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## Q1 Ultrasonic characteristics and clinical significance of umbilical cord blood flow in acute fetal distress

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### ABSTRACT

**Objective:** To study ultrasonic characteristics of umbilical cord blood flow in acute fetal distress and its correlation with umbilical artery blood gas parameters, oxidative stress parameters, neonatal brain injury and myocardial injury.

**Methods:** The pregnant women delivered in Department of Obstetrics of our hospital were chosen during the period from May 2012 to August 2015. The pregnant women with acute fetal distress were included in the distress group, and the healthy pregnant women with no acute fetal distress were included in the control group. The resistance index (RI), pulsatility index (PI) and systolic/diastolic (S/D) ratio of umbilical artery were measured at 24–30 weeks, 31–36 weeks and 37–41 weeks of pregnancy. After delivery, umbilical artery blood was taken for analysis of blood gas and determination of oxidative stress parameters. The venous blood of newborns was taken to measure the myocardial injury and brain injury parameters.

**Results:** At 24–30 weeks, 31–36 weeks and 37–41 weeks of pregnancy, RI, S/D and PI in pregnant women of distress group were significantly higher than those in control group. The pH, contents of arterial partial pressure of oxygen, vitamin C, vitamin E, superoxide dismutase and glutathione peroxidase in umbilical artery blood in pregnant women of distress group was significantly lower than that in control group and negatively correlated with the umbilical artery RI, PI and S/D. The contents of partial pressure of carbon dioxide in artery, lactic acid and malondialdehyde in pregnant women of distress group were significantly higher than those in control group and positively correlated with the umbilical artery RI, PI and S/D. The contents of lactate dehydrogenase, hydroxybutyrate dehydrogenase, creatine kinase, creatine kinase-MB, S100B, neuron-specific enolase, creatine kinase-BB and Tau in newborns' venous blood in distress group were significantly higher than those in control group and positively correlated with the umbilical artery RI, PI and S/D.

**Conclusions:** The ultrasonic characteristics of umbilical cord blood flow in patients with acute fetal distress are increase of the resistance, reduction of blood flow, and significant reduction of ultrasonic parameters of RI, PI and S/D. The degree of hypoxia, oxidative stress, myocardial injury and brain injury can also be evaluated.

## 1. Introduction

Acute fetal distress is one of the serious complications in perinatal period and it refers to acute hypoxia of the fetus in the

womb. Its pathological features are the circulatory and respiratory dysfunctions of the fetus in the womb, which will damage the heart, lung and brain of the fetus and other important visceral organs and lead to fetal death, neonatal asphyxia when it's serious. Besides, the survived fetus will leave the intrauterine nerve injury because of hypoxia for a long time<sup>[1–3]</sup>. The occurrence of fetal distress is related to various factors such as umbilical cord, placenta, maternal, fetal factors, etc. Hypertension during pregnancy is a common maternal factor to cause fetal distress. Placental abruption and placental previa are the common placental factors to cause fetal distress. Fetal malformation and congenital heart disease are the common fetal factors to cause fetal distress. And umbilical cord around

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the neck is the common umbilical cord factor to cause fetal distress<sup>[4,5]</sup>. At present, the fetal distress is mainly predicted and diagnosed by fetal heart rate monitoring and amniotic fluid monitoring in clinic. However, the sensitivity is not very satisfactory and it cannot detect the disease in the early phase and make intervention.

The growth, development and metabolism of fetus in the womb need umbilical cord to provide nutrition and oxygen. Under physiological conditions, the pressure differences between umbilical cord blood and maternal blood can guarantee adequate blood flow in the umbilical artery and adequate nutrition and oxygen of fetus. When the umbilical cord blood flow is reduced and the blood flow is not enough due to different pathological factors, the parent cannot provide the necessary nutrition and oxygen for the growth and development of the fetus, which can result in fetal distress<sup>[6,7]</sup>. Umbilical cord blood flow is an important channel to connect the fetus and the maternal body. Evaluating the characteristics of umbilical cord blood flow with ultrasound can provide references for the prediction and diagnosis of fetal distress<sup>[8]</sup>. In the following study, the characteristics and clinical significance of umbilical cord blood flow in patients with acute fetal distress was analyzed.

