Relationship between ultrasound parameters of the umbilical and middle cerebral arteries and intrauterine fetal distress

Abstract

BACKGROUND

By comprehensively analyzing the blood flow parameters of the umbilical and middle cerebral arteries, doctors can more accurately identify fetal intrauterine distress, as well as assess its severity, so that timely interventions can be implemented to safeguard the health and safety of the fetus.

AIM

To identify the relationship between ultrasound parameters of the umbilical and middle cerebral arteries and intrauterine distress.

METHODS

Clinical data of pregnant women admitted between January 2021 and January 2023 were collected and divided into the observation and control groups (n = 50 each), according to the presence or absence of intrauterine distress. The ultrasound hemodynamic parameters of the uterine artery (UtA), fetal middle cerebral artery (MCA), and umbilical artery (UmA) were compared with neonatal outcomes and occurrence of intrauterine distress in the two groups.

RESULTS
Comparison of ultrasonic hemodynamic parameters, resistance index (RI), pulsatility index (PI), and systolic maximal blood flow velocity of umbilical artery (UA) compared to diastolic blood flow velocity (S/D), revealed higher values of fetal MCA, PI, and S/D of UmA in pregnant women with UtA compared to controls (P<0.05), while there was no difference between the two groups in terms of RI (P<0.05) The incidence of a neonatal Apgar score of 8-10 points was lower in the observation group (66.7%) than in the control group (90.0%), and neonatal weight (2675.5±27.6g) was lower than in the control group (3117.5±31.2g). Further, cesarean section rate was higher in the observation group (70.0%) than in the control group (11.7%), and preterm labor rate was higher in the observation group (40.0%) than in the control group (10.0%). The incidence of fetal distress, neonatal growth restriction and neonatal asphyxia were also higher in the observation group (all P<0.05).

CONCLUSION
Fetal MCA, UmA, and maternal UtA hemodynamic abnormalities all develop in pregnant women with intrauterine distress during late pregnancy, which suggests that clinical attention should be paid to them, and monitoring should be strengthened to provide guidance for clinical intervention.

Key words: Late pregnancy; Fetal intrauterine distress; Ultrasound blood flow parameters; Uterine artery; Middle cerebral artery; Umbilical artery

Core tip:
Monitoring these ultrasound parameters is particularly important in high-risk pregnancies such as umbilical cord bypass, fetal growth restriction, or multiple pregnancies.

**INTRODUCTION**

Fetal intrauterine distress is a condition in which the fetus has an insufficient supply of oxygen and nutrients, thus affecting its normal growth, development, and safety; this condition can be caused by a variety of reasons. It most commonly develops when the transfer of oxygen and nutrients from mother to fetus is affected by placenta previa, abruption, and insufficiency. Second, problems such as umbilical cord entanglement, prolapse, and obstruction of umbilical cord blood flow severely limit the blood supply to the fetus. Third, if the mother suffers from severe hypertension, diabetes mellitus, renal disease, cardiovascular disease, or infection, the oxygen and nutritional supply from the mother to the fetus may be affected. In addition, if the fetus has genetic disorders, congenital heart disease, intrauterine infection, or fetal hydrops, it may lead to an increased demand for oxygen or a less efficient utilization of oxygen by the fetus. Intrauterine distress is often accompanied by abnormal changes in the fetal heart rate, abnormal amniotic fluid, decreased fetal activity, and changes in biochemical indicators, such as fetal acidosis. Fetal heart monitoring, ultrasonography, and biochemical indicator tests are commonly used to diagnose this disease.

