ORIGINAL RESEARCH ARTICLE

Prevalence of abnormal umbilical arterial Doppler indices in apparently normal pregnancies in Calabar

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Abstract

Intrauterine growth restriction (IUGR) may occur in the presence of normal fetal growth parameters, with resultant unanticipated perinatal morbidity and mortality. Umbilical arterial Doppler evaluation determines the fetuses susceptible to compromise by detecting IUGR early enough for successful intervention measures to be implemented. This study was aimed at determining the prevalence of abnormal umbilical arterial Doppler indices (UADI) in apparently normal pregnancies and to assess its correlation with amniotic fluid index (AFI). In this prospective cross-sectional study, obstetric sonographic examination and UADI evaluation were done on 310 apparently normal pregnant women between 26 to 40 weeks within a 6-months period. Abnormal UADI had a prevalence of 10.3%. Educational level (P = 0.000) and employment status (P = 0.000) were significantly associated with abnormal UADI. Abnormal umbilical arterial resistivity index (RI) had a significant correlation with EFW (P = 0.000) and HC/AC (P = 0.000) but no significant relationship with AFI (P = 0.593). The prevalence of abnormal umbilical arterial Doppler indices was high in apparently normal pregnancies mostly among women with low socio-economic status, with no demonstrable association with AFI. *(Afr J Reprod Health 2023; 27 [1]: 63-72).*

Keywords: Umbilical artery doppler indices, pregnancy, intra-uterine growth restriction, amniotic fluid

Résumé

Un retard de croissance intra-utérin (RCIU) peut survenir en présence de paramètres de croissance fœtale normaux, entraînant une morbidité et une mortalité périnatales imprévues. L'évaluation Doppler artérielle ombilicale détermine les fœtus susceptibles d'être compromis en détectant le RCIU suffisamment tôt pour que des mesures d'intervention efficaces soient mises en œuvre. Cette étude visait à déterminer la prévalence d'indices Doppler artériels ombilicaux anormaux (UADI) dans des grossesses apparemment normales et à évaluer sa corrélation avec l'indice de liquide amniotique (AFI). Dans cette étude transversale prospective, un examen échographique obstétrical et une évaluation UADI ont été effectués sur 310 femmes enceintes apparemment normales entre 26 et 40 semaines sur une période de 6 mois. L'UADI anormal avait une prévalence de 10,3 %. Le niveau d'éducation (P = 0,000) et le statut d'emploi (P = 0,000) étaient significativement associés à un UADI anormal. L'indice de résistivité artérielle ombilicale anormale (RI) avait une corrélation significative avec EFW (P = 0,000) et HC/AC (P = 0,000) mais aucune relation significative avec AFI (P = 0,593). La prévalence des indices Doppler artériels ombilicaux anormaux était élevée dans les grossesses apparemment normales, principalement chez les femmes de faible statut socio-économique, sans association démontrable avec l'AFI. *(Afr J Reprod Health 2023; 27 [1]: 63-72).*

Mots-clés: Indices doppler de l'artère ombilicale, grossesse, retard de croissance intra-utérin, liquide amniotique

Introduction

Antepartum fetal surveillance with Doppler ultrasound evaluation of the umbilical artery has shown a significant diagnostic efficacy in identifying fetal growth restriction[1]. Intrauterine growth restriction (IUGR) refers to the pathological inhibition of growth that prevents the fetus from attaining its maximum growth potential consequently, the estimated fetal weight (EFW) becomes less than the 10th percentile for its gestational age[2,3]. The incidence of IUGR has a

relatively lower rate of occurrence in developed countries (4 to 8%) than in developing countries (6 to 30%)[4]. IUGR is the second leading cause of perinatal morbidity and mortality in developing countries[5]. Timely diagnosis and management is key towards a significant reduction of perinatal mortality associated with IUGR[5].

During pregnancy, placental insufficiency causes poor umbilical arterial blood flow capable of initiating IUGR in a developing fetus. When this scenario is suspected, Doppler evaluation of the umbilical artery becomes imperative since it offers valuable direct information on vascular resistance and blood flow to the fetus[1,6,7]. Umbilical artery Doppler study prevents premature medical interventions by differentiating pathologic growth restriction from constitutionally small fetuses, which is a significant advantage over conventional ultrasound[6,8]. Moreover, the fetuses with IUGR that are normal for age but still at increased risk for morbidity and mortality are also identified[6,8].

