IJBPAS, November, 2021, 10(11): 4210-4224

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

DOPPLER INDICES FOR UMBILICAL AND MIDDLE CEREBRAL ARTERIES IN SECOND AND THIRD TRIMESTER NORMAL SINGLETON PREGNANCIES AMONG YORUBA WOMEN IN LAGOS STATE NIGERIA

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Received 22nd Feb. 2021; Revised 20th April. 2021; Accepted 19th July 2021; Available online 1st Nov. 2021

https://doi.org/10.31032/IJBPAS/2021/10.11.6230

ABSTRACT

Background: Doppler ultrasonography velocimetry of the fetal vessels is a well-known method for the evaluation of fetal well-being, especially in the assessment of small-for-gestational-age (SGA) fetuses at risk of adverse perinatal outcome. This study aimed to determine the Umbilical and Middle Cerebral Arteries mean Doppler indices values in the second and third trimester of normal singleton pregnancies among Yoruba women in Lagos, Lagos State, Nigeria. **Materials and methods:** A prospective cross-sectional research design was adopted in this study. Trans-abdominal color Doppler ultrasound was performed on each participant in the semi-recumbent position with a slight lateral tilt using a curved array 3.5-5.0MHz transducer to generate the umbilical and middle cerebral arteries Doppler indices by the researchers. Anthropometric variables were measured. Descriptive and inferential statistics were used for statistical analysis of the data. **Results**: The Umbilical artery (UA) Doppler indices are (PI= 1.314 ± 0.6575, RI = 0.7125± 0.167, and S/D ratio =3.07± 0.925). The Middle Cerebral artery (MCA) Doppler indices are (PI= 2.170 ± 1.631, RI = 0.8590± 0.4035 and S/D ratio = 4.14 ± 2.083). There were weak and negative statistically significant correlations between gestational age and umbilical artery

Doppler indices (PI[r= -0.239, p = 0.001], RI [r= -0.297, p = 0.000] and S/D ratio [r= -0.470, p = 0.000]. There were weak and negative non-statistically significant correlations between gestational age and umbilical artery Doppler indices (PI[r= -0.022, p= 0.760], RI [r= -0.114, p = 0.106]. **Conclusion:** Normal mean values for the Doppler indices for UA and MCA of the Yoruba ethnic group in Lagos State have been determined. The Doppler indices decrease with increased gestational age. Both maternal age and body mass index have an influence on the Doppler indices of UA and MCA.

Keywords: Doppler indices, umbilical artery, uterine artery

1.0 INTRODUCTION

Doppler ultrasonography velocimetry of the fetal vessels is a well-known method for the evaluation of fetal well-being. This velocimetry is used to evaluate small-for-gestational-age (SGA) fetuses at risk of adverse perinatal outcomes **[1-3]**. With advancements in ultrasound equipment technologies, the study of fetal vessels such as umbilical and middle cerebral arteries was possible. Doppler abnormalities in the umbilical artery (UA) are associated closely with placental pathology **[3-5]**. Meanwhile, changes in the fetal middle cerebral artery indicate fetal cardiovascular adaptations to hypoxia or blood flow redistribution **[3, 6, 7]**. Recent research work has suggested that the ratio of MCA-PI to UA-PI, the cerebroplacental ratio is an independent predictor of fetal compromise **[8]**, Cesarean section **[9, 10]**, and adverse perinatal outcome **[8, 11, 12]**. Good knowledge of the normal reference mean values/ranges for MCA and UA Doppler indices will help reduce perinatal mortality greatly through adequate fetal monitoring and appropriately timed delivery **[13, 14]**. Although several authors have described and established gestational age-associated reference curves **[13, 14]**, none has been published for Africa to the best of the our knowledge. The available reference ranges were more of those for Caucasian women, which may not be useful in our setting. Based on the scanty available data on Doppler indices in Southwest women, none captured information on both umbilical and middle cerebral arteries combined, thereby affecting the proper management of at-risk fetuses. This study was designed to determine the umbilical and middle cerebral arteries normal mean Doppler indices values in second and third-trimester of singleton pregnancies in Yoruba women in Lagos, Lagos State, Nigeria.

