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Original Article

Color Doppler ultrasound detection of hemodynamic changes in pregnant women with GDM and analysis of their influence on pregnancy outcomes

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Abstract: Objective: To study the influence of color Doppler ultrasound on hemodynamic changes and pregnancy outcome of pregnant women with gestational diabetes mellitus (GDM). Methods: From October 2018 to October 2019, a total of 76 pregnant women with GDM treated in the obstetric outpatient department of our hospital were selected as the experimental group, and 76 healthy pregnant women were selected as the control group. The uterine artery (UA) hemodynamic parameters, fetal middle cerebral artery (MCA) hemodynamic parameters and umbilical artery (Ut-A) hemodynamic parameters of the two groups of pregnant women were examined by color Doppler ultrasound. The arterial blood flow of the two groups of pregnant women was evaluated, and the incidence of early diastolic notches and pregnancy outcome were counted. The correlation between blood flow index changes during pregnancy [peak systolic velocity/end-systolic blood flow velocity (S/D), resistance index (RI), pulsation index (PI)] and GDM was analyzed. Results: The arterial hemodynamic parameters and arterial blood flow scores of pregnant women in the experimental group were better than those in the control group ($P < 0.05$); the incidence of early diastolic notch in the experimental group was significantly higher than that in the control group ($P < 0.05$); the number of neonates with the Apgar score ≥ 7 points in the experimental group was significantly smaller than that in the control group ($P < 0.05$). PI, RI and S/D of arterial blood flow during pregnancy were positively correlated with the occurrence of GDM ($P < 0.05$). Conclusion: Clinically, color Doppler ultrasound may be used to understand the abnormal blood glucose of GDM pregnant women, identify the cause of the abnormality through symptoms, and detect the maternal arterial blood flow indicators to achieve timely understanding of the abnormal condition of the fetus, and provide a basis for preventing adverse pregnancy outcomes.

Keywords: Color Doppler ultrasound, gestational diabetes mellitus, hemodynamics, pregnancy outcome

Introduction

Gestational diabetes mellitus (GDM) exhibits as abnormal glucose metabolism during pregnancy but normal glucose metabolism before pregnancy [1]. It is reported that the incidence of GDM in China is 1%-5%, and is increasing in recent years [2]. During pregnancy, the main source of energy for the fetus is from maternal glucose through the placenta. With the growth of the fetus, particularly in the later stages of pregnancy, the fetus requires more energy, and the blood sugar level of the pregnant woman will decrease with the increase in gestational age. During pregnancy, the action of estrogen and progesterone will increase the mother's use of glucose, and the plasma flow and glomerular filtration rate of pregnant women will also increase, but the kidney tubular reabsorption rate will not increase. As a result, their ability during pregnancy to remove glucose will be enhanced compared to non-pregnancy. This is why many pregnant women are prone to hypoglycemia or ketoacidosis when fasting [3, 4]. Consequently, in the third trimester of pregnancy, the proper amount of insulin must be supplemented to meet normal glucose metabolism. Due to the condition of pregnant woman, this physiological change can hardly be met, which will elevate blood sugar [5]. The blood glucose level of GDM patients can basically return to normal after the end of pregnancy, but it will increase the potential risk of diabetes in the future. The pregnancy process is a rather

complicated process, and diabetes will increase the risk of pregnant women and fetuses, so due importance should be attached [6]. We attempted to explore the effect of color Doppler ultrasound on the hemodynamics and pregnancy outcome of pregnant women with GDM, and to analyze its clinical application value, and to provide a basis for preventing adverse pregnancy outcomes in the future.

Materials and methods

General information

From October 2018 to October 2019, a total of 76 pregnant women with GDM were admitted to the obstetric outpatient clinic of our hospital, and they were set as the experimental group. Another 76 healthy pregnant women were selected as the control group. The experimental group included 52 primiparous women and 24 postpartum women; they aged 21-36 (28.71±4.62) years old, and the gestational age was 24-31 (27.88±2.31) weeks; the control group included 51 primiparous women and 25 postpartum women; they aged 21-37 (28.62±4.55) years, and the gestational age was 24-31 (26.37±2.35) weeks. They were of comparability with regard to age and gestational age and other general data ($P > 0.05$).