In pregnancies with IUGR, the evaluation of umbilical artery Doppler indices, which consists of pulsatility index (PI), resistivity index (RI) and peak systolic velocity/diastolic velocity (S/D ratio), yields a rise in their values above normal levels. In addition, the spectral wave-form displayed may show an absence of the diastolic flow component (absent end-diastolic flow, AEDF) or a reversal of the diastolic flow (reversed end-diastolic flow, REDF). These abnormal umbilical arterial Doppler velocimetric findings and aberrant spectral flow patterns have an association with perinatal mortality that ranges from 28% to 80%[1,2,8,9].

Amniotic fluid assessment is an integral part of the antenatal evaluation of pregnancies that are at high risk of an adverse outcome[10]. A reduction in the amniotic fluid termed oligo-hydramnios, reflects a fetus in chronic distress which produces reduced urinary output due to the re-direction of blood to the brain at the expense of renal blood perfusion, is intimately associated with IUGR[5,10-12].

Evaluation of the umbilical blood flow in women with high-risk pregnancies has been shown to prevent perinatal deaths[2]. On the other hand, there is insufficient evidence to support the use of routine umbilical artery Doppler in apparently normal pregnancies[6]. The World health organization (WHO) encourages vigorous study on Doppler ultrasound assessment of fetal blood vessels during the third trimester especially in low- and middle- income countries, such as the locality of this study, where the rate of stillbirth resulting from IUGR is high[2]. Succinctly put, three-quarters of stillbirths occur in sub-Saharan African and southern Asia[6].

The aim of this research was to determine the prevalence of abnormal umbilical arterial Doppler findings in apparently normal pregnancies and assess its correlation with asymmetric intrauterine growth restriction and amniotic fluid index (AFI).

Methods

Study design

The study was a prospective cross-sectional study that was conducted in the Radiology Department of the University of Calabar Teaching Hospital (UCTH), Calabar, from December 2021 to May 2022. The UCTH is a tertiary teaching hospital under the auspices of the Federal Ministry of Health in Nigeria.

The following inclusion criteria were used; Women with singleton intrauterine pregnancies within 26 to 40 weeks gestational age attending antenatal clinic (ANC) at the UCTH. The exclusion criteria included; intrauterine fetal death, congenital fetal anomaly, sickle cell disease, multiple pregnancy, pregnancy induced hypertension, gestational diabetes, human immunodeficiency virus, hydrops fetalis, antepartum hemorrhage, renal disease, single umbilical artery.

Ethical clearance

In strict compliance with the Helsinki declaration, an approval for this study was obtained by the Researchers from the health research ethics committee (HREC) of the UCTH, Calabar. The HREC assigned number is UCTH/HREC/33/VOL.111/031.

Sample population and selection

The sample comprised of women with apparently normal pregnancies, based on their obstetric and clinical assessment, who attended ANC of the Obstetrics and Gynecology Department, UCTH,

Calabar. Following the application of purposive sampling method, 310 subjects who met the aforementioned inclusion and exclusion criteria were enrolled for the study. Each subject was administered a consent form and a questionnaire.

Data collection procedure and instrument

Data was collected by performing obstetric ultrasound scans and umbilical arterial Doppler velocimetric study on the subjects by experienced Radiologists using Toshiba TUS-X100S (Xario 100 manufactured in 2015 by Toshiba Medical Systems corporation in Japan) equipped with vascular soft-ware for 4-D imaging, colour and spectral Doppler. The curvilinear transducer of the machine with a frequency range of 3.5 to 5 MHz, was used for the scans and the Doppler interrogation. The fetal anthropometric parameters [bi-parietal diameter, head circumference (HC), abdominal circumference (AC), femur length, estimated fetal weight (EFW) and estimated gestational age (EGA)] were determined for each subject and the HC/AC ratio, EFW and EGA were recorded for analysis.