Once fetal intrauterine distress is detected, immediate measures should be taken to improve the fetal blood and oxygen supply, such as changing the position of the pregnant woman, administering oxygen and fluids, and administering contraction
inhibitors. For severe intrauterine distress, early delivery may need to be considered to ensure the safety of mother and baby[3]. Regular prenatal checkups are performed to control maternal diseases and to avoid risk factors that may lead to fetal intrauterine distress. Ultrasound blood flow parameters of the umbilical and middle cerebral arteries are important tools for assessing fetal intrauterine distress. By monitoring changes in these parameters, physicians can more accurately determine the health status of the fetus and formulate appropriate treatment strategies accordingly. However, these parameters should be interpreted in conjunction with the clinical presentation and other test results, as blood flow parameters alone do not fully determine fetal health. Intrauterine fetal distress is a serious pregnancy complication that requires close monitoring and management by physicians and pregnant women to ensure both fetal health and safety. Early detection of intrauterine fetal hypoxia and reasonable interventions are important. In this study, the middle cerebral, umbilical, and uterine artery parameters and fetal intrauterine distress are discussed.

MATERIALS AND METHODS

General information

Pregnant women with intrauterine distress admitted to our hospital between January 2021 and January 2023 were included in the observation group, while normal pregnant women were enrolled as the control group. The inclusion criteria were as follows: Observation group, abnormal fetal heart rate and clear signs of intrauterine distress; Control group, no abnormal fetal heart rate and no signs of hypoxia. The exclusion criteria were a history of smoking and alcohol consumption
during pregnancy, complications during pregnancy, hereditary diseases, breech or transverse fetal position, and abnormal placenta or fetal malformations. This study was approved by the Ethics Committee of our institute.

**Inspection methods**

Ultrasonography was performed with a probe frequency of 2.5-5.0 MHz, and color Doppler ultrasound was used to measure hemodynamics after verification of gestational age. The following hemodynamic parameters were examined: resistance index (RI), pulsatility index (PI), and systolic maximal flow velocity of the umbilical artery compared to diastolic flow velocity (S/D) in a sampling volume of 2 mm and a vascular angle of 60°. Three complete, clear, continuous, and stable spectral images of the blood flow were obtained, and the parameters were measured and recorded. The examination was divided into three steps. The first was performed at the beginning of the middle cerebral artery (MCA) and was repeated three times to obtain the highest peak value. The second was performed at the free section of the umbilical cord and the umbilical artery near the entrance of the umbilical cord to the placenta (UmA). The third was performed at the vertical branch of the iliac vessels facing the uterine arteries (UtA) to measure blood flow parameters.

**Observed indicators**

PI, RI, and S/D values of each blood flow parameter of the maternal UtA and fetal MCA and UmA; neonatal birth Apgar score; and pregnancy outcome.

**Statistical analysis**

All data were included using SPSS21.0 statistics. Variables conforming to normal distribution are expressed as (x±s), categorical variables as (%), and
comparisons between groups were performed using the t or χ² tests. P<0.05 was considered statistically different.

RESULTS

Basic information

There were 50 cases in the control group (age 29.1±3.3 (24-40) years, gestational period 38.4±1.8 (32-41) weeks). The observation group comprised a further 50 cases (age 28.9±3.3 (24-40 years), gestational period 38.4±1.4 36-42 weeks). There was no significant difference between the two groups (P>0.05).

Comparison of blood flow parameters

All hemodynamic parameters of pregnant women's UtA were higher in the observation group than in the control group (P<0.05); PI and S/D of the fetal MCA were lower in the observation group than in the control group; those of UmA were higher than in the control group (both P<0.05), and there was no difference in the RI values between the two groups (P>0.05). See Table 1.

Logistic regression correlation analysis of fetal UtA and MCA ultrasound blood flow parameters of umbilical cord bypass and fetal intrauterine distress

Logistic regression analysis revealed a significant correlation between PI, RI, and S/D of the UA and MCA in umbilical cord-wrapped fetuses and intrauterine distress (P < 0.05, Table 2).

Neonatal situation

The neonatal weight was found to be lower in the observation group (2675.5±27.6g) than in the control group (3117.5±31.2g) (t=14.354, P=0.002); neonatal score of 8-10 points was 40 cases, while in the control group there were 2 cases of ≤3 points, 4 cases of 4-7 points, and 54 cases of 8-10 points, and the proportion of
patients with a score of 8-10 points in the observation group (66.7%) was lower than that of the control group (90.0%) (both P<0.05).

