Normal Second and Third Trimester Uterine and Umbilical Doppler Indices among Healthy Singleton Gestation Nigerian Women

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ABSTRACT

Background: Uterine and Umbilical artery Doppler ultrasound is an established and safe tool for quantitative analysis of the utero-placental and the feto-placental blood flow in pregnancy. **Aim:** To evaluate the Doppler indices in the uterine and umbilical arteries of healthy pregnant women. These will serve as baseline values in predicting impaired blood flow velocimetry in hypertensive disorders of pregnancy that leads to serious maternal and foetal health compromise. **Methodology:** This was a prospective longitudinal study in consenting singleton gestation women. The right and the left uterine arteries and the umbilical arteries were interrogated. Doppler parameters; Peak Systolic Velocity (PSV), End Diastolic Velocity (EDV), Resistive Index (RI), Pulsatility Index (PI) and the systolic to diastolic ratio(S/D) were obtained from each healthy pregnant indigenous Nigerian women. Pearson's correlation analysis of the relationship between these parameters and selected maternal demographic parameters was done. $P < 0.05$ was considered statistically significant. **Results:** The mean of the normal uterine and umbilical arteries values were different from most published reference values from other parts of the World. No correlation between these indices and maternal parameters were found in this study. **Conclusion:** Uterine and umbilical artery Doppler indices among normal indigenous pregnant African women are different from those from the developed World. Using other reference values may be inaccurate for pregnant women in our environment.

Key words: Doppler ultrasound; indices; normal pregnancy; umbilical artery; uterine artery

Introduction

The use of Doppler ultrasound in pregnancy to evaluate the uterine and umbilical arteries is an important clinical tool in detecting obstetric complications resulting from uteroplacental insufficiency, which may increase the risk of an adverse effect on both the mother and the fetus during pregnancy, labor, and delivery.[1] Disease entities related to uteroplacental deficiency, majorly from hemorrhage (39%) and maternal hypertensive (9.1%) disorders, have been observed to account for the largest proportion of maternal death in developing countries.[1] The maternal mortality rate in Nigeria is among the highest in the world with preeclampsia-eclampsia documented as the third largest cause of the high maternal mortality.[2] The World Health Organization report of 2015 documented a maternal mortality rate of 814/100,000 live births in Nigeria.[3]

Access this article online	
Quick Response Code:	Website: www.wajradiology.org
	DOI: 10.4103/1115-3474.198078

How to cite this article: Adekanmi AJ, Roberts A, Adeyinka AO, Umeh EO, Anor F, Odo JC, *et al*. Normal second and third trimester uterine and umbilical doppler indices among healthy singleton gestation Nigerian women. West Afr J Radiol 2017;24:1-7.

During pregnancy, there is modification of the vascular structure within the uterus leading to the development of neovascularization within the placenta and the fetus including redistribution of blood flow and alteration in circulating blood volume.[4] Hypertensive disorders in pregnancy lead to impairment of this normal physiological vascular modification resulting in abnormal hemodynamics and obstetric complications of impaired placentation. These complications are fetal growth restriction (intrauterine growth restriction [IUGR]), preeclampsia, intrauterine death, and placental abruption.[5]

Doppler ultrasound provides a noninvasive method for the study of maternal and fetal hemodynamics in pregnancy. Doppler interrogation of the uterine and umbilical arteries gives information on the perfusion of the uteroplacental and fetoplacental circulations, respectively.[4] Doppler ultrasonography has been used in the detection of complications of pregnancy and complications of fetal abnormality.[4]

A high mean resistance greater than the 95th percentile for RI or PI, absent or reversed end-diastolic flow will indicate abnormal Doppler waveforms, an indicator that the pregnancy may be at high risk of developing the complications of impaired placentation.[5] The relationship between abnormal Doppler velocimetry of uterine and umbilical artery in preeclampsia, intrauterine growth retardation, and adverse pregnancy outcome is well-established.[6-8] Doppler studies of uterine artery blood flow in the second trimester have been documented to be useful in predicting preeclampsia and/or IUGR.[7,8]

Fetal umbilical artery Doppler ultrasound, on the other hand, is often performed in the fetus suspected to be at risk of adverse pregnancy outcomes such as growth restriction, reduced amniotic fluid or movement, preterm delivery, and stillbirth. FitzGerald and Drumm[9] and other researchers[10,11] have published different reports on Doppler ultrasound of the umbilical artery and documented that in the assessment of uteroplacental circulation, high-resistance waveforms were obtained in preeclampsia.