The participants were made to lie supine on the ultrasound examination couch and the transducer was manipulated to obtain a sagittal view colour Doppler of the free-floating loop of the umbilical cord which was interrogated to monitor the umbilical arterial Doppler indices (UADI) during the systolic and diastolic phases. The angle of insonation was kept below 30^0. When 4 to 5 spectral waveforms were demonstrated in an episode of Doppler interrogation, the image was frozen and the waveform was examined afterwards for any abnormality[3,7,13]. Immediately the trace button was clicked the ultrasound machine automatically measured the umbilical arterial Doppler indices by selecting and utilizing an appropriate waveform. Three waveforms were obtained and the mean values of these for each UADI were recorded. The Doppler interrogation was done during the period of fetal inactivity and/or absent uterine contraction[7,14]. Abnormal UADI, were indicative of IUGR, and included the following; RI >0.72, S/D ratio >3, a spectral waveform that demonstrated AEDF or REDF[4,7]. Umbilical arterial RI and PI were observed to have the same diagnostic accuracy[4], therefore, the researchers decided to evaluate only RI and S/D as the UADI for use in this study.

Amniotic fluid index (AFI) is the sum of the largest vertical pocket of amniotic fluid, devoid of umbilical cord or fetal parts, within each quadrant of the uterus in centimeters. The AFI is derived by mentally dividing the pregnant abdomen into 4 quadrants by using the umbilicus as the reference point. The linea nigra divides the abdomen into left and right halves while the umbilicus separates the uterus into upper and lower halves. The four sonographic measurements were summed to obtain the AFI in cm [15]. Oligohydramnios refers to an amniotic fluid index < 5cm, borderline oligohydramnios refers to an amniotic fluid index above 5cm but below 10 cm while the normal range is between 10 to 23 cm[12,16,17].

Each procedure per participant lasted about 10 minutes. Urgent referrals were made to the managing obstetricians following the detection of an abnormal UADI in the pregnant women involved in this study for the next level of care to be administered. The prevalence of abnormal umbilical arterial Doppler indices (UADI) in this study was obtained with the equation below.

$$\text{Prevalence of abnormal UADI} = \frac{\text{Number of cases in a given time period}}{\text{Total number of population in that period}} \times 100^{18}$$

The data obtained were entered and analyzed using the Statistical package for social sciences (SPSS) for windows (SPSS Inc., USA) version 23. Appropriate descriptive (including numbers and percentages) and inferential statistical methods were used to analyze the data. Tables and bar charts were the means of displaying the results where applicable. Chi-square test was used to check statistical associations between the socio-demographic variables and abnormal UADI while Pearson correlation test assessed the degree to which the fetal variables were related with the UADI and their changes in direction (either in the same direction or in opposite direction). The outcome variables with P <0.05 were regarded as significant.

Results

The study group comprised 310 singleton pregnant women with gestational ages between 26 weeks and 40 weeks. Twenty-four pregnant women were excluded from this study on the basis of multiple pregnancy (14 pregnant women), congenital fetal anomaly (6 pregnant women) and intra-uterine fetal death (4 pregnant women). The mean RI and S/D ratio in the study were 0.58±0.09 and 2.50±0.54, respectively with a range of 0.30 to 0.77 for RI and 1.42 to 4.38 for S/D ratio. The mean (SD) maternal age of the participants was 29.74±4.48 years with a

Table 1: Socio-demographic and fetal characteristics of the subjects

Variables	Frequency (n, %)	Minimum	Maximum	Mean	STD
Age (years)		20.00	42.00	29.74	±4.48
20 – 24	36 (11.60%)				
25 – 29	111 (35.70%)				
30 – 34	120 (38.90%)				
>34	43 (13.80%)				
Parity		0.00	4.00	0.92	±0.99
0	133 (42.9%)				
1	96 (31.00%)				
2	55 (17.70%)				
3	24 (7.70%)				
4	2 (0.60%)				
Educational level		-	-		
Primary	48 (15.48%)				
Secondary	119 (38.39%)				
Tertiary					
1st Degree	131 (42.26%)				
2nd Degree	10 (3.23%)				
3rd Degree	2 (0.64%)				
Employment status		-	-		
E	201 (64.84%)				
U.E	109 (35.16%)				
EGA (weeks)		26.00	39.57	32.93	±3.85
26 – 30	97 (31.29%)				
31 – 35	134 (43.23%)				
36 – 40	79 (25.48%)				
EFW (kg)		0.63	3.99	2.18	±0.82
0.50 – 1.49	81 (26.13%)				
1.50 – 2.49	103 (33.23%)				
2.50 – 3.49	113 (36.46%)				
>3.50	13 (4.18%)				
HC/AC		0.86	1.33	1.04	±0.07
<1.20	300 (96.77%)				
>1.20	10 (3.23%)				
AFI (cm)		4.15	20.77	12.52	±3.38
Normal (10 – 20)	196 (63.23%)				
Borderline (6 – 9.99)	110 (35.48%)				
Oligohydramnios (≤5)	4 (1.29%)				

