

Nomogram of Umbilical, Mean Cerebral and Uterine Arteries Resistive Index at 28 – 40 Weeks of Gestation in Cameroonian Population: A Pilot Study

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Abstract

Background:

Mother and fetal Doppler ultrasound during pregnancy is an established and safe tool for quantitative analysis of the utero-placental and the fetoplacental blood flow and seems to be affected by Ethnic heterogeneity.

Objective.

To establish normative data for the resistive index of Uterine arteries, Umbilical artery and middle cerebral artery of Cameroonian pregnant women in the second half of pregnancy using multiples of the median and percentile reference range.

Methods.

We conducted a cross-sectional study on 93 low risk singleton gestation women aged above 18 years between 28 and 39 weeks of gestation in two hospitals in Cameroon during 7 months. We seek for resistive index (RI) of both left and right uterine arteries (LUt and RUt), Umbilical artery (UmA) and Middle cerebral artery (MCA). We also estimated the gestational age (GA), the mother age, the fetal weight (EFW) and the cerebro – placental ration (CPR). Pearson's correlation analysis of the relationship between these RI and selected maternal parameters was done. Regression modeling across gestational age was performed to obtain the reference values and normogram curve with values ranged at 5 and 95th percentiles. $P < 0.05$ was considered statistically significant.

Results.

The mean GA and EFW was 33.5 +/- 2.92 weeks (median of 34) and 2337.5 +/- 734 g respectively. The means RI value of target vessels were 0.55 +/- 0.077; 0.76 +/- 0.071 ; 0.48 +/- 0.077 and 0.46 +/- 0.087 for UmA, MCA, RUt and LUt with extremes values of des 0.38 to 0.77 ; 0.49 to 0.87; 0.30 to 0.70 and 0.29 to 0.69 respectively. Only UmA RI and CPR values had shown correlations with GA ($r = -0.338$, $p \leq 0.01$ and $r = 0.314$; $p \leq 0.001$) and EFW ($r = -0.445$, $p \leq 0.001$ and $r = 0.234$; $p = 0.02$). No difference between LUt and RUt RI values was found. The nomogram curve for UmA, MCA, RUt and LUt value revealed a general low RI values of in our sample.

Conclusions.

Fetal Doppler should carefully interpreted according to general low RI values during low risk singleton pregnancy shown by this study. The generated 5 and 95th percentiles RI values curves for each target vessel could be useful in that way.

Trial registration:

Background

The use of Doppler ultrasound in pregnancy is actually the most reliable, non-invasive and low cost method for exploration of hemodynamic changes in mother and fetus (1). Antepartum fetal surveillance with Doppler ultrasound has shown significant diagnostic efficacy for hemodynamic complications, such as intrauterine growth restriction (IUGR) and preeclampsia. This great interest of Doppler mode in pregnancy is not only due to be capable of studying materno – fetal blood circulation but mainly by the opportunity to provide novel indicators to evaluate the well-being of the fetus in utero (1).

Many vessels can be explored by the antenatal use of Doppler (such as umbilical artery, cerebral arteries, Arantius canal, fetal aorta, uterine arteries, etc.) with different meanings in term of feasibility and utility (2). For instance, umbilical arteries are the most explore vessel in pregnancy. Blood flow evaluation of umbilical arteries permits abnormal perfusion diagnosis (3). Focus clinical situations included intrauterine growth retardation, impaired amniotic fluid volume or active fetal movement, prematurity or suspected fetal death. Other vessels show similar utilities such as uterine arteries in preeclampsia (4–7) and Middle cerebral artery in situation of worse fetal prognostic due to hypoxia (8–11). Utero – placental blood fow is supply by uterine arteries and their analysis is useful in placentation abnormalities by exploring the utero – placental resistance and abnormalities associated (12).

