenges.

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