AFI: Amniotic fluid index, E: Employed, EFW: Estimated fetal weight, EGA: Estimated gestational age, HC/AC: Head circumference to abdominal circumference ratio, RI: Resistivity index, S/D: Systolic to diastolic ratio, STD: Standard deviation, U.E: Unemployed

range of 20 years to 42 years and a median of 30 years. Majority of the participants (38.90%) were in the 30 to 34 years age group. Nulliparous women and those with a university 1st degree made up more than two-fifths of the sample (42.90% and 42.26%, respectively). Almost two-thirds of the participants (64.84%) were employed. Greater than two-fifths of the participants (43.23%) had pregnancies within the 31 to 35 weeks gestational age group and none of the participants had intrauterine fetuses with EFW above 4 kg, as the highest was 3.99 kg. Only 4 participants had oligohydramnios in the study and

10 participants (3.23%) had values of HC/AC that were above 1.2. Majority of the participants (63.23%) had AFI values within the normal range (Table 1).

Employing chi-square test, educational level was seen to be significantly associated with abnormal umbilical arterial Doppler indices (P = 0.000) and the participants with a primary education had the highest percentage frequency (25%). Although the frequency was also high among those with a second degree (22.22%), their sample size was rather small (2). Abnormal

Table 2: Association of socio-demographic variables with abnormal umbilical arterial Doppler indices (chi square test)

Variables	Frequency of abnormal UA Doppler velocimetric indices (n, %)	Frequency of normal UA Doppler velocimetric indices (n, %)	P - value
Age (years)			0.187
20 – 24	4 (11.11%)	32 (88.89%)	
25 – 29	12 (10.91%)	98 (89.09%)	
30 – 34	10 (8.20%)	112 (91.80%)	
>34	6 (14.29%)	36 (85.71%)	
Total	32 (10.3%)	278 (89.7%)	
Parity			0.218
0	14 (10.53%)	119 (89.47%)	
1	10 (10.42%)	86 (89.58%)	
2	2 (3.64%)	53 (96.36%)	
3	6 (25%)	18 (75%)	
4	0 (0%)	2 (100%)	
Total	32 (10.3%)	278 (89.7%)	
Educational level			0.000*
Primary	12 (25.00%)	36 (75.00%)	
Secondary	6 (5.04%)	113 (94.96%)	
Tertiary			
1st Degree	12 (9.09%)	120 (90.91%)	
2nd Degree	2 (22.22%)	7 (77.78%)	
3rd Degree	0 (0%)	2 (100%)	
Total	32 (10.3%)	278 (89.7%)	
Employment status			0.000*
E	22 (11.00%)	178 (89.00%)	
U.E	10 (9.09%)	100 (90.91%)	
Total	32 (10.3%)	278 (89.7%)	

P value <0.05 is significant (*). E: Employed, U.E: Unemployed, UA: Umbilical arterial

Table 3: Correlation of abnormal UADI with fetal variables (n=310)

Variables	Correlation coefficient ®	P - value
EGA (weeks)	-0.370	0.000*
EFW (kg)	-0.379	0.000*
S/D	+0.953	0.000*
HC/AC	+0.388	0.000*
AFI (cm)	-0.030	0.593

P value <0.05 is significant (*). AFI: Amniotic fluid index, EFW: Estimated fetal weight, EGA: Estimated gestational age, HC/AC: Head circumference to abdominal circumference ratio, S/D: Systolic to diastolic ratio, UADI: Umbilical arterial Doppler indices

umbilical arterial Doppler indices was most common in participants above 34 years (14.29%) and multiparous women with three previous pregnancies (25%) that progressed beyond 28 weeks. A significant association (P = 0.000) was

seen between employment status and abnormal umbilical arterial Doppler indices (Table 2).

Table 3 shows that the total number of participants with abnormal umbilical arterial velocimetric indices were 32.