The Doppler parameters used in obstetrics to measure the blood flow in these vessels are end-diastolic velocity (EDV), peak systolic velocity (PSV), pulsatility index (PI), resistance index (RI), and systolic to diastolic ratio (S/D ratio).[12] While the PI and RI are measures of resistance to flow in a blood vessel and resistance to flow in a blood vessel distal to the part being assessed at an instant in a cardiac cycle, respectively; the S/D ratio on the other hand is the ratio of the PSV to the EDV. Reference values of normal uterine artery Doppler indices (UtADIs) and umbilical artery Doppler indices (UmADIs) have been established in the developed world.[13-19] However, there is paucity of data in the area of uterine and umbilical artery velocimetry in Africa. The use of these reference values from developed countries may not be appropriate in African populations who are black people with a higher burden of preeclampsia. In this study, we sought to determine the PSV, EDV, S/D ratio, RI, and PI values among healthy Nigerian women with singleton gestation, and to determine if there is any relationship between the Doppler indices and the subjects' clinicodemographic parameters.

Materials and Methods

This is a hospital-based prospective longitudinal clinical study to obtain normal reference values of UtADIs and UmADIs in the second and third trimester of pregnancy among healthy normotensive pregnant women at the University College Hospital (UCH), Ibadan Oyo State in Southwestern Nigeria. The study was approved by the Oyo State Ministry of Health, Institutional Review Committee.

This study involved evaluation of arterial blood flow velocimetry in both the uterine and umbilical vessels with color and spectral Doppler ultrasound scans (USSs) among a cohort of 102 normal singleton pregnancy that booked early. This cohort was randomly recruited from the Booking Clinic and Antenatal clinic of UCH, a tertiary health institution in Ibadan. The UCH serves as a major referral center for other institutions in Ibadan, the Southwestern region and from other parts of the country.

Only pregnant women at gestational ages (GA) below 20 weeks were recruited at the booking and the antenatal clinics of the UCH Ibadan. We estimated the GA from the last menstrual period (LMP) in patients with reliable dates. Where patients were unsure of the GA; dating was based on the obstetrics USSs done in the first 13 weeks of pregnancy. Informed consent was obtained from all patients who agreed to participate in the study.

Pregnant women with singleton gestation who had no demonstrable fetal abnormality were recruited if they satisfy other inclusion criteria of: appropriate GA, normal blood pressure (BP), tested negative for proteinuria, and had none of the following exclusion criteria such as history of diabetes, chronic hypertension, alcohol and drug abuse, uterine anomaly, fetal anomaly, use of medication for hypertension, corticosteroids use, sickle cell, or vascular disorders that may affect Doppler measurements and gave informed consent to participate throughout the scan session were selected as cohort.

The PSV, EDV, RI, PI, and S/D ratio were obtained at the second trimester (21–25 weeks). The patients in the study who remained normotensive, proteinuria free, and did not develop any of the exclusion criteria conditions were scanned again in the third trimester between 31 and 35 weeks of gestation. The aforementioned five Doppler parameters were documented at every ultrasound examination session.

Clinical evaluation

Demographic and obstetric data, such as LMP and number of deliveries after 28 completed weeks of gestation (parity)

of the patients were documented. The brachial artery systolic and diastolic BP were obtained manually with a Mercury sphygmomanometer (Accoson, Harlow, England) using the standard method with the patient at rest. The measured values were recorded in mmHg. These data were recorded on the pre-prepared data form.