2.0 MATERIALS AND METHODS

2.1 Study Design and Setting

This was a prospective cross-sectional study conducted at the medical imaging department of a private diagnostic centre in Lagos State, Southwest geopolitical zone of Nigeria.

2.2 Ethical consideration and population of study

Ethical clearance for this study was obtained from the management of the study centre. All participants signed a written informed consent form. Participants were assured about their rights to discontinue the study course at any stage of the study. No harm was done to the participants during their participation in this study and the obtained data were considered confidential. The target population included pregnant Yoruba women with normal singleton pregnancies in their second and third trimester with the estimation of umbilical and middle cerebral arteries by Doppler ultrasound examinations.

2.3 Inclusion and Exclusion Criteria

2.3.1 Inclusion Criteria

i) Normal singleton pregnancy
ii) Gestational age 16-42 weeks
iii) Yoruba women of origin

2.3.2 Exclusion Criteria

i) None Yoruba pregnant women
ii) Multiple gestations
iii) Abnormal pregnancies

2.4 Sample Size Determination

The sample size used in this study was determined using Yaro **[15]** formula for a known population.

n = N/1+N (e)^2

Where n = desired sample size
N = population of the study (442)
e = accepted error limit (0.05)

From the archives of the study center, 442 pregnant women of Yoruba origin underwent Doppler ultrasound for the evaluation of fetal well-being from January 2016 to December 2017.

n = 442/1+442(0.05)^2

n = 210

The sample size of 210 participants included in this study was selected purposely since only Yoruba pregnant women with normal singleton pregnancies in their second and third trimesters of gestation were selected.

2.5 Instruments and Procedures for Data Collection.

All the Doppler ultrasound examinations were carried by the researcher with the support of a certified Sonographer using the General Electric Medical System (Voluson Expert 730, USA) with a curvilinear low-frequency transducer. Before the commencement of the investigation, the entire procedure was thoroughly explained to all the participants. An obstetric ultrasound

scan was performed first on each participant to establish obstetric parameters such as fetal head circumference, abdominal circumference, and femur length to determine the gestational age, number of fetuses to rule out multiple gestation and fetus with abnormalities. The gestational age was determined by measuring the fetal head circumference (**Figure 1**)

The umbilical and middle cerebral arteries were evaluated with Doppler ultrasound from 16-42 weeks gestational ages. Transabdominal color Doppler was performed on each participant in the semi-recumbent position with a slight lateral tilt using a curved array 3.5-5.0MHz transducer as also reported by several authors **[5, 16]**. For the investigation of the umbilical artery, each fetus underwent only one investigation of the umbilical artery. Immediately after the color localization of the umbilical artery, the sample volume gate was adjusted to cover the entire artery (sample volume of 2mm and wall filter of 50-100Hz). The Doppler indices (PI, RI, PSV, EDV and S/D ratio) were measured at the free loop portion of the umbilical cord midway between the placental and abdominal wall insertion where there was absence of fetal breathing or body movements (**Figure 2**) has also done in similar studies conducted by Figueira *et al* **[5]** *and* Akolekar *et al* **[16]**. During the investigation of the Middle Cerebral Artery (MCA), a transverse image of the foetal head was obtained at the level of the lesser wing of the sphenoid bones. Color flow imaging was used to show the Circle of Willis. The MCA in the near field was insonated about 1cm distal to its origin from the internal carotid artery. The Doppler indices (PI, RI, PSV, EDV and S/D ratio) were measured at the proximal portion of the vessel as also documented by **[5, 17]**. For arteries, spectral waveforms analysis, automatic tracing /manual tracing of the waveforms was done to ascertain the Doppler indices. The values of three consecutive waveforms were averaged and the mean documented.