Prevalence of abnormal UADI = $\frac{32}{310}$ x 100
$$= 10.3\%$$

Out of the 32 participants who had abnormal UADI and were subsequently referred for urgent obstetric evaluation, 2 intrauterine fetal deaths were recorded. One occurred 24 hours after the examination while the other occurred 72 hours afterwards. The correlation between fetal variables and abnormal umbilical arterial RI are shown in Table 4. EGA, EFW, S/D and HC/AC were statistically significantly correlated with abnormal umbilical arterial RI (P = 0.000), respectively. AFI had no significant correlation with abnormal umbilical arterial Doppler indices (P = 0.593) (Table 3). The mean EGA of the participants with abnormal UADI was 31.35±3.76 weeks while in

Table 4: Mean values of the variables with abnormal UADI versus normal UADI

Variables	Mean Value			
	Abnormal UADI	Normal UADI	t	P-value
EGA (weeks)	31.35±3.76	33.81±3.81	-2.55	0.015*
EFW (kg)	1.84±0.748	2.22±0.82	-2.75	0.015*
HC/AC	1.06±0.06	1.04±0.07	+1.78	0.083
AFI (cm)	11.01±2.49	12.69±3.44	-3.41	0.001*

P value <0.05 is significant (*). AFI: Amniotic fluid index, EFW: Estimated fetal weight, EGA: Estimated gestational age, HC/AC: Head circumference to abdominal circumference ratio
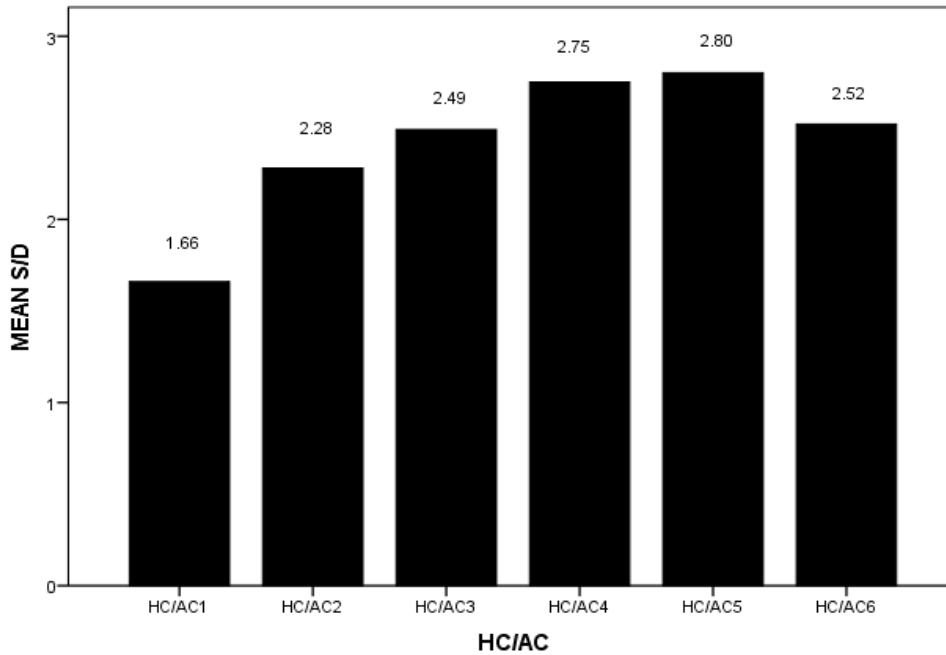
Figure 1: The relationship between the mean S/D and the mean HC/AC. S/D=Systolic velocity/Diastolic velocity, H/AC=Head circumference/Abdominal circumference. HC/AC1 = Values between 0.80 – 0.89, HC/AC2 = Values between 0.90 – 0.99, HC/AC3 = Values between 1.00 to 1.09, HC/AC4 = Values between 1.10 – 1.19, HC/AC5 = Values between 1.20 – 1.29, HC/AC6 = Values between 1.30 – 1.39

normal UADI it was 33.81±3.81 weeks and the difference was significant (P = 0.015). Thus, the gestational period where abnormal UADI occurred most in apparently normal pregnancies was 31.35±3.76 weeks, which approximates a 27-to-35-week gestational age interval. The difference between the mean EFW and AFI of abnormal UADI and normal UADI were also significant (P = 0.015) and (P = 0.001), respectively. However, the difference between the mean HC/AC of the participants with abnormal UADI and normal UADI was not significant (Table 4).