Inclusion criteria

① The experimental group met the clinical diagnostic criteria for GDM; ② The blood glucose level in the control group was normal; ③ Age ≥ 20 years old; ④ B-ultrasound showed a singleton pregnancy; ⑤ This study was approved by the hospital ethics committee, and the patients and their families knew purpose and process of the study, and signed the informed consent.

Exclusion criteria

① Combined with brain, heart, kidney, liver and other organ tissue diseases; ② Twin or multiple pregnancies; ③ With mental or other cognitive impairment or refused to cooperate with the experiment; ④ Combined with pregnancy-induced hypertension or uterine organic disease.

Methods

Color Doppler ultrasound system was used to examine the two groups of pregnant women, with an ultrasound abdominal probe with a frequency of 3.5-5.0 MHz [7]. Prior to the examination, the pregnant woman should be reminded to hold the urine to ensure that the bladder is in a full state. During the examination, the pregnant woman was in a supine position. The doctor placed the ultrasound probe on the pregnant woman's abdomen for scanning observation, and used a color Doppler ultrasound instrument to measure the hemodynamic parameters of fetal middle cerebral artery (MCA), umbilical artery (UA) and pregnant uterine artery (Ut-A), including peak systolic velocity/end-systolic blood flow velocity (S/D), resistance index (RI), pulsation index (PI), the peak systolic velocity and the minimum diastolic velocity [8, 9]. ① MCA: Two-dimensional ultrasound was applied to find the fetal head. When the fetal biparietal diameter standard measurement section was observed, move the probe parallel to the skull base. MCA can be clearly seen by the color Doppler ultrasound diagnostic apparatus, and the middle section of the artery was selected for measurement [10, 11]. ② UA: The ultrasound was used to find the umbilical cord of the free segment, and the site where the blood flow signal is filled was selected to measure. ③ Ut-A: The internal iliac artery was found along up the groin on both sides, and then the UA was found from the branch of the internal iliac artery. The sampling volume of the color Doppler ultrasound system was adjusted to 2 mm to obtain at least 5 continuous, stable and standard frozen image of the waveform. The measurement was performed 3 times per person, and finally average value was obtained; according to the blood flow spectrum of the pregnant woman, the blood flow of the uterine artery of the pregnant woman was scored 0-4 points. 0 point means bilateral uterine artery blood flow is normal. Scores of 1-4 points indicate the occurrence of 1, 2, 3, and 4 abnormal blood flow parameters. Whether pregnant women have early diastolic notches, and the pregnancy outcomes of pregnant women were observed [12].

Observation indicators

The fetal MCA, UA and Ut-A blood flow indexes of the two groups of pregnant women were detected, the arterial blood flow parameters and arterial blood flow scores of the two pregnant women were compared, and the incidence of early diastolic notches of the pregnant

Table 1. Comparison of the fetal MCA hemodynamic parameters of the two pregnant women

Groups	S/D	RI	PI	peak systolic velocity	Minimum diastolic velocity
Experimental group	3.55±1.14	1.41±0.44	0.67±0.21	43.58±5.23	7.35±1.88
Control group	2.21±0.54	1.02±0.29	0.52±0.16	50.30±6.50	9.64±2.31
t	9.2608	6.4518	4.9532	7.0220	6.7029
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

