THE CORRELATION BETWEEN NECK CIRCUMFERENCE AND UMBILICAL ARTERY BLOOD FLOW IN PHYSIOLOGIC PREGNANCIES

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Abstract

Objective. To study the correlation between neck circumference (NC) and umbilical artery blood flow in physiologic pregnancies.

Methods. One hundred and one healthy pregnant woman in the third trimester were enrolled. Anthropometric measurements and ultrasonic testing were done.

Results. The women with NC ≥ 34.7 cm had a more elevated umbilical artery pulsatility index (PI) and systolic/diastolic ratio (S/D) than the women with NC < 34.7 cm ($P < 0.01$). NC were positively correlated with PI ($r = 0.224, P = 0.024$) and S/D ratio ($r = 0.415, P = 0.0001$). In multivariate analysis, NC was independently associated with PI ($\beta = 0.026, P = 0.016$) and S/D ratio ($\beta = 0.132, P = 0.0001$).

Conclusions. Obesity has an adverse impact on fetal-placental vessels, and NC was superior to body mass index.

Key words: pregnancy, umbilical Doppler velocimetry, neck circumference.

distribution (5). But these techniques are not suitable for pregnancy. Neck circumference (NC) is another index for evaluating upper body fat distribution, and it is also significantly correlated with abdominal visceral adipose tissue (6). Previous research showed that NC was an independent risk factor for pregnancy-induced hypertension (7). In our previous analysis, we also found that NC is independently related to pregnancy-induced hypertension in our city (8). The relationship between NC and uteroplacental circulation was also observed in this study. Women with pregnancy-induced hypertension (PIH) have abnormal velocity waveforms (9). But the effect of PIH was not excluded in our previous study.

The study evaluates a possible correlation between NC and umbilical artery Doppler velocimetry, and compares BMI in relation to umbilical artery blood flow in physiologic pregnancies.

METHODS

One hundred and one healthy pregnant women in the third trimester were enrolled at an antenatal clinic in 2011. Only uncomplicated pregnancies were included in our study. After completing an informed consent form, anthropometric measurements and ultrasonic testing were done. This study was approved by the ethics committee of the First Hospital of Qinhuangdao.

Height, weight, NC and blood pressure were obtained while the subjects were measured. According to the NC, they were divided into two groups: normal group (NC < 34.7 cm, $n = 78$) and obese group (NC ≥ 34.7 cm, $n = 23$).

Ultrasound machines utilized included standard Philips IU22 (Philips, USA) with curved linear array transabdominal transducers (2-5 MHz). The measurements of the umbilical artery parameters were performed on a free loop. Umbilical artery pulsatility

INTRODUCTION

In China, the prevalence of obesity has significantly increased in recent years (1,2). The epidemic of obesity in women with childbearing age has become a serious public health problem. Obesity increased the risks of adverse obstetric outcomes in women, such as gestational diabetes, pre-eclampsia and preterm delivery (3). However, it remains unclear whether obesity is an independent predictor of an adverse pregnancy outcome. Recently, Sarno *et al.* found that maternal obesity, assessed by body mass index (BMI), has a adverse impact on fetal-placental vessels in physiologic pregnancies (4).

As is well-known, many indexes can evaluate obesity. BMI is the most frequently used index for evaluating the overall fat. Body fat distribution is more important. Magnetic resonance imaging and computed tomography are golden standards to assess body fat

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index(PI) and systolic/diastolic ratio (S/D) were measured.

All analyses were done by the SPSS 11.5 statistical software (SPSS 11.5 for Windows; SPSS, Inc., Chicago, IL). The Student t-test and Pearson correlation were used. Multiple linear regression analysis was used to examine the relationship between obesity and umbilical artery Doppler velocimetry. $P < 0.05$ was considered statistically significant.

RESULTS

Clinical and ultrasonographic data are presented in Table 1. The obese related index and diastolic blood pressure (DBP) were all significantly higher in obese group than in normal group ($P < 0.05$). The age, gestational weeks and systolic blood pressure (SBP) were similar in the two groups ($P > 0.05$). Obese group had a higher PI and S/D ratio of umbilical artery than normal group ($P < 0.01$).