Figure 1 shows the rise in the mean S/D from HC/AC1, which was at 1.66, to HC/AC5, that was at 2.80. However, at HC/AC6 a drop in the mean S/D occurred.

Discussion

The detection of fetuses in apparently normal pregnancies that may be at risk of developing IUGR is a challenge due to resource constraints. The subjectivity of the current antenatal growth monitoring tools in determining IUGR (in apparently normal pregnancies) in low- and middle-income countries, where only fetal biometric parameters are commonly assessed, is a source of concern[6].

In this research, the occurrence of an abnormal umbilical arterial RI was accompanied by an abnormal S/D in the subjects and there was a strong positive correlation between both indices (r = +0.953, P = 0.000). The prevalence of abnormal umbilical arterial Doppler indices (UADI) in apparently normal pregnant population was 10.3%. A similar observation was reported by Hlongwane *et al.*[6], in a multi-center South African based study, who noticed a prevalence of abnormal umbilical arterial RI of 13.0% and AEDF of 1.2%. In the same disposition, Nkosi *et al.*[19] found out that the prevalence of abnormal RI in their study which was also done in South Africa was 11.7%. However, the research instrument utilized by Hlongwane *et al.*[6] and Nkosi *et al.*[19] was an Umbi-flow, which is a low-cost continuous-wave Doppler device while this study made use of a pulsed-wave Doppler set up in an ultrasound scanning machine. In a systematic review of documented researches and case reports conducted by Vogel *et al.*[2] that had to do with low-risk or unselected-risk pregnancies, it was realized that the prevalence of abnormal UADI (mainly AEDF and REDF) was 0.08 to 2.13%, which is low when compared to the findings of this study. In another Nigerian based research, which in contrast involved high-risk pregnancies, Ayyuba et al.[1] discovered a prevalence of 58.06% of their subjects had abnormal UADI. However, an RI value above 0.57 was considered abnormal in their research.

The educational level of the subjects was significantly associated with abnormal UADI (P = 0.000) and exactly 25% of the subjects with only primary education had abnormal UADI. In addition, employment status was demonstrated to be significantly associated with abnormal UADI (P = 0.000) and it was observed that 11% of the subjects who were employed had abnormal UADI. Based on these findings the researchers assumed that since majority of the affected subjects were poorly educated but employed, they might be generally involved in menial jobs that required lengthy periods of working hours with much physical demands. Sustained maternal stress during pregnancy stimulates a hike in the production of serotonin which progressively accumulates in the placenta. The hormone, serotonin, is a potent vasoconstrictor that ends up elevating the vascular arterial resistance considerably. The strong correlation that exists is such that the greater the maternal stress is, the higher will be the umbilical arterial RI level[20]. Buttressing these findings, Bouthoorn *et al.*[21] noticed that the mean value of umbilical arterial RI was higher in the lowly educated pregnant women within the 3rd trimester (P < 0.01) compared to the more educated. A negative socio-economic gradient in health was discovered to be responsible for the increase in 3rd trimester umbilical arterial RI in their study. Consequently, they inferred that pregnant women with lower educational level were susceptible to develop abnormal umbilical arterial RI (P = 0.003), especially in the 3rd trimester.

Chronic consumption of nutrient deficient diet, which could have been the norm in most of this study's subjects, in excess of 4 months, has an immediate and strong effect on the placenta by initiating a gradual reduction in the umbilical blood flow and ultimately a rise in the umbilical artery RI which then sets in motion the development of asymmetric IUGR[7,22]. Further research on the outcome of poor nutrition on umbilical arterial flow velocities in pregnant women is imperative. In variance with this study, Tolu *et al.*[8] found out that educational level (P = 0.721) and employment status (P = 0.193) were not associated with abnormal UADI.

EFW was demonstrated to have a significant negative correlation with abnormal umbilical arterial RI (r = -0.379, P = 0.000). The possible impact of a rising umbilical arterial RI is a corresponding reduction of the fetal weight in utero and after delivery because of the impairment in the requisite process required to attain optimal fetal growth perpetrated by high levels of umbilical arterial RI. In alliance with our study, Hlongwane *et al.*[6] observed that apparently normal pregnancies with abnormal umbilical arterial RI had more low birth weight fetuses than those with normal RI (20.5% versus 9.8%) and the difference in the values was significant (P < 0.0001). Also, in alignment with this study, Ganju *et al.*[7] in an Indian-based study noticed that 90% of the fetuses with pregnancies that had abnormal umbilical arterial RI and 92% of the fetuses with abnormal umbilical arterial S/D ratio had birth weight lower than 2.5kg on delivery. On the contrary, Agbaje *et al.*[3] observed that there was no relationship between UADI and fetal weight but this inference was

probably because their study was only done on pregnancies at 26 weeks gestational age.