## 2. Materials and methods

### 2.1. Clinical data

Pregnant women delivering in our hospital in obstetrical department during the period of May 2012–August 2015 were selected and their medical history was reviewed. Inclusion criteria: (1) Receiving prenatal examination on a regular basis in our hospital and having complete medical history data; (2) umbilical arterial blood gas was analyzed immediately after delivery; (3) umbilical artery blood samples and peripheral blood samples of newborns were collected; (4) informed consent was obtained. Exclusion criteria: (1) Fetus with congenital heart disease or deformity; (2) with complications of placental abruption, placenta previa and premature rupture of membranes; (3) incomplete medical history data or missing clinical samples. A total of 179 pregnant women were included. Apgar score was used to determine whether they have fetal distress or not, and accordingly, they were divided into distress group and control group. There were 52 pregnant women in distress group with average age of (29.93 ± 4.78) years old. The pregnant weeks on average were (37.41 ± 5.51) weeks at delivery. There were 127 in control group. The average age was (29.34 ± 4.25) years old. The pregnant weeks on average were (38.32 ± 5.23) weeks at delivery.

### 2.2. Methods

#### 2.2.1. Detection of umbilical cord blood flow using ultrasonography

Cord blood flow ultrasound examinations were taken by using four-dimensional color ultrasonic diagnostic apparatus (GE, USA). The probe frequency was 3.5 MHz and the examinations were taken at 24–30 weeks, 31–36 weeks and 37–41 weeks of their pregnancy. Firstly, the conditions of biparietal diameter, placenta, umbilical cord, amniotic fluid and other parts were examined. Then, the ultrasound probe was placed at the

ventral side of the fetus to acquire the umbilical artery blood flow signal and continuous blood flow signals of five cardiac cycles. The end-diastolic blood flow velocity and the end-systolic blood flow velocity were measured. The systolic/diastolic (S/D) ratio, resistance index (RI) and pulsatility index (PI) were calculated.

#### 2.2.2. Analysis of umbilical cord blood gas and molecular detection

Umbilical cord arterial blood was taken to measure the pH, partial pressure of oxygen in artery (PaO<sub>2</sub>), partial pressure of carbon dioxide in artery (PaCO<sub>2</sub>) and lactic acid contents by using blood-gas analyzer. The contents of superoxide dismutase (SOD), glutathione peroxidase (GSH-pX), malondialdehyde (MDA), vitamin C (VitC) and vitamin E (VitE) were measured by radioimmunity precipitation assay kit provided by Nanjing Jiancheng Biological Company.

#### 2.2.3. Detection of venous blood indexes of newborns

The neonatal peripheral vein blood was withdrawn and centrifuged. The contents of S100B protein, neuron specific enolase (NSE), creatine kinase-BB (CK-BB) and Tau protein in serum were determined by using ELISA, and the content of lactic dehydrogenase (LDH),  $\alpha$ -hydroxybutyrate dehydrogenase (HBDH), creatine kinase (CK) and creatine kinase-MB (CK-MB) was measured by using automatic biochemical analyzer.

### 2.3. Statistical analysis

The data was input and analyzed by SPSS20.0. The measurement data was analyzed by *t*-test. The correlation analysis was carried out by Pearson test. Difference was regarded as statistical significance when  $P < 0.05$ .

## 3. Results

### 3.1. Umbilical artery blood flow indexes at different phases in pregnant women in the two groups

At 24–30 weeks, 31–36 weeks and 37–41 weeks of pregnancy, the values of RI, S/D and PI of pregnant women in distress group were significantly higher than those in control group (Table 1).

### 3.2. Parameters of umbilical arterial blood gas and oxidative stress

Analyses of umbilical arterial blood gas parameters of pregnant women in the two groups are as follows: pH (6.96 ± 0.78 vs. 7.21 ± 0.95) and PaO<sub>2</sub> [(36.53 ± 6.14) vs. (55.25 ± 7.85) mmHg] of umbilical artery blood of pregnant women in distress group were significantly lower than those of control group. PaCO<sub>2</sub> [(60.41 ± 9.25) vs. (35.42 ± 4.86) mmHg] and lactic acid [(4.51 ± 0.78 vs. 2.25 ± 0.33) mmol/L] were significantly higher than those of control group. Analyses of oxidative stress parameters are as follows: the contents of SOD [(69.33 ± 9.14) vs. (94.52 ± 11.47) IU/L], GSH-Px [(98.67 ± 11.76) vs. (165.65 ± 22.37) IU/L], VitC [(22.15 ± 3.52) vs. (35.25 ± 5.69)  $\mu$ g/mL], VitE [(4.68 ± 0.74) vs. (7.92 ± 1.03)  $\mu$ g/mL] of arterial blood of pregnant women in distress group were significantly

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