Many Doppler parameters can be used in obstetrics like end-diastolic velocity (EDV), peak systolic velocity (PSV), pulsatility index (PI), resistance index (RI), and systolic to diastolic ratio (S/D ratio) (5). It is the RI which is widely used in Obstetrical clinical routine in ours milieu. It reflects the measurement of flow resistances distal to the point assessed unlike of PI that reflect resistance at the level assessed. Doppler waveforms and parameters help to predict and detect clinical situations linked to utero - placental insufficiency and impaired fetus well-being by comparing with normal value contains in nomograms. The use of nomogram established by other countries particulary north developed countries (3,13–17) may not be appropriate in sub saharan african populations who have different heterogenicity in ethnicity than in north people. In fact, there are some evidences that heterogenicity in the ethnicity influence both fetal and maternal blood flow, thus affects the fetal growth during pregnancy particularly during the last trimester (18). Our purpose in this study was to establish normative data for the resistive index of Uterine arteries, Umbilical artery and middle cerebral artery at the second half of pregnancy in a Sub Saharan country like the Cameroon.

Methods

This is a hospital-based cross sectional clinical study to obtain normal reference values of Umbilical, Mean cerebral and uterine resistive index in the second and thirdtrimester of pregnancy among healthy

normotensive pregnant women at two Gynecological and obstetrical Hospitals in Yaoundé and in Douala in Cameroon during December 2016 and June 2017.

We evaluated once 93 women with normal singleton pregnancy with their gestation age between 28 to 39 +6 weeks. Fetal age was calculated based on the last menstrual period and cross checked by sonographic measurement of the biometrical parameters (Biparietal diameter, Cranial and abdominal circumferences, femoral length) using the Hadlock method (19).

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, normal estimated fetal weight within 5th and 95th percentiles 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

Of the 129 pregnant women during the studied period, we excluded those patients without regular prenatal surveillance and birth records. Patients were also excluded if they had any disease during the study or received a regimen of tocolytic and antihypertensive agents during pregnancy. Pregnancy outcome was confirmed by reviewing hospital medical records.

Ultrasound examination

All sonographic examination was performed with a MINDRAY DC-6/DC-7, de high definition equipped with a 2.5 – to 6 MHz transducer. For beginning, each pregnant women benefit for a routine obstetrical US scan which help us to exclude multiple pregnancy, any placental, amniotic fluid or congenital abnormalities and permit us to obtain the estimated fetal weight by Hadlock formulae generated by the machine. Then we seek for RI of targeted arteries in this order:

First the umbilical arteries, color Doppler mode measures had been taken at the placental emergence of the cord after obtained waves separated from venous flux with an insonation angle inferior to 30°.

Second the mean cerebral arteries, a bi-dimensional axial scan of the fetal brain, including the thalami and cavitas septi pellucidi, was obtained. The circle of Willis and middle cerebral arteries were visualized using color flow mapping. Pulsed-wave Doppler velocimetry of the MCA closest to the transducer was obtained. The Doppler gate size of 4 – 5 mm was positioned close to the origin of the artery, near the internal carotid artery. The beam–blood vessel angle was kept near to 0° but always less than 20°.

At last the uterine arteries, the patients were scanned in a semi-recumbent 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* (16). Color Doppler imaging was then used to identify the uterine artery as it is seen crossing the external iliac artery. 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. Both uterine arteries were insonated, the right before the left.

For all arteries, measurements were made on three consecutive uniform waveforms after recording six consecutive spectral waveforms of similar size and shape. We collected each generated RI by the machine with the formulae used (SD)/S. We calculated the Cerebro – placental ration by dividing each UmA RI value to McA RI value of the same fetus adjusted to two decimals.

Statistical analysis

Statistical analysis was performed using SPSS 14.0 (SPSS Inc., Chicago, IL, USA). Variables demonstrated as Mean \pm Standard Deviation (SD). A value of $P < 0.05$ was considered statistically significant. Pearson correlation and Regression were used for evaluation of correlation between indices and gestational age. Reference ranges (90% range between 5th and 95th centiles) and the 95% confidence interval were constructed for each parameter and displayed in graphic form. Linear, quadratic and cubic regression models were fitted to estimate the relationship between fetal Doppler variables and gestational age (in weeks). The best fitting model for each variable was selected.

Results

Data of the 93 eligible participants fulfilling the inclusion and exclusion criteria were analyzed. The mean maternal age was 29.6 \pm 5.03 (range 18 to 51) years. Each GA week were represented. Mean GA was 33.5 \pm 2.92 weeks similar to median (34 weeks). The mean EFW was 2337.5 \pm 734 g. Both GA and EFW had a normal distribution. Maternal and fetal demographic data and percentiles of Doppler RI of target arteries of this study are shown in Table 1.