Anthropometric measurements (height and body weight) were made using Stadiometer (Madiped Medical Exports, Delhi) and a portable weighing machine (Scure). Both the machines were standardized and calibrated and the reliability of measurements was established by the test-retest method. The weight of the participant was taken by the weighing machine in kilograms. The height of the subject was recorded by the stadiometer to the nearest centimeter which was then converted into the meter. Body Mass Index (BMI) was calculated as BMI (kg/m^2): weight (kg)/ height $(m)^2$. The PSV,

EDV, PI, RI, S/D ratios, biodata and anthropometry variables information and other obstetric parameters were collected using a structured proforma.

2.6 Method of Data Analysis

The obtained data were analyzed in line with the study-specific objectives using software statistical package for social sciences (SPSS) for Windows version 17(SPSS, Chicago, Illinois). Appropriate descriptive (mean, standard deviation, frequency table, and percentage) and inferential statistics (Pearson's Correlation test) were used for statistical analysis of the data. The Pearson's Correlation test was used to determine the relationship between maternal characteristics (age and body mass index), gestational age and the arteries Doppler indices (PI, RI, PSV, EDV and S/D ratio). The level of statistical significance was set at $p < 0.05$.

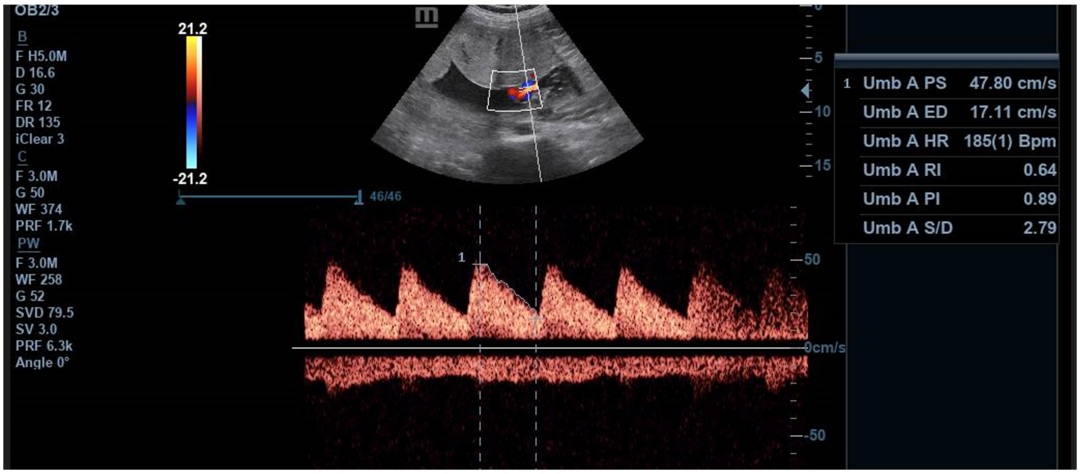

Figure 1: Measurement of the Umbilical Artery Doppler Indices

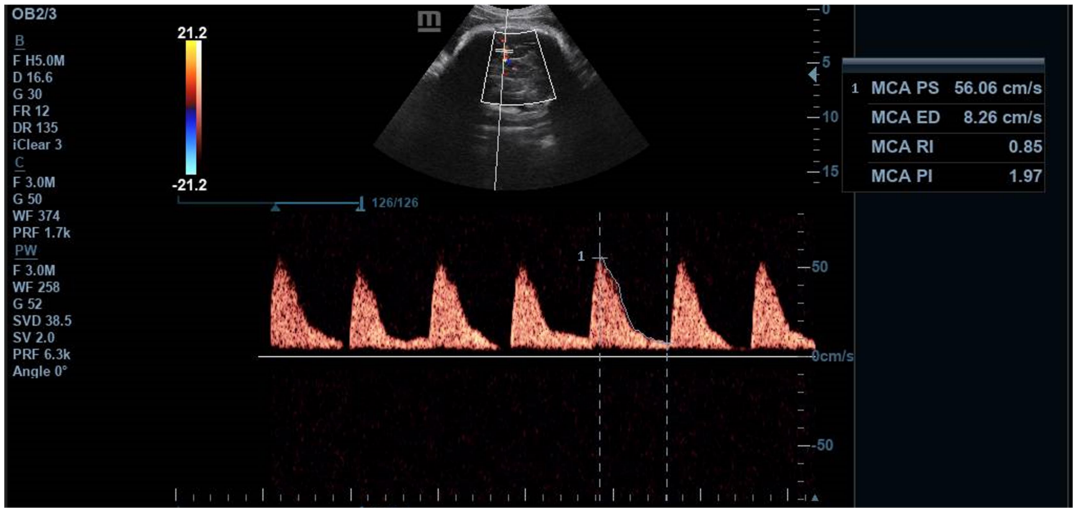

Figure 2: Measurement of the Middle Cerebral Artery Doppler Indices

RESULTS

3.0 Demographic variables of the participants

The maternal age of participants ranged from 16-44 years with age mean and standard deviation of 27.16±5.54 years. The majority of the participants 112 (53.33%), were within the age group 20-29 years, followed by age group 30-39 years 69 (32.86%) and the least were within the age group 40 years and above, which