Cesarean section was more common in the observation group (42 cases, 70.0%) than in the control group (7 cases, 11.7%), while the rates of preterm delivery was also higher in the observation group (24 cases, 40.0%) than in the control group (6 cases, 10.0%); the incidence of fetal distress (12 cases, 20.0%), neonatal growth restriction (24 cases, 40.0%), and neonatal asphyxia (4 cases, 6.7%) was higher in the observation group than in the control group (2 cases, 3.3%) (0) (all P<0.05). (4 cases,6.7%)(0) (all P<0.05).

**DISCUSSION**

Fetal intrauterine distress in late pregnancy is primarily caused by three reasons: first, the poor development of the fetus itself; second, a decline in the oxygen content of the pregnant woman's own blood; and third, poor transportation or exchange of blood oxygen between the mother and baby. Once intrauterine distress occurs, it directly affects the growth and development of the fetus, and further affects the intellectual and nervous systems[4,5]. Fetal movement counting and fetal heart rate monitoring have different degrees of limitations and low diagnostic value, whereas ultrasonography has become a major means of prenatal examination because of its good economy, reproducibility, and non-invasiveness[6,7]. In late pregnancy, hypoxia is determined by blood flow parameters related to the fetal MCA, that is, S/D is less than 4, PI is less than 1.6, and RI is less than 1.6. It should be emphasized that there is a bidirectionality of RI; it decreases in the hypoxic compensatory state and remains normal, or increases in the hypoxic
decompensatory state. A significant increase in MCA-PSV can be considered as an indicator of anemia[8-10]. In fetal hypoxia, end-diastolic blood flow was first affected and then decreased, while PI, RI, and S/D values increased. When the diastolic waveform was inverted or absent, the hypoxic condition was considered to be severe[11,12]. A series of MCA, UmA, and UtA parameters detected using two-dimensional ultrasound and ultrasound Doppler allow a clear diagnosis of intrauterine fetal hypoxia and anemia.

In the present study, the incidence of intrauterine distress was found to be increased in the presence of abnormal changes in the UtA, UmA, and MCA, which was further confirmed by examination the neonatal score and pregnancy outcomes. As the main source of fetal blood supply, the alteration of blood flow in the UtA has a direct impact on growth and development[13], while the UmA effectively reflects the state of placental-fetal blood circulation, which is greatly increased in the presence of intrauterine distress[14]. This can provide a clinical reference and make prevention of intrauterine distress more targeted. In the present study, logistic regression analysis revealed a significant correlation between the PI, RI, and S/D of the UA and MCA and fetal intrauterine distress (P < 0.05), indicating that fetal UA and MCA blood flow parameters could be detected by ultrasound and objectively used to judge and predict fetal intrauterine distress.

Ultrasound parameters of umbilical artery and middle cerebral artery are important tools for evaluating fetal distress, but there are still significant limitations. First of all, the technology has high requirements for operator experience and equipment quality, and the measurement results are easily affected by subjective
factors and image quality. Secondly, fetal hemodynamic parameters will change dynamically with factors such as fetal status, maternal health status, and examination time. A single test is difficult to fully reflect the entire pregnancy. Furthermore, abnormal blood flow parameters are not directly equated with fetal distress, and false positive and false negative results may occur. In addition, different blood flow parameters are interrelated and have different responses under pathological conditions, which need comprehensive analysis to accurately determine. At present, the normal range and abnormal standard of relevant blood flow parameters have not been unified in the world, which increases the difficulty of clinical interpretation. Therefore, in clinical practice, it is often combined with other monitoring methods to evaluate the risk of fetal distress in order to improve the diagnostic accuracy.

CONCLUSIONS

In conclusion, the ultrasound blood flow parameters (RI, PI, S/D) of the UtA and MCA were higher in umbilical cord-bypassed fetuses than in non-umbilical cord-bypassed fetuses and were more prominent in late pregnancy. The RI, PI, and S/D of the UA and MCA were highly correlated with intrauterine distress.
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