Ultrasound (ultrasound scan) Examination

Ultrasound examination was performed using a General Electric LOGIQ P5 (GE healthcare, Waukesha, WI, USA) ultrasound unit. An initial obstetric USS was carried out to document obstetric parameters, number of fetuses, and to rule out fetal malformations. Those with multiple gestations and fetal anomalies were excluded from the study. Color and Pulsed Doppler study was carried out with a transabdominal pulsed, curved array 3.5 MHz – 5.0 MHz transducer on eligible patients.

All scans were done independently by two certified radiologists at each visit. The degree of agreement between findings reported by the radiologists was evaluated with the initial ten patients scanned (k = 0.9) in the pilot study. The second trimester scan was done between 21 and 25 weeks and the third trimester scan was at 31–35 weeks of gestation. The PSV, EDV, RI, PI, and S/D ratio were generated with automatic tracing of the spectral waveforms by the ultrasound machine.

Uterine artery Doppler

For uterine artery investigation, the patients were scanned in a semirecumbent position with a slight lateral tilt. This minimizes the risk of developing supine hypotension syndrome due to inferior caval compression. The patient's abdomen was exposed from the xiphisternum to the groin hairline. The uterine artery was located by the transabdominal approach by placing the transducer longitudinally in the lower lateral quadrant of the abdomen with a slight medial angulation according to the method of Bhide *et al*.[19] Color Doppler imaging was then used to identify the uterine artery as it is seen crossing the external iliac artery.[19] The wall filter was kept at a low value (50–60 Hz) and the angle of insonation set below 20°. Then, pulsed wave Doppler with a gate size of 2 mm was placed over it at about 1 cm below the crossover point to generate the wave pattern.[19]

Both uterine arteries were insonated, the right before the left. After recording six consecutive spectral waveforms of similar size and shape, measurements were made on three consecutive uniform waveforms. The PSV, EDV, PI, RI, and S/D ratio were measured from the waveforms and the mean value from the three measurements was obtained for each parameter.

Umbilical artery Doppler

A free loop of umbilical cord was then located with B-mode ultrasonography for simplicity and consistency of measurements.[19,20] The umbilical artery was identified using color Doppler interrogation.[19] Pulsed Doppler with a gate size of 2 mm was applied. Spectral peak average intensities were set below 100 m/wcm^2 in this study.[21] Doppler velocities were recorded in the absence of fetal movement or uterine contraction.[21] The PSV, EDV, PI, RI, and S/D ratio were measured from three consecutive uniform umbilical arterial waveforms and the mean for each parameter documented.

Data analysis

All data were analyzed using the statistical package for social sciences (SPSS) version 20.0 (IBM, Armonk, NY, USA). The mean and standard deviation of the uterine and umbilical artery Doppler velocimetry were derived for descriptive analysis. The Kolmogorov–Smirnov (K-S) test was used to determine normality of distribution of the values of the Doppler parameters. Paired Student's *t*-test was used to evaluate the difference between the Doppler parameters in the right and left uterine arteries. While the difference between the Doppler velocimetry in the second and third trimesters was also evaluated with paired Student's *t*-test, the correlation between the Doppler parameters and GA and parity was determined with correlation analysis.

Results

One hundred and two patients who met the inclusion criteria and gave informed consent to participate in the study were enrolled. Eighty-five (83.3%) had complete first and second scan while 17 were either lost to follow-up or had high BP accounting for an attrition rate of 16.7%. The age group of the cohort, who were mostly nulliparous women, was between 23 and 45 years with a mean age of 31.6 ± 4 years. Most of the patients (40%) were in the 30–40 year age range while those aged 40 years and above accounted for only 2.3% [Table 1].