is 5(2.38%) (**Table1**). Fetal gestational age ranged from 17-42 weeks, with a mean and standard deviation of 29.911 ± 5.32 weeks. Fetuses within the 27-42 weeks gestational age accounted for 148 (70.48%) of the study population, while those within the 14-26 weeks gestational age comprised 62 (29.52%) (**Table1**).

3.1 Umbilical Artery Doppler Indices at 16-42 weeks of singleton normal pregnancies.

The mean and standard deviations of the Umbilical artery Doppler indices are (PSV=22.234±34.236c/m, EDV=7.116 ± 13.028c/m, PI= 1.314 ± 0.6575, RI = 0.7125± 0.167 and S/D ratio =3.07±0.925) (**Table 2**). The maximum and minimum values for the Doppler indices are (PSV= 75.45 and -60.79, EDV=34.53 and -35.21, PI = 3.89 and 0.43, RI = 1.30 and 0.36 and S/D ratio = 7 and 2 with ranges of 136.24c/m, 69.74c/m, 3.46, 0.94 and 5 for PSV, EDV, PI, RI and S/D ratio respectively (Table 2). The 25th, 50th and 75th percentiles of the Doppler indices are (PSV = [21.20, 33.60 and 42.50], EDV=[16.10, 10.20 and 15.32], PI=[0.94, 1.12 and 1.37], RI =[0.61, 0.69 and 0.77] and S/D ratio= [2.50, 2.87 and 3.64]) (**Table 2**).

3.2 Middle Cerebral Arteries Doppler Indices at 16-42 weeks of singleton normal pregnancies

Out of the 210 pregnancies examined, the mean and standard deviation of the Middle Cerebral artery Doppler indices are (PSV= 32.038 ±19.900c/m, EDV=6.2802 ± 6.070c/m, PI= 2.170 ± 1.631, RI = 0.8590± 0.4035 and S/D ratio =4.14 ± 2.083) (**Table 3**). The maximum and minimum values for the Doppler indices are (PSV= 83.40c/m and -41.90, EDV=36.00c/m and -10.21c/m, PI = 10.74 and 0.36, RI = 6.00 and 0.27 and S/D ratio = 8 and -11 with ranges of 125c/m, 46.62 c/m, 10.38, 5.73 and 19 for PSV, EDV, PI, RI and S/D ratio respectively (Table 3). The 25th, 50th and 75th percentiles of the Doppler indices are (PSV = [24.20, 32.50 and 45.10], EDV=[00.00, 7.42 and 8.85], PI=[1.25, 1.57 and 2.50], RI =[0.72, 0.81 and 1.00] and S/D ratio= [3.32, 4.22 and 5.28]) **(Table 3)**.

