Respiratory gases and acid base parameter of the fetus during the second and third trimester

B. LAZAREVIĆ - A. LJUBIĆ - - R. STEVIĆ - V. ŠULOVIĆ
B. ROSIĆ - N. RADUNOVIĆ - S. ILIĆ

Summary: Respiratory gases and acid base parameters were determined in the samples of fetal blood collected by cordocentesis from 70 patients with normal course of pregnancy, between 18th and 38th gestational week. The mean pH value was 7.386±0.05; partial pCO_2 pressure −4.819± 1.464 kPa; O_2−5.712±1.24 kPa; bicarbonate 21.528±0.494 mMol/l; base excess −2.284±0.647 mMol/l and saturation 74.86±13%. Statistically significant negative correlation between gestational age and pH ($r=0.841$, $p<0.01$) and partial O_2 pressure ($r=-0.961$, $p<0.01$) was revealed. Partial CO_2 pressure correlated significantly with gestational age ($r=0.923$, $p<0.01$). The values of bicarbonate and base excess do not change significantly during gestation. Our own standards of examined parameters were formed.

INTRODUCTION

The normal physiological and biochemical milieu of the human fetus is of utmost importance in fetal medicine, this being a new, developing field of medical science. Knowledge of fetal physiology was limited by the fact that all the evidence was obtained through experimental models. The introduction of the percutaneous umbilical blood sampling created a new field of diagnostic and therapeutic possibilities ([1, 2, 3, 4]).

Fetal hypoxia, as well as its nature, can be revealed thanks to this new procedure, by the analysis of the respiratory gases and acid base parameters in fetal blood. That is why cordocentesis is the method of choice in prenatal follow up of physiological and pathophysiological processes in the fetus. The aim of this study is the analysis of the respiratory gases and acid base parameters in fetal blood during the second and third trimester of pregnancy.

MATERIAL AND METHODS

The study comprised 70 pregnant women, who were managed at the Gynecology and Obstetrics Clinic, UKC, Belgrade. The gestational ages were between 18 and 38 weeks, as determined on the bases of the last menstrual period, and confirmed by the ultrasound examination before the 20th week. All the pregnancies had clinically normal course.

The indications for cordocentesis were determination of karyotype and detection of fetal infection. The technique of cordocentesis has been described in our earlier papers ([5]). The sample was collected in a heparinized syringe and immediately sent for the determination of particle

Gynecology and Obstetrics Clinic,
UKC Belgrade (Yugoslavia)

volume (Coulter Counter S Plus II) and for the determination of purity of blood sample (6). In the second syringe we collected 0.5 ml of blood in order to determine the blood group and hematological factors (hematocrit and red blood cells). In the third heparinized syringe 0.5 ml of fetal blood was collected for the estimation of acid base parameters with the use of a gas analyzer (Radiometer ABL 330, Copenhagen). This sample was used for determination of pH value, partial CO_2 (pCO_2) and O_2 (pCO_2) and O_2 (pO_2) pressure, bicarbonate (HCO_3), base excess (BE) and saturation.

Correlation between gestational age and acid-base parameters was examined by Pearson's correlation coefficient and it was represented by linear regression analysis. Statistical packet Statgraf 2.2 on IBM AT PC was used.

RESULTS

The mean values of the parameters examined (X), standard deviation (SD), and coefficient of variability (CV) are presented on Table 1.

Chart no. 1 shows mean values of the fetal pH during gestation. The mean value of pH is 7.386, SD is 0.033, and CV 0.4%. The decline of pH value from 7.415 in 18th week to 7.357 in 38th week of pregnancy is statistically significant ($p<0.01$). It can be expressed by a negative linear correlation ($r=-0.841$, $p<0.01$).

Chart no. 2 presents the values of pCO_2 in fetal blood during pregnancy. The mean value of partial pressure of CO_2 is 4.819 kPa, SD this 0.464, and CV 30%. It increases from 4.486 kPa in 1 8to 5.426

Table 1.