Table 1: Age and clinical parameters of the cohort

Parameters	Frequency (*n*=85)	Percentage
Age group (years)		
<30	27	31.8
30-34	34	40.0
35-39	22	25.9
≥40	2	2.3
Parity		
0	36	42.4
1	27	31.8
2	11	12.9
≥3	11	12.9
Systolic BP (mmHg)		
<100	9	10.6
100-109	23	27.1
110-119	30	35.2
≥120	23	27.1
Diastolic BP (mmHg)		
<60	4	4.7
61-69	41	48.2
70-79	26	30.6
≥80	14	16.5

BP – Blood pressure

The distribution of their systolic BP was mostly between 100 and 120 mmHg while their diastolic BP was 60 and 80 mmHg in most patients as shown in Table 1.

Uterine artery Doppler indices

The mean values and standard deviations of the PSV, EDV, S/D, RI, and PI of the uterine arteries on both sides at the second and third trimester scans, are shown in Tables 2 and 3 respectively. The K-S test of normality showed that these indices had a normal distribution.

The mean right and left uterine artery PSV at the second trimester was 63.05 ± 28.21 cm/s and 64.95 ± 26.26, EDV was 33.56 ± 16.83 cm/s and 34.74 ± 15.81 cm/s, S/D was 1.95 ± 0.41 and 1.99 ± 0.57, RI was 0.54 ± 0.17 and 0.53 ± 0.18, and PI was 0.74 ± 0.81 and 0.81 ± 0.28. There was no statistically significant difference in the uterine artery indices on the right and left in the second trimester [Table 2]. At the third trimester scan, the right and left PSV were 65.70 ± 28.31 cm/s and 80.85 ± 31.42 cm/s, EDV was 36.75 ± 17.44 cm/s and 46.20 ± 19.55 cm/s, S/D was 1.86 ± 0.41 and 1.83 ± 0.44, RI was 0.50 ± 0.19 and 0.48 ± 0.20, and PI was 0.70 ± 0.24 and 0.72 ± 0.23 on the right and left, respectively. The PSV and EDV showed significant differences between the right and left uterine arteries, with the left uterine artery recording higher mean values at both scans.

Table 2: Uterine artery Doppler indices at second trimester scan

Variables	Mean±2SD		*t*	*P*
	Right uterine artery	Left uterine artery		
PSV (cm/s)	63.05±28.21	64.95±26.26	−0.615	0.540
EDV (cm/s)	33.56±16.83	34.74±15.81	−0.587	0.558
S/D ratio	1.95±0.41	1.99±0.57	−0.512	0.610
RI	0.54±0.17	0.53±0.18	0.410	0.683
PI	0.74±0.81	0.81±0.28	−1.994	0.049

SD – Standard deviation; PSV – Peak systolic velocity; EDV – End diastolic velocity; S/D – Systolic to diastolic; RI – Resistance index; PI – Pulsatility index

Table 3: Uterine artery Doppler indices at third trimester scan

Variables	Mean±2SD		*t*	*P*
	Right uterine artery	Left uterine artery		
PSV (cm/s)	65.70±28.31	80.85±31.42	−4.547	<0.001*
EDV (cm/s)	36.75±17.44	46.20±19.55	−4.271	<0.001*
S/D ratio	1.86±0.41	1.83±0.44	0.739	0.462
RI	0.50±0.19	0.48±0.20	1.185	0.240
PI	0.70±0.24	0.72±0.23	−0.778	0.439

*Statistically significant (P<0.05). SD – Standard deviation; PSV – Peak systolic velocity; EDV – End diastolic velocity; S/D – Systolic to diastolic; RI – Resistance index; PI – Pulsatility index

At the third trimester scan, the mean values of the PSV and the EDV showed consistent increase while the S/D, RI, and PI demonstrated consistent decrease in the mean values. No statistically significant difference was noted between the second and the third trimester scans in this study, except in the uterine artery PSV and EDV which showed significant difference [Tables 3 and 4].