3.3 The correlation between fetal gestational age (weeks) and Doppler of umbilical and middle cerebral arteries

There was a weak positive non- statistically significant correlation between umbilical artery peak systolic velocity and fetal gestational age (r = 0.051, p = 0.467). The umbilical artery end diastolic velocity has weak positive statistically significant correlation with gestational age (r=0.163, p = 0.020). There were weak and negative statistically significant correlations between gestational age and umbilical artery Doppler indices (PI [r= -0.239, p= 0.001], RI [r= -0.297, p = 0.000] and S/D ratio [r= -0.470, p = 0.000] (**Table 4**).

There were weak positive statistically significant correlations between MCA peak systolic velocity and fetal gestational age (r = 0.314, p= 0.000). The middle cerebral artery end diastolic velocity has weak positive statistically significant correlation with gestational age (r=0.316, p = 0.000). There were weak and negative non-statistically significant correlations between gestational age and umbilical artery Doppler indices (PI[r= -0.022, p= 0.760], RI [r= -0.114, p = 0.106]. There was a weak positive non-statistically significant correlation between gestational age and middle cerebral artery S/D ratio[r= 0.47, p = 0.560] **(Table 4)**.

3.4 The correlation between maternal characteristics (age and body mass index) and Doppler indices of umbilical and middle cerebral arteries at 16-42 weeks of singleton normal pregnancies

There were weak positive non-statistically significant correlations between maternal age and umbilical artery Doppler indices (PSV[r= 0.012, p = 0.870], PI [r= 0.082, p = 0.243], RI [r=0.111, p = 0.116] and S/D ratio[r= 0.037, p = 0.604]), while there was a weak and negative non-statistically significant correlation between maternal age and umbilical artery S/D ratio(r= -0.012, p = 0.870) (**Table 5**). There were weak and negative statistical correlations between maternal body mass index and umbilical artery Doppler indices (PSV[r=-0.193, p = 0.006] and EDV[r= -0.179, p = 0.010]) while S/D ratio has weak and negative non-statistically significant correlation with BMI(r= -0.098, p = 0.169) (Table 5). There were weak positive non-statistically significant correlations between BMI and umbilical artery Doppler indices (PI[r=0.068, p = 0.332] and RI[r= 0.051, p = 0.471]) **(Table 5)**.

There were weak and negative non-statistically significant correlations between maternal age and middle cerebral artery Doppler indices (PSV[r= -0.050, p = 0.480]

and EDV[r= -0.118, p= 0.095]), while weak but positive non-statistically significant correlations exist between maternal age and MCA Doppler indices (PI [r= 0.033,p= 0.645], RI [r=0.002, p = 0.974] and S/D ratio [r= 0.023, p = 0.772]) **(Table 5)**. There were weak positive non-statistically significant correlations between BMI and MCA artery Doppler indices (PSV[r=0.055, p = 0.439] and EDV[r= 0.096, p = 0.171]) **(Table 5)**. There were weak and negative non-statistically significant correlations between BMI and MCA Doppler indices (RI[r=-0.069, p = 0.328] and S/D ratio[r=-0.003, p = 0.968]), while PI showed a weak and negative statistically significant correlation between BMI (r= -0.141, p = 0.044) **(Table 5)**.

Table 1: Descriptive statistics of the participant's characteristics

	Participant's characteristics	Frequency (n)	Percentage (%)
a)	Maternal Age group		
	< 20 years	24	11.43
	20 – 29 years	112	53.33
	30 – 39 years	69	32.86
	40 years and above	15	2.38
	Total	210	100
Mean ± = SD = 27.16 ± 5.538 (Range = 2.8 [44 - 16)			
b)	Body Mass Index classification		
	18.50 – 24.49kg/m^2 (Normal weight)	40	19.05
	25.0 – 29.90 (Overweight)	115	54.76
	30.00 – 34.90 (Class I Obesity)	44	20.95
	3500 – 39.90 (Class II Obesity)	10	4.76
	≥ 40 kg/m^2 (Class III Obesity)	1	0.48
	Total	210	100
Mean ± = SD = 27.433 ± 4.032(Range = 21.91[41.01 – 19.10)			
c)	Foetal Gestational Age (weeks)		
	1- 13 weeks	–	–
	14-26weeks	62	29.52
	27- 42 weeks Mean ± = SD = 29.911 ± 5.32 (weeks)	148	70.48
	Total	210	100

