

Doppler ultrasound of the fetomaternal circulation: a preliminary study on differences between ethnic groups

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Summary

Purpose of investigation: The aim of this study was to investigate whether the same reference values might be used for the pulsatility index obtained by Doppler examinations of the fetal umbilical and middle cerebral artery and the maternal uterine arteries in autochthonous Belgian, Turkish and Moroccan women in Belgium. Notching of the uterine artery was also studied in the three ethnic groups.

Methods: Doppler measurements were performed in 206 autochthonous Belgian, 36 Moroccan and 36 Turkish pregnant women between 20 and 24 weeks gestational age for the umbilical artery, middle cerebral artery and uterine arteries. The mean uterine artery pulsatility index and the placental index were calculated. Intra-observer variation was calculated by repeat measurements on 20 videotaped examinations and inpatient variation was determined by repeat examination in 60 patients.

Results: Maternal length was higher and body mass index lower in Belgian women; more of these admitted smoking during pregnancy. There were no statistically significant inter-ethnic differences for the pulsatility index of the umbilical artery, middle cerebral artery, placental-site uterine artery and the placental index. The pulsatility index in the non-placental-site uterine artery and the mean uterine artery was lower in the Moroccan group. Intra-patient variation expressed as intra-patient standard deviation of the umbilical and middle cerebral artery pulsatility index was relatively large compared to inter-patient variation, being 57% to 88% of the inter-patient standard deviation. This was not the case for the uterine artery. Notching of the uterine artery was not contributive for the prediction of intrauterine growth restriction or preeclampsia in these ethnic groups.

Conclusion: Only small statistically significant differences were demonstrated. For clinical practice, the use of different reference charts for fetomaternal Doppler measurement in Belgian, Turkish and Moroccan women is not warranted.

Key words: Doppler ultrasound; Middle cerebral artery; Umbilical artery; Uterine artery; Ethnic differences.

Introduction

Doppler flow measurement of the fetal circulation is a valuable tool to evaluate fetal well-being; evaluating the maternal (uterine artery) circulation can predict complications such as intrauterine growth restriction or preeclampsia [1, 2]. It has been said that the Doppler examination is not influenced by race and ethnic origin [3]. On the other hand it has been suggested that for intrauterine growth restriction and preeclampsia the sensitivity, specificity, positive and negative predictive values of Doppler ultrasound of the uterine artery as a screening tool is higher in Afro-Caribbean versus Caucasian women [1, 2]. The aim of this study was to determine if significant differences exist for the pulsatility index of the umbilical artery, the uterine arteries and the middle cerebral artery and for the presence of notching of the uterine artery among three ethnic groups in Belgium.

Materials and Methods

Only uncomplicated singleton pregnancies with gestational ages between 20 and 24 weeks were included. Gestational age was confirmed by ultrasound before 16 weeks. Patients with

medical disorders such as diabetes, asthma, hypertension and kidney disease were excluded, as were those in whom a fetal malformation was detected during the ultrasound examination and patients with a history of intrauterine growth restriction, macrosomia or preeclampsia. The study was cross-sectional with only one set of measurements for every patient included. Autochthonous Belgian, Turkish and Moroccan women were included. Ethnicity was determined by asking the patient while explaining the study, not by nationality. For every woman, maternal age, parity, body length, pre-pregnancy weight and smoking behaviour were noted. Body mass index was calculated as pre-pregnancy weight (kg)/length² (m²). All measurements were made by the same examiner (YJ) on a commercially available machine (Aloka SSD2000) with a 3.5MHz curvilinear abdominal probe. The sample volume was placed in the middle of the vessel, avoiding the vessel walls. The angle of insonation was between 0° and 45°. At least four subsequent flow velocity waveforms of identical form and amplitude were obtained and the pulsatility index was calculated by the machine after manual delineation of the frequency-envelope with a roller-ball.

The mean pulsatility index (PI) [4] of two subsequent waveforms was calculated and used for the study.

For the umbilical artery, measurements were made at a free loop, not at the placental or fetal insertion site. The uterine artery was examined as described by Bower [5] at the crossing with the iliac artery. Both placental and non-placental sites were measured and the mean of both was calculated. The presence of uni- or bilateral uterine artery notching was noted. Measurement of the middle cerebral artery was performed as described

by Vyas [6]. The sampling volume was placed in the proximal part of the middle cerebral artery near the circle of Willis.

All measurements were performed in the absence of fetal body movements, fetal breathing movements, fetal tachycardia (fetal heart rate > 160 beats per minute) or bradycardia (fetal heart rate < 120 beats per minute).

The placental index was defined as: umbilical artery PI/middle cerebral artery PI. To determine intra-observer variation calculations were repeated on two consecutive days on videotaped registrations for 20 patients.

Intra-patient variation was studied in 60 patients who underwent a repeat examination 10-15 minutes after the first one. Analysis of intra-patient and intra-observer variation was performed as proposed by Bland and Altman [7]. Statistical analysis was with ANOVA-testing with ethnicity as a factor and χ^2 -test as appropriate.

Results

Demographic data of the study group are presented in Table 1. All three groups were equally distributed between 20 and 24 weeks' gestational age. Maternal age was higher in the Belgian group and maternal length and body mass index were lower in this group. Significantly more Belgian women smoked during pregnancy.