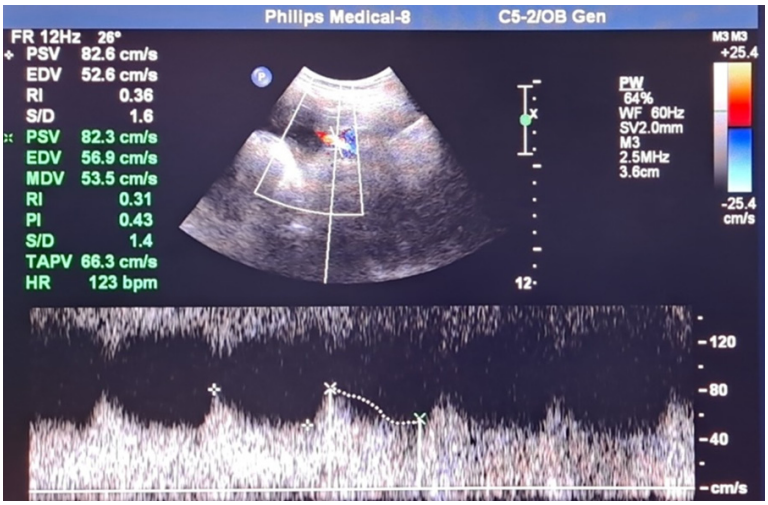

Figure 1. The blood flow spectrum of the left uterine artery of a pregnant woman at 30 weeks of normal pregnancy.

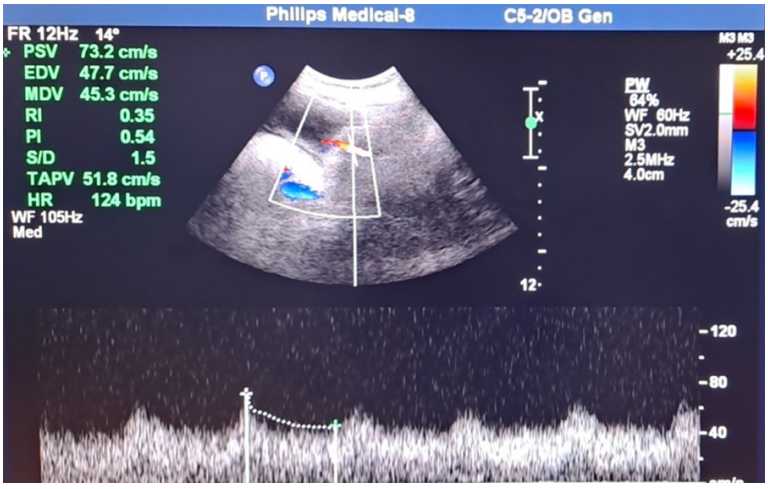

Figure 2. The blood flow spectrum of left uterine artery in pregnant women with GDM at 29 weeks of pregnancy.

women were calculated for analysis and comparison.

The Apgar score was used to evaluate the growth of the newborn. After the baby is born, the newborn's skin color, heart rate, respiration, muscle tension, exercise, and reflex were immediately evaluated. The outcome of pregnancy was compared and analyzed; the full score is 10 points. Less than 7 points indicate different degrees of asphyxia, lower scores indicate more severe asphyxia, 7-10 points are normal, and less than 7 points are abnormal. The correlation between changes in blood flow indicators (S/D, RI and PI) during pregnancy and GDM was analyzed.

Statistical analysis

The experimental data were statistically analyzed by the software SPSS20.0. Continuous variables are presented as (mean ± SD) or median (range) and categorical variables as n (%) as appropriate. Statistical analysis was performed by paired t student test and X^2 test. Correlation analysis was performed using Pearson test. Statistical significance was considered at p value < 0.05.

Results

Comparison of fetal MCA hemodynamic parameters between the two groups

The experimental data showed that the S/D value, RI value and PI value of the MCA of the experimental group were noticeably higher compared with those of the control group (P < 0.05), and the values of the peak systolic velocity and the minimum diastolic velocity were remarkably lower than those of the control group (P < 0.05, **Table 1**; **Figures 1** and **2**).