Table 1. Means, and standard deviations of demographic and quartiles Doppler Resistive index findings in study population

	Mean	SD	Percentiles				
			10 ^e	25 ^e	50 ^e	75 ^e	90 ^e
Age (yr)	29.6	5.03					
Estimated fetal weight (g)	2337.5	734.7					
Gestational age (wk)	33.5	2.92					
Resistive Index							
Umbilical artery	0.55	0.077	0.46	0.51	0.56	0.60	0.67
Middle cerebral artery	0.76	0.071	0.67	0.73	0.78	0.81	0.84
Cerebro –placental ratio	1.39	0.212	1.14	1.26	1.39	1.52	1.65
Uterines arteries							
Right	0.48	0.077	0.39	0.41	0.46	0.53	0.55
Left	0.46	0.087	0.35	0.41	0.48	0.53	0.57

Resistive index reference curves

The reference curves of the resistive index (RI) of all the target arteries is characterized by a cubic pattern according to GA in week. Showing for UmA and McA RI values, a decrease from 0.61 to 0.48 and from 0.82 to 0.79 at 28 – 40 weeks' gestation respectively with a peak RI at 34 weeks (0.59) and 32 weeks (0.79). Otherwise LUt and RUt RI shown an increase from 0.43 to 0.45 and from 0.45 to 0.61 without a real peak. The assume total of subject out of the 5th – 95th percentiles curves for each RI value of the targeted arteries was less than 4%. **Table 2, 3, 4, 5** shows 5th, 50th, 95th percentile values for Doppler waveform RI of Umbilical artery, Mean cerebral artery and both Left and right uterine arteries.

Table 2. 5th, 50th, 95th percentile values for Doppler waveform RI of Umbilical artery,

		Doppler waveform RI of Umbilical artery						
		n	Mean	SD	5thcentile	Median	95thcentile	Maximum
AG	28	6	0.61	0.07	0.55	0.58	0.74	0.74
(wk)	29	5	0.65	0.07	0.53	0.66	0.72	0.72
	30	7	0.54	0.08	0.42	0.53	0.67	0.67
	31	5	0.56	0.08	0.49	0.52	0.66	0.66
	32	8	0.58	0.03	0.52	0.58	0.64	0.64
	33	12	0.57	0.10	0.39	0.57	0.70	0.70
	34	8	0.59	0.10	0.43	0.58	0.77	0.77
	35	18	0.55	0.06	0.47	0.55	0.67	0.67
	36	9	0.50	0.09	0.38	0.49	0.69	0.69
	37	7	0.52	0.04	0.43	0.53	0.56	0.56
	38	6	0.55	0.03	0.52	0.54	0.59	0.59
	39	2	0.48	0.04	0.45	0.48	0.51	0.51

Table 3. 5th, 50th, 95th percentile values for Doppler waveform RI of Mean cerebral artery

		Doppler waveform RI of Mean cerebral artery						
		n	Mean	SD	5th centile	Median	95th centile	Maximum
AG	28	6	0.82	0.04	0.76	0.82	0.87	0.87
(wk)	29	5	0.80	0.07	0.69	0.81	0.86	0.86
	30	7	0.73	0.05	0.64	0.75	0.80	0.80
	31	5	0.72	0.13	0.49	0.77	0.82	0.82
	32	8	0.79	0.05	0.71	0.79	0.85	0.85
	33	12	0.77	0.07	0.65	0.77	0.87	0.87
	34	8	0.77	0.06	0.68	0.79	0.84	0.84
	35	18	0.76	0.08	0.50	0.79	0.85	0.85
	36	9	0.75	0.08	0.60	0.77	0.85	0.85
	37	7	0.74	0.05	0.64	0.73	0.82	0.82
	38	6	0.76	0.08	0.63	0.79	0.83	0.83
39	2	0.79	0.05	0.75	0.79	0.82	0.82	

Table 4. 5th, 50th, 95th percentile values for Doppler waveform RI of left uterine artery,