PI was positively correlated with NC($r = 0.224$, $P = 0.024$), and negatively correlated with gestational weeks($r = -0.316$, $P = 0.001$). S/D ratio was positively correlated with pre-pregnancy weight($r = 0.202$, $P = 0.045$), pre-pregnancy body mass index (BMI) ($r = 0.242$, $P = 0.016$), pregnancy BMI($r = 0.206$, $P = 0.038$) and NC($r = 0.415$, $P = 0.000$), and negatively correlated with gestational weeks($r = -0.334$, $P = 0.001$)(Table 2).

When PI was considered as the dependent variable in a multiple regression analysis with age, gestational weeks, pre-pregnancy BMI, pregnancy BMI, weight increase during pregnancy, neck circumference, SBP and DBP as independent variables, PI maintained an independent association with gestational weeks($\beta = -0.021$, 95%CI: $-0.033 \sim -0.009$, $P = 0.001$) and

NC($\beta = 0.026$, 95%CI: $0.005 \sim 0.047$, $P = 0.016$)(Table 3).

When S/D ratio was considered as the dependent variable in a multiple regression analysis with age, gestational weeks, pre-pregnancy BMI, pregnancy BMI, weight increase during pregnancy, NC, SBP and DBP as independent variables, PI maintained an independent association with NC($\beta = 0.132$, 95%CI: $0.079 \sim 0.186$, $P = 0.000$) and gestational weeks($\beta = -0.063$, 95%CI: $-0.094 \sim -0.032$, $P = 0.000$)(Table 4).

DISCUSSION

The present study shows that the levels of PI and S/D ratio were negatively correlated with gestational weeks. Decline in the values of all Doppler indices was found with advancing gestational weeks in the third trimester pregnant women suggesting decreased vascular resistance and increased blood flow in fetomaternal circulation. Our results are consistent with previous results of similar studies (9, 10).

The present study also shows that the levels of PI and S/D ratio were higher in healthy pregnant women with larger NC. NC and BMI were all positively correlated with umbilical artery Doppler indices in the third trimester pregnant women. However, NC has an independent association with S/D ratio and PI in multiple regression analyses, BMI was excluded. In contrast with BMI, the relationship between NC is more closely associated to umbilical artery Doppler velocimetry.

Doppler examination of the umbilical artery flow velocity waveform is widely used in the evaluation of fetal well-being in the third trimester. The waveform is easily demonstrated using impedance indices such as the PI and S/D ratio permits the waveform to be described. Doppler examination may be used to predict

Table 1. Clinical and ultrasonic characteristics of the subjects with different neck circumference

Variable	NC<34.7cm (n=78)	NC≥34.7cm (n=23)	<i>t</i>	<i>P</i>
Age (y) mean (SD)	27.6(4.3)	27.8(5.5)	0.208	0.835
Gestational weeks (w) mean (SD)	36.0(2.9)	36.0(2.8)	0.015	0.988
Height(m) mean (SD)	161.9(4.9)	164.2(3.9)	2.115	0.037
Pre-pregnancy weight(kg) mean (SD)	54.4(7.4)	60.7(6.4)	3.645	0.000
Pre-pregnancy BMI (kg/m ²) mean (SD)	20.7(2.4)	22.5(2.5)	3.072	0.003
Pregnancy weight(kg) mean (SD)	69.9(7.7)	79.6(7.5)	5.326	0.000
Pregnancy BMI (kg/m ²) mean (SD)	26.6(2.3)	29.5(2.8)	4.876	0.000
Weight increase during pregnancy(kg) mean (SD)	15.6(4.8)	18.7(6.6)	2.387	0.019
Neck circumference(cm) mean (SD)	32.5(1.0)	35.6(1.1)	11.647	0.000
SBP (mmHg) mean (SD)	116.8(9.2)	120.2(6.8)	1.903	0.063
DBP (mmHg) mean (SD)	76.9(7.5)	80.8(5.3)	2.749	0.008
PI mean (SD)	0.96(0.16)	1.09(0.20)	3.325	0.001
S/D ratio mean (SD)	2.59(0.42)	3.04(0.64)	3.878	0.000

Values are expressed as mean (SD). NC: neck circumference; SD: standard deviation; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; PI: pulsatility index; S/D: systolic/diastolic.

the preeclampsia and intrauterine growth restriction to reduce the maternal and perinatal morbidity and mortality (11). Our results demonstrate the obesity has a close relationship with uteroplacental circulation.