In pregnant women with asymmetric IUGR, the fetus is malnourished due to the diversion of nutrients to vital organs such as the brain and the heart at the expense of the abdominal organs (liver, muscle and abdominal fats). The underlying cause is usually placental insufficiency and its persistence culminates to the disproportionate growth of the head in relation to the abdomen. The head circumference to abdominal circumference ratio (HC/AC) normally reduces linearly between the 20th week to the 34th week of gestation from 1.2 to 1.0 but in asymmetric IUGR it rather increases above 1.2[5,7].

This study demonstrated a positive significant correlation between abnormal umbilical arterial RI and HC/AC (r = +0.388, P = 0.000). When the value of S/D is > 3 it is regarded to be abnormal and indicative of IUGR, which in turn is suspected when the HC/AC is > 1.2. In this study there was a corresponding linear increment observed in the value of S/D when the HC/AC increased and when the HC/AC was between 1.20 to 1.29, which is suggestive of asymmetric IUGR, the highest mean S/D was attained, which was 2.8 but this value was below 3 nevertheless, there were 2 fatalities (stillbirths) recorded. In a similar trend, Nnamani *et al.*[23] realized that the mean S/D in their subjects, with pregnancies suspected of having IUGR fetuses, was 2.62±0.41, but it still witnessed 10 fatalities. However, Adekanmi *et al.*[14] revealed that the mean umbilical artery S/D was 2.95±1.13 in their study which had to do with high-risk pregnancies complicated with pre-eclampsia.

AFI was observed to have no significant correlation with abnormal arterial RI (r = -0.030, P = 0.593). However, Peleg *et al.*[5] lucidly stated that the rate of fetal morbidity was high in pregnancies whose amniotic fluid index was below 5 cm and that this level was usually seen in IUGR. The mean AFI of the subjects with abnormal UADI, in this study, was 11.01±2.49 cm and we accordingly postulated that probably in the vicinity of this study, pregnant women in the last trimester with borderline oligohydramnios should be closely monitored for IUGR with scrupulous evaluation of UADI. In consonance with our disposition, Madaan *et al.*[10], whose research involved high-risk pregnancies above 30 weeks of gestation, noted that

the mean value of AFI in women with IUGR was 9.82 cm, and this value is within our range for borderline oligohydramnios.

The study was conducted in a single center which limited the enrollment of subjects from other facilities within the city, who might possibly demonstrate abnormal UADI. Another limitation was that since this study was cross-sectional in design, there was no follow-up protocol in place to assess apparently normal pregnancies with abnormal UADI who might subsequently migrate to the status of "high-risk" pregnancies and also their perinatal outcome.

Conclusion

The prevalence of abnormal umbilical arterial Doppler indices in apparently normal pregnancies within the low educational population was high. This was probably due to the negative socio-economic gradient in health expected of the predominantly affected women in this study who were employed but less educated and as such might have menial jobs, which were likely strenuous. They may also be suffering malnutrition because of low income and poor education. Abnormal UADI occurred most in women above 34 years with apparently normal pregnancies at a mean estimated gestational age of 31.35±3.76 weeks. Abnormal umbilical arterial Doppler indices in apparently normal pregnancies had no relationship with amniotic fluid index.

Recommendations

The prevalence of abnormal umbilical arterial Doppler indices in this study depicts its high incidence in apparently normal pregnancies and consequently accentuates the need to include the evaluation of umbilical arterial velocimetric studies in routine obstetric scan from the 26th week of gestational age till term. It is essential for the coordinators and stakeholders of the ANCs to increase the intensity of educating pregnant women on the necessity to drastically reduce their work-load, at home and at work, and avoid environmental stressors that might place the life of the unborn child in peril of growth restriction and possible demise. It is pertinent for there to also be a consistent education of pregnant women on the

importance of ensuring that meals containing different nutrients, especially from low-cost sources, in suitable quantity to produce a balanced diet is regularly consumed.

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