The mean of the right and left UtADIs at the second and third trimester were compared. The PSV was 63.59 ± 23.11 cm/s and 72.97 ± 25.65 cm/s ($P = 0.007$), EDV was 34.15 ± 13.42 cm/s ($P = 0.001$) and 41.47 ± 15.47 cm/s in the second and third trimester, respectively. Similarly, the S/D and PI showed a significant decrease at the third trimester. The RI showed a marginal decrease and was 0.53 ± 0.15 at the second and 0.49 ± 0.18 at the third trimester scan, but the decrease was not statistically significant ($P = 0.073$) as shown in Table 5.

Umbilical artery Doppler parameters

The mean values and the standard deviation of the umbilical artery Doppler parameters in the second and third trimester are as shown in Table 6. All the parameters showed a significant change in their mean value at the third trimester scan. There was significant increase in the mean values of the PSV and EDV while the S/D, RI, and PI decreased significantly between the second and third trimesters scan [Table 6].

Correlation between Doppler indices and maternal parameters

The Pearson correlation analysis was done to evaluate the relationship between the age of the mothers, parity, and GA and the UtADIs as well as the UmADIs. The correlation

Table 4: Comparison of Doppler indices in both right and left uterine arteries at 21-25 weeks and 31-35 weeks

Variables	Second trimester (21-25 weeks)			Third trimester (31-35 weeks)		
	Mean±SD		*P*	Mean±SD		*P*
	Right uterine	Left uterine		Right uterine	Left uterine	
PSV (cm/s)	63.05±28.21	64.95±26.26	0.540	65.70±28.31	80.86±31.41	<0.001*
EDV (cm/s)	33.56±16.83	34.74±15.81	0.558	36.75±17.44	46.20±19.55	<0.001*
SD ratio	1.95±0.41	1.99±0.57	0.610	1.86±0.41	1.83±0.44	0.462
RI	0.53±0.17	0.53±0.18	0.683	0.50±0.19	0.48±0.20	0.240
PI	0.74±0.24	0.81±0.28	0.049	0.70±0.24	0.73±0.23	0.439

*Statistically significant (P<0.05). SD – Standard deviation; PSV – Peak systolic velocity; EDV – End diastolic velocity; S/D – Systolic to diastolic; RI – Resistance index; PI – Pulsatility index

coefficients between the maternal age, GA, and PSV and EDV in the second and third trimester, the PI in the second trimester and the RI in the third trimester all showed very weak positive correlations. There was also weak positive correlation with S/D in the third trimester but weak negative correlation in the second trimester. While the RI showed weak positive correlation with the mothers' ages in the second trimester, there was moderate negative correlation between S/D with maternal age only in the second trimester but this was not statistically significant [Table 7].

Generally, very weak correlation was found between these maternal characteristics and UmADIs [Table 8].

Discussion

Doppler ultrasound is an established, easily accessible and cheap noninvasive method for the study of the uteroplacental and fetoplacental circulations in pregnancy. Uterine and umbilical Doppler ultrasonography have been used in the detection of complications of pregnancy and of fetal abnormality.[4]

In this study, we have documented the normal mean values of uterine and umbilical artery Doppler indices in gravid normal singleton gestation Nigerian women. This will be useful in the management of at-risk patients with abnormal vascular changes associated with impaired placentation in preeclampsia that is more common among black African women.

Table 5: Comparison of the mean values of both uterine arteries indices at the second and third trimester scan

Doppler indices	Mean±SD		*t*	*P*
	Second trimester (21-25 weeks)	Third trimester (31-35 weeks)		
PSV (cm/s)	63.59±23.11	72.97±25.65	−2.778	0.007*
EDV (cm/s)	34.15±13.42	41.47±15.47	−3.408	0.001*
S/D ratio	1.97±0.37	1.85±0.35	2.554	0.012*
RI	0.53±0.15	0.49±0.18	1.816	0.073
PI	0.77±0.21	0.71±0.19	2.013	0.047*

*Statistically significant (P<0.05). SD – Standard deviation; PSV – Peak systolic velocity; EDV – End diastolic velocity; S/D – Systolic to diastolic; RI – Resistance index; PI – Pulsatility index