Table 2. Comparison of the UA hemodynamic parameters of the two pregnant women

Groups	S/D	RI	PI	peak systolic velocity	Minimum diastolic velocity
Experimental group	3.66±1.08	1.53±0.41	0.72±0.19	43.33±5.41	7.46±1.88
Control group	2.49±0.63	1.14±0.31	0.44±0.58	50.37±6.50	9.42±2.31
t	8.1578	6.6146	3.9995	7.2572	5.7370
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Table 3. Comparison of Ut-A hemodynamic parameters of the two pregnant women

Groups	S/D	RI	PI	peak systolic velocity	Minimum diastolic velocity
Experimental group	3.52±1.08	1.42±0.67	0.70±0.21	42.97±5.30	7.29±2.04
Control group	2.09±0.67	1.01±0.4	0.50±0.14	50.33±6.55	9.60±2.28
t	9.8088	4.5806	6.9082	7.6151	6.5823
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

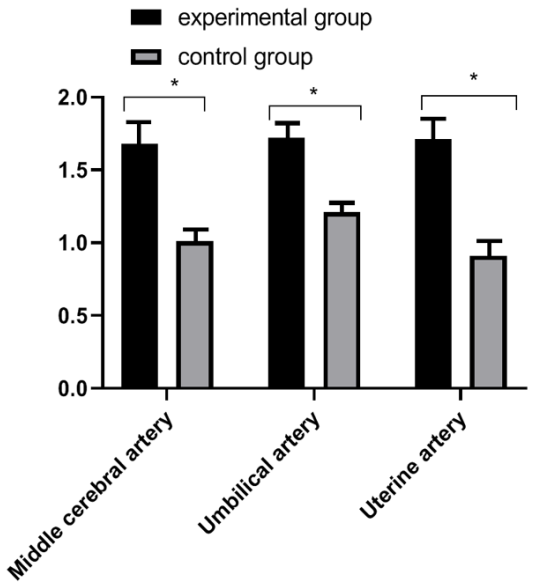

Figure 3. Comparison of the arterial blood flow scores of the two groups of pregnant women. Note: The abscissa represents the category of maternal arteries, and the ordinate represents the arterial blood flow score; The blood flow scores of the fetal middle cerebral artery, umbilical artery and uterine artery of the pregnant women in the experimental group were (1.68±0.53), (1.72±0.38) and (1.71±0.49); The blood flow scores of the fetal middle cerebral artery, umbilical artery and uterine artery of pregnant women in the control group were (1.01±0.28), (1.21±0.30) and (0.91±0.32) respectively; * indicates that the blood flow scores of the fetal middle cerebral artery, umbilical artery and uterine artery of the pregnant women in the experimental group were significantly higher than those in the control group (t = 9.7443, 9.1833, 11.9169, respectively, P = 0.000).

Comparison of UA hemodynamic parameters

The UA S/D, RI and PI values of pregnant women in the experimental group were observably higher than those of the control group (P < 0.05), and the values of the peak systolic velocity and the minimum diastolic velocity were significantly lower compared to those of the control group (P < 0.05, **Table 2**).

Comparison of Ut-A hemodynamic parameters

The S/D value, RI value and PI value of the experimental group were remarkably higher than those of the control group (P < 0.05). The values of the peak systolic velocity and the minimum diastolic velocity were significantly lower than those of the control group (P < 0.05, **Table 3**).

Comparison of the arterial blood flow scores

The blood flow scores of the fetal MCA, UA and Ut-A of the experimental group were dramatically higher than those in the control group (P < 0.05, **Figure 3**).

Comparison of the incidence of early diastolic notches

The incidence of early diastolic notch in the experimental group was notably higher than that of the control group (P < 0.05, **Table 4**).

Comparison of pregnancy outcomes

The number of neonates with the Apgar score ≥ 7 points in the experimental group was significantly smaller than that in the control group (P < 0.05, **Table 4**).

Correlation between arterial blood flow during pregnancy and GDM

PI, RI and S/D of arterial blood flow during pregnancy were positively correlated with the occurrence of GDM (P < 0.05, **Table 5**).