Table 2: Descriptive Statistics of Umbilical Artery Doppler Indices (PSV, EDV, PI, RI and S/D ratio) at 16 – 42 weeks gestational age

Umbilical Artery Doppler Indices	Mean ± SD	Range		Percentiles		
		Max	Min	25	50	75
PSV cm^{-1}	22.236± 13.026	75.45	-60.79	21.20	33.60	42.50
EDV cm^{-1}	7.116 ± 13.028	34.53	35.21	6.10	10.20	15.32
PI	1.3144±0.65749	3.89	0.43	0.94	1.12	1.37
RI	0.65749±0.16651	1.30	0.36	0.61	0.9	0.77
S/D Ratio	3.07 ± 0.925	7	2	2.50	2.87	3.64

PSV = Peak Systolic Velocity, EDV= End Diastolic Velocity, PI= Pulsatility Index, RI= Resistive Index, S/D= Systolic/ Diastolic, Max= Maximum, Min= Minimum

Table 3: Descriptive Statistics of Middle cerebral Artery Doppler indices (PSV, EDV, PI, RI and S/D ratio) at 16-42 weeks gestational age

Middle Cerebral Artery	Mean ± SD	Range		Percentiles		
		Max	Min	25	50	75
PSV cm^{-1}	32.038 ± 19.900	83.40	-41.90	24.20	32.50	45.10
EDV cm^{-1}	6.2802 ± 6.0670	36.00	-10.62	0.00	7.42	8.85
PI	2.1701 ± 1.631	10.74	0.36	1.25	1.57	2.50
RI	0.8590 ± 0.4035	6.00	0.27	0.72	0.81	1.00
S/D Ratio	4.14 ± 2.083	8.00	–11.00	3.32	4.22	5.28

PSV = Peak Systolic Velocity, EDV= End Diastolic Velocity, PI= Pulsatility Index, RI= Resistive Index, S/D= Systolic/ Diastolic, Max= Maximum, Min= Minimum

Table 4: The Correlation between Gestational Age and the Doppler Indices of Umbilical and Middle Cerebral Arteries

	Variables	Doppler Indices	Correlation Coefficient (r)	P-values	Remarks
a)	Umbilical Artery	Gestational Age (weeks)			
		PSV	0.051	0.467	N/S
		PI	0.163	0.020	Sig
		RI	-0.239	0.001	Sig
		S/D Ratio	-0.297	0.000	Sig
b)	Middle Cerebral Artery	P	-0.470	0.000	Sig
		PSV	0.314	0.000	Sig
		EDV	0.316	0.000	Sig
		PI	-0.022	0.760	N/S
		RI	-0.11	0.106	N/S
		S/D Ratio	0.047	0.56	N/S

Sig: Significant and N/S: Non-significant

Table 5: The Correlations between Maternal Characteristics (Age and BMI) and the Doppler Indices of Umbilical and Middle Cerebral Arteries

	Variables	Doppler indices	Maternal Age Correlation Coefficient (r)	P-values	Body Mass Index r	P-values
a)	Umbilical artery					
		PSV	0.012	0.870	-0.193	0.006
		EDV	-0.012	0.861	0.179	0.010
		PI	0.082	0.243	0.068	0.332
		RI	0.111	0.6116	0.051	0.471
		S/D ratio	0.037	0.604	-0.098	0.169
b)	Middle Cerebral Artery	PSV	-0.050	0.480	0.055	0.439
		EDV	-0.118	0.0965	0.096	0.171
		PI	0.033	0.645	-6.141	0.044
		RI	0.002	0.974	-0.069	0.328
		S/D ratio	0.023	0.772	-0.003	0.968