		Doppler waveform RI of left uterine artery						
		n	Mean	SD	5thcentile	Median	95thcentile	Maximum
AG	28	6	0.43	0.11	0.29	0.41	0.61	0.61
(wk)	29	5	0.48	0.06	0.41	0.47	0.57	0.57
	30	7	0.46	0.11	0.36	0.44	0.69	0.69
	31	5	0.48	0.07	0.40	0.45	0.56	0.56
	32	8	0.48	0.09	0.33	0.51	0.59	0.59
	33	12	0.46	0.08	0.32	0.47	0.57	0.57
	34	8	0.45	0.06	0.37	0.43	0.54	0.54
	35	18	0.49	0.09	0.31	0.50	0.60	0.60
	36	9	0.48	0.08	0.40	0.44	0.61	0.61
	37	7	0.52	0.10	0.38	0.49	0.65	0.65
	38	6	0.37	0.06	0.29	0.38	0.42	0.42
	39	2	0.45	0.00	0.45	0.45	0.45	0.45

Table 5. 5th, 50th, 95th percentile values for Doppler waveform RI of right uterine artery,

		Doppler waveform RI of right uterine artery						
		n	Mean	SD	5thcentile	Median	95thcentile	Maximum
AG	28	6	0.45	0.03	0.41	0.44	0.49	0.49
(wk)	29	5	0.49	0.02	0.46	0.50	0.51	0.51
	30	7	0.46	0.11	0.36	0.44	0.70	0.70
	31	5	0.52	0.08	0.41	0.56	0.60	0.60
	32	8	0.49	0.05	0.42	0.49	0.55	0.55
	33	12	0.47	0.08	0.35	0.48	0.58	0.58
	34	8	0.52	0.09	0.39	0.51	0.68	0.68
	35	18	0.50	0.07	0.36	0.51	0.62	0.62
	36	9	0.44	0.10	0.30	0.44	0.59	0.59
	37	7	0.53	0.07	0.44	0.53	0.66	0.66
	38	6	0.46	0.05	0.40	0.45	0.53	0.53
	39	2	0.61	0.01	0.60	0.61	0.62	0.62

Association between Resistive index and the materno – fetal parameters

Inverse mild correlation was found between RI UmA values and both GA in week ($r=-0.338$, $p = 0.001$) and EFW (-0.445 , $p = 0.00$) meaning that the resistivity of the umbilical arteries links with GA and EFW; it reduces with the progress of pregnancy.

None of MCA, RUt nor LUt revealed such association with materno –fetal parameters. All these Pearson correlation coefficients is presented in details in **Table 6**.

Table 6: Correlation between Resistives index and materno –fetal parameters

Parameters	Maternal age		Gestational age		EFW	
	r	p	r	p	r	P
Ombilical artery RI	0.215	0.03	-0.338	≤0.001	-0.445	≤0.001
Mean cerebral artery RI	-0.029	0.78	-0.117	0.26	-0.160	0.13
CPR	-0.174	0.09	0.314	≤0.001	0.234	0.02
Uterine artery RI						
Right	-0.040	0.70	0.132	0.20	-0.051	0.63
Left	0.018	0.87	-0.006	0.95	-0.098	0.35

Cerebro –placental ratio

The calculated CPR was positively correlated with fetal characteristics (Table 6). It suppose that the CPR increase with the evolution of pregnancy and may varies at the same GA with the EFW. The mean, 5th and 95th percentiles values of CPR is shown in table 7.

Table 7: 5th, 50th, 95th percentile values for Cerebro –placental ratio values

		Cerebro –placental ratio values					
		n	5thcentile	Mean	SD	Median	95thcentile
AG (wk)	28	6	1.18	1.36	0.15	1.37	1.51
	29	5	1.05	1.26	0.22	1.19	1.62
	30	7	1.06	1.38	0.19	1.39	1.64
	31	5	1.00	1.29	0.23	1.27	1.61
	32	8	1.19	1.37	0.13	1.36	1.56
	33	12	1.10	1.40	0.25	1.37	1.97
	34	8	0.99	1.35	0.27	1.35	1.78
	35	18	0.75	1.41	0.23	1.42	1.76
	36	9	1.23	1.53	0.22	1.48	2.01
	37	7	1.31	1.44	0.21	1.36	1.91
	38	6	1.19	1.39	0.13	1.39	1.53
	39	2	1.61	1.64	0.04	1.64	1.67

Normogram curves of RI and CPR values (5th to 95th percentiles)

Regression model fit well by parabolic patterns for all RI values of each target arteries with $R = 0.115$; $R = 0.028$; $R = 0.037$ and $R = 0.035$ respectively to UmA, McA, Lut and RUt (Fig 1).