Table 2 gives an overview of the results of the Doppler measurements. A lower PI in the non-placental uterine artery and a lower mean uterine artery PI in the Moroccan as compared to the Turkish group is the only significant difference.

Uterine artery notching was a relatively rare event in this group of low-risk pregnancies (Table 3). None of these patients developed preeclampsia. No significant difference for the presence of uni- or bilateral uterine artery notching between the three ethnic groups was present ($p = 0.359$). The sensitivity for IUGR (defined as a birthweight < 2500 g) was 5% for the Belgian group, 0% for the Turkish and 33% for the Moroccan group. Sensitivity for preeclampsia was 0% in all groups. Intra-observer variation and intra-patient variation are presented in Tables 4 and 5. Intra-observer variability was small compared to intra-patient variability. For the umbilical artery the ratio of intra-patient to inter-patient standard deviation was 57%, 88% and 79% for Belgian, Turkish and Moroccan women, respectively. For the middle cerebral artery this ratio was 64%, 62% and 58%, indicating a relatively large intra-patient variation.

Table 1. — Demographic data.

	Belgian	Moroccan	Turkish	Significance
N	206	36	36	ANOVA
Age (years)	29.1±4.4	25.3±5.4	26.2±5.2	$p < 0.0001$
Pre-pregnancy weight (kg) ¹	63.7±13.2	66.8±15.5	66.4±14.5	$p = 0.275$
Length (cm) ¹	166.4±6.8	161.1±4.9	160.4±6.2	$p < 0.0001$
BMI (kg/m ²) ¹	22.9±4.3	25.8±5.6	25.7±4.4	$p < 0.0001$
				χ^2
Primiparous	118	18	14	$p = 0.109$
Multiparous	88	18	22	
Smoking	49	1	4	$p = 0.005$
Male fetus	106	20	19	$p = 0.899$
Female fetus	100	16	17	

¹: median and standard deviation; BMI: Body Mass Index.

Table 2. — Results of Doppler measurements (mean and standard-deviation).

	Belgian	Moroccan	Turkish	p
PI umbilical artery	1.32±0.26	1.28±0.17	1.32±0.21	0.552
PI placental uterine artery	0.83±0.24	0.77±0.22	0.91±0.31	0.072
PI non-placental uterine artery	1.15±0.42	0.9±0.45	1.31±0.52	0.035 ²
PI mean uterine artery	0.99±0.28	0.88±0.29	1.10±0.37	0.02 ³
PI middle cerebral artery	1.72±0.28	1.81±0.29	1.77±0.31	0.224
Placentocerebral index	0.79±0.21	0.74±0.18	0.76±0.19	0.310

Table 3. — Notching of the uterine artery.

Ethnicity	Unilateral notch	Bilateral notch	Gestational age (weeks)	Gestational age at birth (weeks)	Birth weight (grams)
Belgian		+	22	39	2700
Belgian	+		23	36	2150
Belgian	+		23	38	2950
Belgian	+		24	39	3435
Turkish		+	24	39	3030
Turkish	+		22	39	2780
Turkish	+		24	39	3210
Moroccan		+	21	42	2320

Table 4. — Intra-observer variation.

	Uterine artery	Umbilical artery	Middle cerebral artery
Intra-patient standard deviation	0.017	0.011	0.022
Repeatability coefficient	0.047	0.029	0.061
Coefficient of variation	1.57%	0.77%	1.15%

Table 5. — Intra-patient variation.

	Uterine artery	Umbilical artery	Middle cerebral artery
Intra-patient standard deviation	0.09	0.15	0.18
Repeatability coefficient	0.27	0.42	0.50
Coefficient of variation	10%	11%	9.5%

Discussion

Differences in intrauterine growth between Belgian, Turkish and Moroccan women have been described [8]. No statistically significant differences could be demonstrated for PI values between 20 and 24 weeks for the umbilical artery, middle cerebral artery and placental uterine artery. However this could be due to the small sample size.

Statistically significant lower values were measured for the non-placental uterine artery and the calculated mean uterine artery PI for Moroccan pregnant women. We have no explanation for this finding. A higher blood flow to the fetus is suggested, which is compatible with higher abdominal circumference and ultrasonically estimated fetal weight for gestational age in Moroccan women as previously reported [8].

Clearly intra-patient variation is larger than intra-observer variation. The relatively high intra-patient variation can not be explained by the influence of fetal movements, fetal breathing movements or extreme fetal heart rates as these were excluded at the beginning of the study. This intra-patient variability should be considered as phy-

siologic and spontaneous thus making the detection of clinically relevant differences in fetal Doppler flow measurements between populations very improbable, even in larger scale studies. Caution should be used in the clinical interpretation of serial PI measurements for the evaluation of fetal well-being [9, 10]. In this selected low-risk group, uterine artery notching was unable to differentiate between "normal" pregnancies and those complicated by IUGR and/or preeclampsia later in the course of pregnancy for all three ethnic groups.

Conclusion

Only small statistically significant differences for the PI of the non-placental and the mean uterine artery were present. The clinical relevance of these small differences is doubtful. This study suggests that the use of different reference charts for Doppler studies of Belgian, Turkish and Moroccan ethnic groups is not necessary.

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