Table 4. Comparison of the incidence of early diastolic notch and neonatal Apgar score between the two groups of pregnant women

Group	Number	Early diastolic notche	The neonatal Apgar score	
			≥ 7 points	< 7 points
experimental group	76	20 (26.3)	67 (88.16)	9 (11.84)
control group	76	4 (5.26)	74 (97.37)	2 (2.63)
X^2		12.6669	4.8021	
P		< 0.001	0.028	

Table 5. Correlation between changes in blood flow indexes during pregnancy and the occurrence of GDM

Index	GDM	
	r	P
PI	0.806	< 0.01
RI	0.845	< 0.01
S/D	0.736	0.014

Discussion

GMD is a common disease unique to pregnant women. With the development of pregnancy, the metabolism of pregnant women will also change, manifested by elevated blood sugar levels and endocrine disorders, which directly affect the safety of mothers and fetuses [13]. Color Doppler ultrasound system is a common instrument for clinical ultrasound examinations of pregnant women. It is non-invasive and of ease to operate, and has been widely used at present. The use of color Doppler ultrasound is convenient for doctors to detect abnormal changes in pregnant women and fetuses in the abdomen [14, 15]. At present, color Doppler ultrasound is often used for prenatal screening of fetuses in obstetrics. It is an important means of health care during pregnancy and has high clinical application value [16]. Nevertheless, very few studies on color Doppler ultrasound to detect maternal arterial blood flow parameters were reported. Relevant study points out that color Doppler ultrasound detection of pregnant women's arterial hemodynamic parameters can effectively reflect pregnant women's adverse conditions during pregnancy [17]. In order to further understand the effect of color Doppler ultrasound on maternal arterial hemodynamic parameters, we selected GDM pregnant women for in-depth research and found that the S/D value, RI value, PI value, the arterial blood flow score and the incidence of early diastolic notch were significantly higher than those in the control group, and the maximum arterial systolic and minimum diastolic velocity were lower than those in the control group. It is indicated that hemodynamic parameters are related to blood flow scores, and the use of color Doppler ultrasound can detect the arterial blood flow indicators of pregnant women to a certain extent. And through correlation analysis, it is found that the increase of blood flow index PI, RI and S/D value during pregnancy is positively correlated with the onset of GDM, indicating that the arterial blood flow condition during pregnancy can reflect the formation process of GDM, and has certain clinical significance for GDM diagnosis and disease monitoring. Pregnant women with GDM mellitus have abnormally higher blood sugar levels than healthy pregnant women, which means that the plasma viscosity of women with GDM is too high, so the blood flow resistance becomes larger and the flow speed decreases, which easily leads to abnormal blood perfusion in the early diastole, and seriously affects the health of mother and child [18]. We statistically analyzed pregnancy outcome of pregnant women and the number of neonates with the Apgar score ≥ 7 points in the experimental group was significantly smaller than that in the control group, indicating that changes in the arterial blood flow of pregnant women would affect the growth and development of the fetus. Generally speaking, healthy pregnant women use placental villus interstitial perfusion to meet the nutrients required for placental growth or to remove metabolites. The source of placental villus interstitial perfusion is maternal arterial blood perfusion. GDM patients are a special disease group, and it may cause premature delivery because of placental blood perfusion caused by the abnormally slow blood flow [19]. Reduced placental blood perfusion can lead to insufficient fetal nutrient intake, which affects fetal development; on the other hand, the delayed removal of metabolites increases the risk of fetal asphyxia. The use of color Doppler ultrasound to detect pregnant women's arterial hemodynamic parameters can be used to timely discover the abnormal perfusion of the placenta and provide effective

predictions for pregnancy outcome. The results of this experimental study are consistent with the study of Sarit Avraham [20] and others who found that color Doppler ultrasound can accurately predict the adverse pregnancy outcome of pregnant women with GDM; color Doppler ultrasound can detect fetal MAC, UA and Ut-A hemodynamic parameters and arterial blood flow score of pregnant women; color Doppler ultrasound can effectively reflect the status of pregnant women with GDM and predict pregnancy outcome.

Conclusion

Clinically, color Doppler ultrasound may be used to understand the abnormal blood glucose of GDM pregnant women, identify the cause of the abnormality through symptoms, and detect the maternal arterial blood flow indicators to achieve timely understanding of the abnormal condition of the fetus, and provide a basis for preventing adverse pregnancy outcomes. However, a study involved larger sample size still needed in the future to further support the conclusion.

Disclosure of conflict of interest

None.

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