Discussion

Fetal hemodynamic study is routine in clinical practice since 1977, with the velocymetric analysis of UmA and the MCA and the capacity to diagnose fetal perfusion abnormalities(6,20). Therefore, evaluation of the perfusion of intra uterine organs and its correlation with the well – being of the fetus become possible (12), giving a reliable and useful method for pregnancy follow – up. During this study, we determined the Cameroonian reference values of Doppler Resistive index of 4 arteries (UmA, McA, LUt and RUt) on which the fetal hemodynamic evaluation lie on and elaborate the reference curve at 5th and 95th percentiles.

This study had shown that these curves have a parabolic pattern and that they have the same shape of others curves found elsewhere in the world (3,6,14,21–26).

Resistive index of umbilical artery.

The same general findings concerning the RI value of UmA had been made in this study. First we found a decrease of RI UmA value according to the evolution of GA. The fall in RI UmA during the progress of pregnancy reveals a progressive increase of fetal cardiac ejection volume and the decrease of placental vessel resistivity giving to the fetus enough blood supply for its growth. This decrease of the resistivity of UmA is the respond mechanism for a progressive fetal need during growth. The moderate inverse relation found ($r = -0.445$, $p \leq 0.001$) between RI UmA and EFW confirm our assertions. The slightly lower RI values on normogram UmA curves (5th and 95th percentiles) found in this studied population may be partly due to the difference of fetal characteristics in general and in EFW in particular. Kehila et al. in tinusia have demonstrated that the RI UmA values are linearly ($r = -0.67$) linked to the fetal growth (here the gain of fetal weight)(27). When we focus on their data like EFW (mean = 2291 g vs 2337 +/- 734 g in ours), RI UmA (mean = 0.63 vs 0.55) and the extremes (0.51 vs 0.51 et 0.77 vs 0.74), we remark that our data seem to follow the same gradient which link the fetal growth but with a deeper decrease of UmA RI. Other Sub Saharan author like Adekanmi et al. in 2016 in Nigeria found the same lower RI tendency in a group of singleton black women with normal pregnancy at the second and the third trimester respectively 0.60 +/- 0.11 et 0.53 +/- 0.11(25). At this point, one could question on either the racial specificity or ethnical tendency of this findings that Misra and al found (18) in USA. They found that the magnitude of change in the Umb A RI predicted the EFW in African

American women. This suggests a careful interpretation of a RI UmA during pregnancy particularly in African women. The relative lack of study in Sub Saharan black African women in general, and in Cameroonian in particular, to the best of our knowledge reveals the interest of the question. Thus, these low normal values tendency of Umb A RI than those generally describe may justify the utility and the need to elaborated national reference curves of RI during pregnancy. Underlying the fact that for UmA RI, any increase of RI value up to two standard deviation is considered as abnormal and which needs an intervention (23).

Resistive Index of Mean cerebral artery

Doppler study of the McA have a primordial place in the evaluation of the well- being of the fetus during pregnancy because it directly reveals fetal suffering by evaluating the diastolic flux disturbance in brain. This due to embryologic ranking of blood supply during organogenesis starting first in the cephalic than the caudal portion (28). In this study, we found a cubic pattern of the normogram curves of RI McA and no correlation with GA nor than others fetal characteristics. This contrast with others findings elsewhere concerning only GA(3,10,21,24). The absence of correlation between RI McA relation with GA found in this study could be explained to fetal characteristics. In fact, our studied population is mostly made up of third trimester pregnant women. During this period, the variation of McA RI does not depend on the fetus himself but depends on the blood flow through placental villi in general, and on the oxygen perfusion in particular (6,14,24). Thus the lack of correlation between McA RI and GA could simply reflect the good staus of placental exchanges and/or the absence of hypoxie or anemia in studied pregnant women that are the direct reflection of the exclusion criterias (Cf materials and methods). It is clearly prove that abnormal oxygen perfusion through placental villi is associated with to a reduction of the brain vessel resistivity and that Doppler analysis of blood flux in the MCA is a substantial tools in the prediction of the worse neurological outcomes after birth(6,12,29). This is why in clinical situations where UmA RI is normal, only McA RI value less than the 5th percentile is considered abnormal (6). We found 5th percentile McA RI values superior to those generally used (3,10,21,22). These high McA RI values in our studied population support ours previous assertions on the good fetal well – being of pregnant women in this study. Moreover, the absence of correlation between EWF and MCA RI values highlight the absence of a direct link between the fetal growth (pregnancy progress) and the vascular resistance of fetal cerebral vessel generally observed and reported at the third trimester during pregnanct (1,10,20,29,30).