4. DISCUSSION

The present study has reported the reference ranges of PI and RI for umbilical artery at 16-42 weeks of gestational age. The mean of PI was found to be higher than that of the RI, with the S/D ratio having the highest mean values. These parameters were found to decline with increasing gestational age. Other studies conducted by Ayoola *et al* **[14]**, Figuerra *et al* **[5]** and Tarzmni *et al* **[18]**, have also reported reference ranges for umbilical arteries Doppler indices, moreover,

the PI that adequately explains the pattern of the wave-form velocity for umbilical artery that is commonly used for evaluating high risk pregnancies. Fetal distress, which often occurs due to blood flow redistribution is usually associated with increased umbilical artery PI values **[5, 19, 20]**. Chanprapaph *et al* **[21]** study that was carried out to determine the normative values of Doppler indices (PI, RT and S/D ratio) for umbilical artery in 332 normal single pregnant women in Thailand, found and reported range normative values of 0.967 – 1.270, 0.609 – 0.0756 and 2.511-3.560 for PI, RI and S/D ratio respectively. Also, Chanprapaph *et al* **[21]**, equally noted that the values of the aforementioned Doppler indices of umbilical artery, declined progressively with increased gestational age and was captured in their constructed normogram. Ayoola *et al* **[14]** in their research work conducted to produce a nomogram of umbilical artery Doppler indices in singleton Pregnancies in south-west Nigerian women in Ile-Ife, Osun state, reported that all Doppler indices decline steadily with increased gestational age. The values are 1.265 – 0.825, 0.760 – 0.585 and 4.068 – 2.365 for PI, RI and S/D ratio respectively. Although the absolute values for these parameters between our findings are different, the pattern of decline of the PI for umbilical arteries in our studies is similar. Figueira *et al* **[5]** study that was conducted to define the fetal hemodynamic parameters in low risk pregnancies Doppler indices of Uterine, umbilical and middle cerebral arteries, in Brazil, found that the mean range value of PI for umbilical artery was 1.43 – 0.81. Their results have shown also that the values of PI decreases as the gestational age increases. The differences in our absolute values for the Doppler indices could be ascribed to the different population of the studies. The result of this study also showed a trend to increasing values from the lowest percentile 25th to the highest, which is 75th percentile, but no definite pattern for the 75^{th} percentile. These increasing value patterns are in agreement with the findings of other related studies conducted by, Sri Kumar *et al* **[2]**, Ayoola *et al* **[14]**. In Ayoola *et al* **[14]** study, which was conducted to establish the normogram for umbilical artery Doppler indices in Ile-Ife, Nigeria, reported increased PI values from the 5^{th} to the 95^{th} percentile across the gestational ages. The values are 1.094, 1.265, 1.422 for 5^{th}, 50^{th} and 95^{th} percentile respectively for the 15^{th} week gestational age and that of RI are 0.594, 0.760 and 0.760 for 5^{th}, 50^{th} and 95^{th} percentile respectively for the 15^{th} weeks gestational age.

Srikumar *et al* **[2]** study, also documented the same trend of the increase in the percentile values in their study conducted to evaluate the Doppler indices of the umbilical and fetal middle cerebral artery at 18-40 weeks of normal gestation in India. According to them at 18^{th} weeks gestational age, the 5^{th}, 25^{th} 50^{th}, 75^{th} and 95^{th} percentile values for PI are: 1.09, 1.26, 132, 1.50 and 1.62 respectively, while that of R1 of the gestational age are 0.67, 0.71, 0.76, 0.80 and 0.90 for 5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles respectively. According to Adekanmi *et al* **[22]**, in their study conducted to determine the Doppler indices in the uterine and umbilical arteries of healthy pregnant women, they were of the opinion that using other reference Doppler indices values in a different environment may be inaccurate for the monitoring of pregnancy in that environment and so, every setting should establish her own reference values.