The normal UtADI and UmADI values were derived by a longitudinal study of the uterine and umbilical arteries in the second and third trimesters by a transabdominal approach performed on a healthy pregnant cohort who served as their own controls at the different points. The longitudinal approach has been documented to be better in the determination of vascular changes in pregnancy states because of susceptibility of pregnancy to intrinsic and extrinsic factors.[2] Most of the studies in literature recruited an average of twenty patients for each GA from about 20–40 weeks employing a cross-sectional method.[13,14,16,17] This small sample size per GA, we believe, may have limited the generalizability of their results. A relatively larger sample size at those categorical GAs was evaluated in this study to improve generalizability of the result.

The mean values of the UtADI on the right and left uterine arteries derived in this study were not significantly different in agreement with the work of Lakhkar and Ahamed.[15] However, Kurmanavicius *et al*.[16] found a significant difference only in the RI in their study.

The mean UtADIs in this study at 21–25 weeks and at 31–35 weeks in PSV, EDV, S/D, RI, and PI reflect the decreased vascular resistance and increased blood flow to the placental bed as normal pregnancy advances.[22,23] This is also in agreement with the findings of many other researchers.[12-16] The S/D, RI, and PI values were almost similar to the findings of Lakhkar and Ahamed[15] in India, and the mean PI values of Bahlmann *et al*.[24] in Germany. However, the values were lower than those reported by Peixoto *et al*.[25] in Brazil and Gómez *et al*. in Spain[14] as well as those of Oloyede and Iketubosin[26] in Lagos, Nigeria. Only Kurmanavicius *et al*. in Thailand, to our knowledge, reported lower UtADI at these GAs. This we presume may be due to the smaller numbers of patients enrolled at each GA, differences in methodology, or equipment. We also believe that racial differences might have an important role in these findings.

In the umbilical arteries, the UmADIs also showed significant differences at the third trimester compared to the second. This we presume is due to the decreasing vascular resistance in the feto-placental unit with increasing GA. The UmADI values in this study (S/D was 2.59 and 2.19, RI was 0.6 and 0.53, and PI

Table 6: The umbilical artery Doppler velocimetry at the second and third trimester

Variables	Mean±SD		*t*	*P*
	Second trimester (21-25 weeks)	Third trimester (31-35 weeks)		
PSV (cm/s)	39.39±8.90	43.85±8.76	−3.079	0.003*
EDV (cm/s)	16.16±5.67	21.08±6.85	−5.113	<0.001*
S/D ratio	2.59±0.0.65	2.19±0.53	4.466	<0.001*
RI	0.60±0.11	0.53±0.11	4.233	<0.001*
PI	1.00±0.20	0.80±0.20	7.384	<0.001*

*Statistically significant (P<0.05). SD – Standard deviation; PSV – Peak systolic velocity; EDV – End diastolic velocity; S/D – Systolic to diastolic; RI – Resistance index; PI – Pulsatility index

Table 7: Correlation of maternal age, gestational age, and parity of cohort with the uterine artery Doppler parameters

	Second trimester uterine artery parameters					Third trimester uterine artery parameters				
	PSV	EDV	S/D	RI	PI	PSV	EDV	S/D	RI	PI
	r (P)	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*
Age of mothers	0.014 (0.900)	0.038 (0.728)	−0.43 (0.694)	0.220 (0.841)	0.059 (0.592)	0.075 (0.495)	0.002 (0.984)	0.014 (0.899)	0.197 (0.071)	−0.052 (0.634)
Parity	−0.083 (0.451)	−0.039 (0.724)	−0.028 (0.802)	0.086 (0.431)	0.005 (0.965)	0.078 (0.478)	0.008 (0.941)	0.059 (0.591)	−0.057 (0.606)	−0.200 (0.067)
GA	0.185 (0.090)	0.083 (0.451)	0.148 (0.176)	0.134 (0.222)	0.195 (0.074)	0.075 (0.495)	0.002 (0.984)	0.131 (0.232)	0.194 (0.075)	0.068 (0.534)