Rigth and Left Uterine arteries Resistive index

The vascularization of materno – fetal complex is done by uterine arteries. This study

did not find any correlation between RI values of both LUt and RUt and the materno – fetal characteristics. There were no differences between RI values of the LUt and the RUt. Like others normogram curves obtained, RUt and LUt curves had a similar cubic pattern seen elsewhere in Africa (25) and in the world (3,30,31) but with the RI values slightly lower in our setting. This could be due to sample size, difference in methodology or may be to some racial factors mentioned earlier.

Cerebro – placental RI ratio

This ratio is often used to clarify clinical situation in which there is opposite variation of UmA, MCA or UmA RI values are normal or low. Our study revealed that the RCP is not constant through the pregnancy after 28 weeks of GA and that its values were correlated either to fetal characteristics (EFW and GA) or Maternal age (Table 6). Many cut of point are proposed in the literature (<1 ; <1.05 ; <1.08) for fetal prognostic prediction during pregnancy (32,33). This study underline, like elsewhere, interest of analysis CPR values according to GA especially after 34 week (3,21,34,35). Then, the decrease of CPR value under the 5th percentile reflect a fetal blood flow redistribution in favor of brain due to decrease of placental perfusion or hypoxia. This phenomenom often observed in pathological situation during pregnancy had been described as the brain sparing effect phenomenom (36).

Study limitation and perspectives

This study is the first study in Cameroon on resistive index on low risk singleton pregnant women. It provide to physician a national normogram of RI values of UmA, McA, both LUt and RUt that could help for clinical situation after been validate in general mass population. But for us to generalize our result, we should carefully take in consideration the reduced sample size of our studied population limited by the will of strictly fulfill the selection criterias of subject. We used only one experienced ultrasonologist to avoid inter-observer variation and only one high resolution ultrasonography machine and one trans-abdominal transducer to avoid equipment's variation. As well as, our data had higher reliability based on this fact that all gestational age was established by careful history to identifying only patients with accurate date and confirmation by early ultrasound examination. Furthermore, all newborns were proved to have normal growth and having no structural abnormality. The choice of RI was guided by the aim to adapt the normogram to physician aptitudes and competences in one hand, and to physiological mechanisms of fetal hemodynamic in other hand.

Conclusion

In conclusion, we believe this study is the first to establish a national normogram of RI values of UmA, McA, both LUt and Rut in Cameroon. It reveals that there is a downward trend of normal RI values of maternal-fetal arteries seen during pregnancy in Sub-Saharan black pregnant women compared to those in literature and thus physicians should be careful when they analyze them. This highlights the interest of establishing a Sub-Saharan black pregnant women normogram and to further introduce them in clinical practice in general and in Cameroon in particular.

Abbreviations

CPR: Cerebro – Placental ratio

EDV: End-systolic velocity

EFW: Estimated fetal weight

GA: Gestational age

IUGR: Intra uterine growth

LUt Left uterine artery

MCA: Middle Cerebral artery

PSV : Peak Systolic velocity

RI : Resistive index

RUt: Right Uterine artery

S/D : Systolic to Diastolic

SD: Standard deviation

Declarations

- **Ethics approval and consent to participate**

The study protocol was approved by the Institutional Review Board at the faculty of Medicine and Biomedical Sciences of University of Yaoundé 1 (N°431/UY1/FMSB/VDRC/CSD du 24 mai 2017), and each participant in the study submitted a signed and approved informed consent form.

- **Consent of publication :**

Not applicable.

- **Availability of data and materials**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

- **Competing interests**

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

- **Funding**

No particular funding was rise by authors for this study.