Parameter	Healthy	M. Hemolyticus
pH	7.39± 0.05	7.31± 0.06*
pCO_2 (kPa)	4.98± 0.31	6.36± 0.64**
pO_2 (kPa)	4.96± 0.90	2.65± 0.89**
HCO_3 (mMol/l)	21.56± 0.27	23.84± 3.02
BE (mMol/l)	−2.30± 0.90	−2.72± 2.66
SAT. (%)	67.23±11.60	28.66±15.56**

(*) $p<0.05$
(**) $p<0.01$

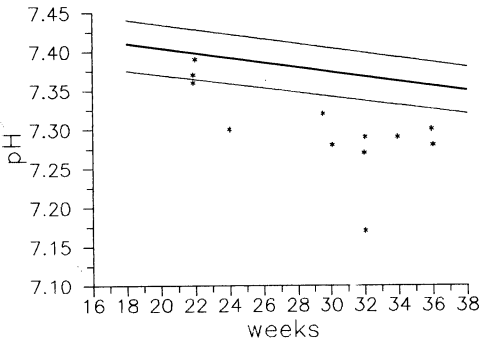

Fig. 1.

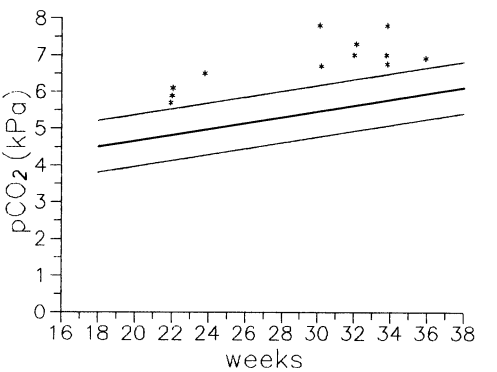

Fig. 2.

creases from 4.486 kPa in 18 to 5.426 Significant correlation is demonstrated by positive linear regression ($r=0.9237$, $p<0.01$).

Chart no. 3 presents O_2 partial pressure in examined fetuses during gestation. The mean value of O_2 partial pressure is 5.712 kPa, SD is 1.240, and CV 22%. It shows a tendency to slow reduction from 7.84 kPa in 18th to 4.312 kPa in 38th week of pregnancy. This decline is statistically highly significant ($p<0.005$). Chart no 3. represents the curve of linear regression ($r=-0.961$; $p<0.01$).

Chart no. 4 presents the bicarbonate values in the fetuses during gestation. The mean value of bicarbonate is 21.528 mMo/l, SD is 0.494, and CV 2.3%. This

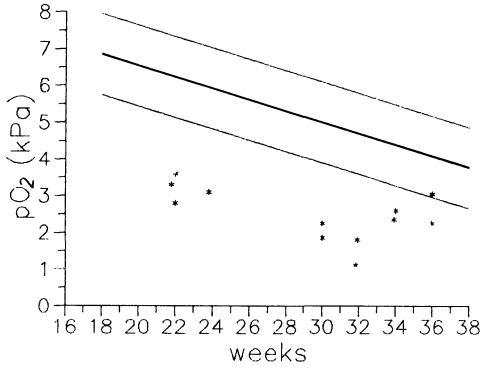

Fig. 3.

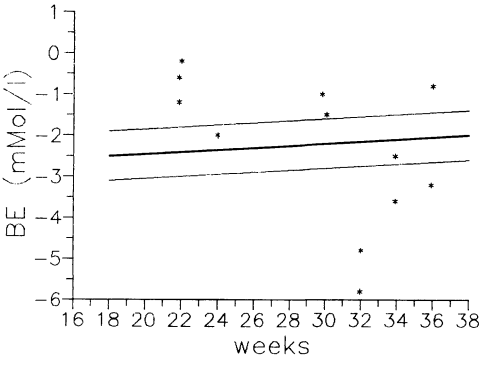

Fig. 4.

parameter shows no significant changes during pregnancy ($r=0.098$; $p>0.05$).

Chart no. 5 presents the values of base excess in examined patients during gestation. The mean value of base excess is −2.284 mMol/l, SD is 0.647, and CV 28%. The changes of this parameter through gestation is not statistically relevant ($r=-0.323$; $p>0.05$).

Finally, chart no. 6 presents the values of saturation of the fetuses during gestation. The mean value of saturation is 74.86%, SD is 13%, and CV 17.3%. Statistically significant reduction of values from 90.86% in 18th to 57.38% in 38th gestational week is noticed ($p<0.005$). Negative correlation is expressed with curve of linear regression ($r=-0.961$; $p<0.01$).