PSV – Peak systolic velocity; EDV – End diastolic velocity; S/D – Systolic to diastolic; RI – Resistance index; PI – Pulsatility index; GA – Gestational age

Table 8: Correlation of maternal age, gestational age, and parity of cohort with the umbilical artery Doppler parameters

	Second trimester umbilical artery parameters					Third trimester umbilical artery parameters				
	PSV	EDV	S/D	RI	PI	PSV	EDV	S/D	RI	PI
	r (P)	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*	*r (P)*
Age of mothers	0.103 (0.347)	0.196 (0.072)	−0.200 (0.066)	0.181 (0.097)	0.054 (0.625)	0.197 (0.071)	−0.052 (0.634)	0.302 (0.005*)	0.150 (0.174)	0.080 (0.472)
Parity	0.060 (0.586)	0.052 (0.638)	−0.055 (0.619)	0.130 (0.237)	0.045 (0.684)	−0.057 (0.606)	−0.200 (0.067)	0.217 (0.046*)	0.134 (0.226)	0.071 (0.524)
GA	0.070 (0.525)	0.062 (0.575)	−0.050 (0.651)	0.019 (0.862)	0.090 (0.411)	0.194 (0.075)	0.068 (0.534)	0.122 (0.267)	0.132 (0.232)	0.132 (0.232)

PSV – Peak systolic velocity; EDV – End diastolic velocity; S/D – Systolic to diastolic; RI – Resistance index; PI – Pulsatility index; GA – Gestational age. *P* value is significant at <0.05.

was 1.00 and 0.80 at the second and third trimester scan) were comparably lower than most previously reported data.[13,15,17]

Chanprapaph *et al*.[13] in Thailand reported an S/D of 3.56, 3.39, 2.94, and 2.53, RI of 0.756, 0.72, 0.679, and 0.62, and PI of 1.27, 1.256, 1.11, and 0.958 at 21, 25, 31, and 35 weeks, respectively. Kurmanavicius *et al*.[16] reported umbilical artery PI of 0.82, 0.77, and 0.73 at 25, 31, and 35 weeks in Switzerland. A PI of 1.90, 1.67, 1.47, and 1.39 at 21, 25, 31, and 35 weeks was documented by Acharya *et al*.[17] The PSV and EDV in this study were higher than what was documented by Acharya *et al*. The discrepancies in the mean values of S/D, RI, and PI may be related to differences in the number of patients recruited at these GAs in most of these studies or differences in the technique and equipment employed. The possibility of the role of racial differences may need to be verified by future studies.

Correlation of the UtADIs RI, PI, and S/D with maternal age, parity, and GA in this study showed no strong significant associations between these variables. This is in agreement with the report of Chanthasenanon *et al*.[27] that documented no correlation in the uterine arteries. Unlike Pirhonen *et al*.[28] and Prefumo *et al*.[29] where correlation was found between the PI and maternal age and parity and RI, respectively. These may be due to most of our cohort being nulliparous and primigravidas and also mostly belong to the 30–39 years age range.

There is paucity of report in literature on the relationship between the UmADIs and maternal age, parity, and GA of normal healthy pregnant women. This study found no strong correlation between these variables. Future studies with a more robust longitudinal study and shorter scan intervals will be necessary to provide data which will span all the GAs and verify the preliminary observations from this study.

Conclusion

From this study, we have deduced preliminary reference values for the UtADIs and UmADIs in healthy pregnant Nigerian women in Ibadan. These values show significant lower indices to that of the developed world.

Acknowledgment

We thank the resident doctors and the staff at the Ultrasound Suite of the Department of Radiology and at the booking clinic of the Obstetrics and Gynecology Department of the University College Hospital, Ibadan, and the research assistant, Mrs. Ola- for their assistance and cooperation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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