The relationship between NC and umbilical artery Doppler velocimetry is likely related to the following mechanism. A correlation was found between *in vivo* umbilical artery Doppler velocimetry and resistance to fetal-side flow in the human *ex vivo* dually perfused placenta, highlighting that the fetoplacental vascular bed is a key site of resistance to umbilico-placental flow in pregnancy. Jones *et al.* found a dysregulated flow-mediated vasodilatation in the human placenta in fetal growth restriction (12). Umbilical artery intima-media and wall thickness strongly correlated with insulin resistance in infants of diabetic mothers (13). Inappropriate secretion of free fatty acid seems to participate in the pathogenesis of obesity-related pathologic processes including endothelial dysfunction and insulin resistance (14). Upper body sc fat, as estimated by NC, is a novel measure of cardiometabolic risk (15). Systemic free fatty acid concentrations are

primarily determined by upper-body sc fat, suggesting that this fat depot may play an important role in risk factor pathogenesis. Elevated free fatty acid concentrations have been associated with insulin resistance and endothelial cell dysfunction (16). This process could also influence uterine and placental perfusion.

We used a sample composed of physiologic pregnant women to avoid the influences of potentially confounding factors, such as preeclampsia or diabetes. Liang *et al.* have found a significant association of high NC with insulin resistance in apparently healthy Chinese adults (17). All these results demonstrated that obesity is an independent predictor of umbilical artery resistance.

Moreover, measuring NC has several merits in practice. First, NC measurement is convenient. NC measurement does not require the patient to remove her clothing. Second, data show that NC is more stable (18).

There are two limitations in our study. First, additional information is lacking on anthropometric characteristics of the neonate as well as on basic metabolic parameters evaluating the maternal status. Second, prospective studies are warranted to elucidate the

Table 2. Simple correlations between the PI, S/D ratio and other variables in the study subjects

Variable	PI		S/D ratio	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Age (y)	0.081	0.420	0.069	0.496
Gestational weeks (w)	-0.316	0.001	-0.334	0.001
Height(m)	0.008	0.934	-0.007	0.944
Pre-pregnancy weight(kg)	0.122	0.230	0.202	0.045
Pre-pregnancy BMI (kg/m ²)	0.144	0.156	0.242	0.016
Pregnancy weight(kg)	0.070	0.488	0.165	0.100
Pregnancy BMI (kg/m ²)	0.081	0.421	0.206	0.038
Weight increase during pregnancy(kg)	-0.080	0.433	-0.047	0.641
Neck circumference(cm)	0.224	0.024	0.415	0.000
SBP (mmHg)	0.008	0.941	0.005	0.963
DBP (mmHg)	0.116	0.248	0.071	0.482

BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; PI: pulsatility index; S/D: systolic/diastolic.

Table 3. Multiple linear regression analyses for pulsatility index (Stepwise Method)

Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients B	<i>t</i>	<i>P</i>	95% CI	R ²
(Constant)	0.889	0.408		2.181	0.032	0.080 to 1.699	
Gestational weeks	-0.021	0.006	-0.323	-3.431	0.001	-0.033 to -0.009	0.097
Neck circumference	0.026	0.011	0.231	2.456	0.016	0.005 to 0.047	0.151

Dependent Variable: pulsatility index.

Table 4. Multiple linear regression analyses for systolic/diastolic ratio (Stepwise Method)

Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients B	<i>t</i>	<i>P</i>	95% CI	R ²
(Constant)	0.578	1.042		0.555	0.580	-1.490 to 2.647	
Neck circumference	0.132	0.027	0.423	4.890	0.000	0.079 to 0.186	0.165
Gestational weeks	-0.063	0.016	-0.347	-4.012	0.000	-0.094 to -0.032	0.285

Dependent Variable: systolic/diastolic ratio.

predictive value of pre-pregnancy NC for uteroplacental circulation in the third trimester pregnant women.

In conclusion, obesity has an adverse impact on feto-placental vessels. NC is an easier and accurate index for evaluating obesity and is superior to BMI in pregnancy.

Conflict of interest

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

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