DISCUSSION

Sonographically controlled percutaneous umbilical blood sampling during the second and third trimester of pregnancy gave us the opportunity to examine biochemical milieu of the human fetus in stable, physiological condition.

Standard values of respiratory gases and acid base parameters were determined in

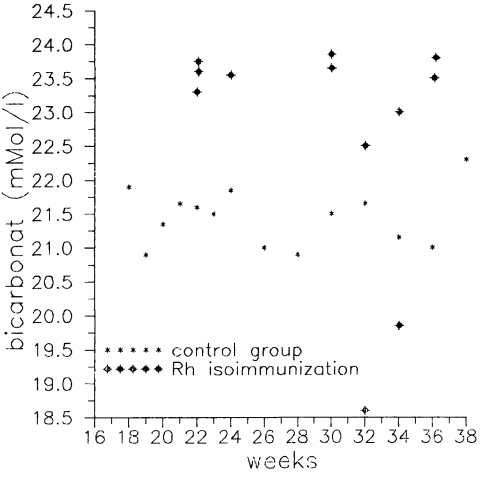

Fig. 5.

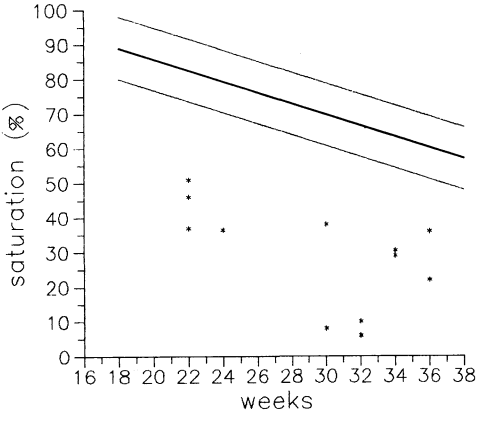

Fig. 6.

70 healthy fetuses from 18th to 38th gestational week. The values of pH, partial O_2 pressure and saturation decreased, while partial CO_2 pressure increased significantly through pregnancy. The values of bicarbonates and base excess did not change significantly during gestation. Compared with adult population, examined parameters of the fetal blood appeared significantly different.

This investigation demonstrated that the value of fetal pH was lower than in maternal blood in physiological conditions, which is in accordance with some previous studies ([7]). Although the value of fetal pH declined through gestation, uterine - umbilical pH gradient from 0.06 to 0,10 demonstrated adequate fetal oxygenation.

Oxygen pressure was lower in fetal than in maternal blood, supporting maternal - fetal gradient, which is very important for the transportation of oxygen through the placenta.

O_2 partial pressure declined through gestation as a result of the increased placental and fetal consumption. In spite of that, oxygen level in fetal blood remained constant due to fetal physiological adaptive mechanisms.

In dependance of oxygen consumption in fetal tissues, adequate quantities of carbon dioxide are produced. Partial CO_2 pressure in fetal blood is slightly higher and reflects the level of pCO_2 in the maternal blood. Maternal - fetal pCO_2 gradient is a result of hypocapnia, with decrease of pCO_2 in healthy pregnant women.

Analysis of respiratory gases in fetal blood revealed that pCO_2 was increasing through gestation. Although the reasons are not well understood, the possible explanation could be the worsening of circulation in utero - placental bed and increased trophoblastic production of CO_2.

The value of bicarbonate was lower in fetal than in maternal blood and showed no correlation to the acid - base status. We found bicarbonate values very uniform, ie. there was no correlation with gestational age.

Base excess was lower in fetal than in maternal blood, and tended to decrease slowly through pregnancy.

We have made our own standards for respiratory gases and acid - base parameters in fetal blood. They are very similar to the values obtained in the investigations of the other authors ([4, 8, 9]).

It could be concluded that sonographically controlled cordocentesis is a safe procedure that enables us to examine fetal physiology. These possibilities of prenatal diagnostics contribute to a significant decrease of perinatal mortality and morbidity.

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Address reprint requests to:
V. SULCVIC
Dept Ob./Gyn.
Belgrade University
Visegradska, 26
Belgrade (Yugoslavia)