In this study, the mean values of Doppler indices (PI, RI, PSV, and S/D ratio) for middle cerebral artery have been reported for normal singleton pregnancy at 16-42 weeks gestational age. The mean value of PI was higher than that of RI with S/D ratio having the highest mean value. The mean value of the peak systolic velocity was higher than that of the end-diastolic velocity. The peak systolic velocity of the middle cerebral artery is Doppler parameter for proper diagnosis of fetal anemia **[19, 23]**. The middle cerebral artery PI, RI, PSV, EDV and S/D ratio values change across the pregnancy in this study. Other studies conducted by **[18, 19, 24]**, which evaluated the MCA PI and RI reported a parabolic curve for MCA PI and RI with plateau between 28 and 30 weeks, which may be as a result of increased requirement of brain during early and late pregnancy. The findings of the aforementioned studies have shown a similar trend in the values of MCA PI and RI obtained in this study, but with differences in the absolute values that can be explained based on the different study population.

The progressive decline in the MCA and UA Doppler indices (PI and RI) with increased gestational age was evaluated using correlation analysis and the result confirmed for UA, that there was a statistical significant and negative linear correlations between UA Doppler indices (PI and RI) and gestational age, while non-statistical significant and negative linear correlations between MCA Doppler indices (PI and RI) and gestational age was found. These findings imply that the Doppler indices (PI, RI and SID ratio) evaluated in this study decreases with increase in the gestational age and vice-versa.

These findings are in agreement with the findings of related studies carried out by Ayoola *et al* **[14]**. Ayoola *et al* **[14]** study, which was conducted to determine the Doppler parameters of the Umbilical artery in normal pregnant women from 15-39 weeks gestational age, they reported that there was statistical significant and negative linear correlation between UA PI and gestational age ($r = -0.598$, $P < 0.05$), but significant and positive correlation between UARI and gestational age ($r = 0.437$, $P < 0.00$). The slight discrepancies observed in our findings could be explained based on the different study population.

The result of this present study showed that MCA PI and RI had non-statistical significant and negative correlations with gestational age. This result is consistent with some aspect of the finding of the study conducted by Srikumar *et al* **[2]**. According to the result of Srikumar *et al* **[2]** study, which was conducted to find the value of PI, RI of UA, and fetal MCA and then calculate CP ratio at 18-40 weeks of normal gestation, reported that from 30 to 40 weeks, the MCA PI values show a negative correlation with gestational age, MCA RI also show a negative correlation with gestational age from 30 weeks till 40 weeks. In Srikumar *et al* **[2]** study also, the values of MCA PI and RI shows a positive correlation with gestational age from 18 to 30 weeks and this finding is consistent with the findings of this present study. These differences in our findings could be ascribed to the nature of the studies, method of data analysis employed as well as the sample size studied.

The result of this study revealed that there were non-statistical significant and positive correlations between UA Doppler indices (PI and RI) and material variables (Age and BMI) respectively. This implies that a weak relationship exists between UA Doppler indices (PI and RI) and maternal variables such age and BMI, meaning that as the material age and BMI increases, UA PI and RI also increases. Weak and positive non-statistical significant correlations were found between MCA Doppler indices (PI, RI and S/D ratio) and maternal age. MCA Doppler indices (PSV and EDV) show weak and negative non-statistical significant correlations with maternal age in this study. These findings imply that despite the fact that the relationship between MCA Doppler indices (PI, RI and S/D ratio) and maternal age are weak, the aforementioned Doppler indices increase with increase in maternal age, while the PSV and EDV decrease with increasing maternal age.

5. CONCLUSION AND RECOMMENDATIONS

Normal mean values for the Doppler indices for UA and MCA of the Yoruba ethnic group in Lagos State have been determined. The Doppler indices decrease with increased gestational age. Both maternal age and body mass index have influence on the Doppler indices of UA and MCA.

The outcome of this study should be used as a guide for the monitoring and management of pregnant women with pregnancy related-complications especially in this study location, as any deviation in the Doppler indices values obtained in this study indicates adverse perinatal outcomes and such pregnant women should be properly monitored. Sonographers, when performing Doppler ultrasound, should take into consideration the maternal characteristics such as age and body mass index following the outcome of this study.

Conflict of Interest: None among the authors

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