- **Authors' contributions**

BM: Conception, design of the work, interpretation of data and substantively revised.

UT: Design of the work, the acquisition, the analysis, the interpretation of data, drafted the work and substantively revised it.

CJ: Conception, design of the work and the acquisition.

JRM: Conception, design of the work and the acquisition,

PF: Conception, design of the work and substantively revised.

All authors have read and approved the manuscript.

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Figures

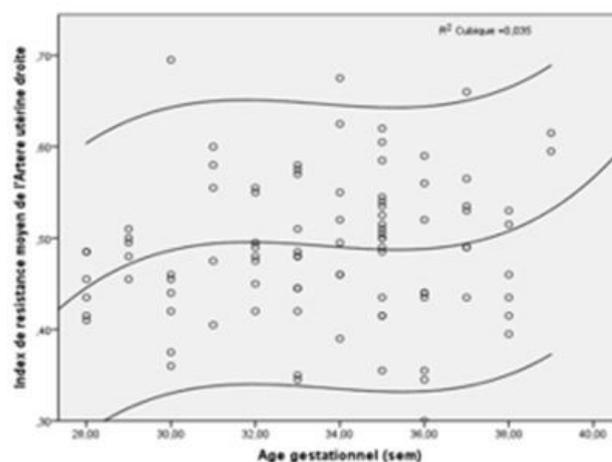
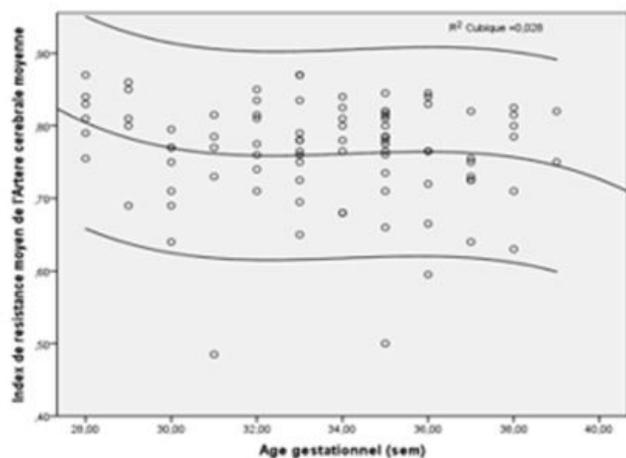
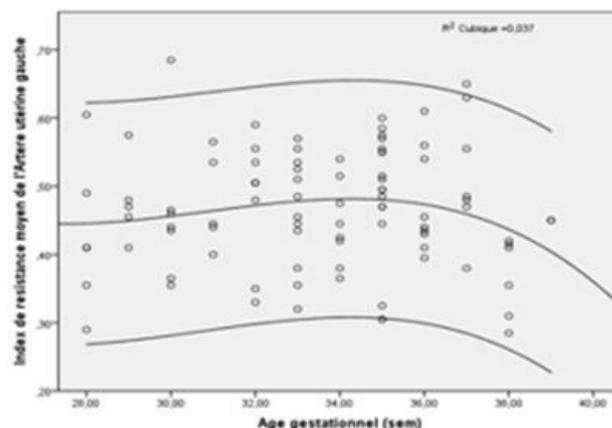
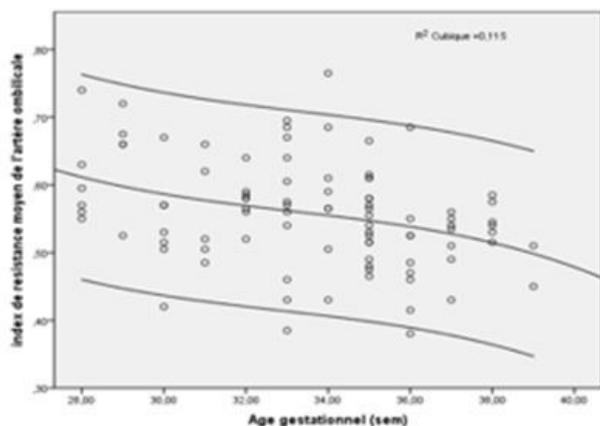


Figure 1

Individual measurements and calculated reference ranges for the resistive index (RI) in the UmA, the MCA, the LUt and RUt.