The influence of anemia on respiratory gases and acid base parameters of the fetus

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Summary: Fetal blood samples were collected by cordocentesis from 82 pregnant women; 12 of whom had severe forms of Rh isoimmunization, while 70 comprised the control group. The mean hematocrit value in the group under investigation was $15.72 \pm 3.62\%$ and indication of severe anemia. The pH value in this group was 7.31 ± 0.06; pCO_2 partial pressure 6.36 ± 0.64; $O_2 - 2.65 \pm 0.89$ kPa; bicarbonate 23.84 ± 3.02 mMol/l: base excess was -2.72 ± 2.66 mMol/l and saturation $28.66 \pm 15.56\%$. In the control group the following values were established: pH -7.386 ± 0.05; partial pressure $pCO_2 - 4.980 \pm 0.31$ kPa; $O_2 - 4.960 \pm 0.90$ kPa; bicarbonate 21.560 ± 0.27 mMol/l; base excess -2.30 ± 0.90 mMol/l and saturation $67.23 \pm 11.60\%$. The pH, partial pressure O_2 and saturation values were significantly lower, while partial pressure CO_2 was significantly higher in the investigated group than in the control group. Bicarbonates and base excess do not change significantly in the presence of anemia. Fetal blood sampling carried out by means of cordocentesis is the most reliable method for assessment of the degree of fetal anemia. The values of acid base parameters and of blood gases are an indication of either respiratory, respiratory-metabolic or metabolic acidosis.

The possibilities of prenatal diagnostics, undoubtedly, contribute to a significant reduction of perinatal mortality.

INTRODUCTION

A essential requirement for normal fetal growth and development is the adequate functioning of the fetoplacental unit. This unit enables an adequate transport of nutrients and O_2 to the fetus while CO_2 is carried away from the fetus towards the mother; in this manner adequate oxygenation of fetal tissue is assured. All etiological factors which contribute to the impairment of this function result initially in hypoxia and later in fetal hypercapnia and in respiratory, respiratory metabolic or metabolic acidosis. Acidosis damages fetal tissue and slows down or even retards fetal growth.

Hemolytic fetal anemia in cases of Rh isoimmunization is one of the obvious clinical examples of decreased quantities of O_2 in fetal circulation. In these cases the mother starts producing anti-D antibodies, class IgG, which after penetrating the placental barrier, bind with the fetal erythrocytes and form immune complexes. These complexes are segmented in the reticuloendothelial fetal system through the process of phagocytosis. The hemolysis induced in this manner results in anemia.

The goal of the author was to study the influence of anemia on the acid base status of the fetus.

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MATERIALS AND METHODS

The study comprised 82 Rh pregnant women, who were managed at the Gynecology and Obstetrics Clinic, University Clinical Center; 12 subjects developed severe forms of Rh isoimmunization. The control group was composed of 70 female patients where cordocentesis was carried out for other reasons (karyotyping, detection of fetal infection). The group under study was composed of pregnant women who manifested no other complications of gestation except isoimmunization.

In the course of the first examination the Rh antibody titer was determined in all cases. The study comprises only subjects with titre $\geq 1:32$ and those where the spectrophotometric analysis of the amniotic fluid indicated that bilirubin was in the B and C zone of Liley's curve. These patients underwent a percutaneous puncture of the umbilical blood vessels to allow for the determination of the fetal blood group, Rh factor and hematocrit.

The acid base parameters were exclusively determined on samples collected prior to the first intrauterine intravascular transfusion, since the effect of the given adult hemoglobin on the fetal acid base status is well known.

The technique of cordocentesis has been described in our earlier papers ([1]). The sample was collected in a heparinized syringe and immediately sent for the determination of particle volume (Coulter Counter S Plus II) and for the determination of purity of blood sample ([2]). 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 aid of a gas analyzer (Radiometer ABL 330, Copenhagen).

Statistical processing was carried out by means of a statistical package Statgraf 2.1 on the IBM AT PC, by means of the t-test and by a two-factor analysis of variants.

RESULTS

Blood samples were collected from twelve fetuses affected by hemolytic disease in order to estimate the degree of anemia and determine the acid base parameters. Hematocrit values in fetal blood ranged from 9 to 20%, the mean value being $15.72 \pm 3.62\%$, which is an indication of a high degree of anemia. Since anemia causes fetal hypoxia, it is to be expected that the acid base parameters will deviate from the normal values.

Table no. I presents the values of the tested parameters of the female subjects under investigation and of the control group. The table shows that pH, pO_2 is significantly higher than in the control group.

Chart no. 1 shows fetal pH in the group of subjects under study which are compared to standard values of pH_2. The mean value of pH in cases of the fetuses with morbus hemolyticus was 7.31 which is lower than pH in the control group by 0.07 pH units. This difference is statistically significant at the level when $p<0.05$; $t=17.063$.

Chart no. 2 presents the values of pCO_2 in the fetuses affected by morbus hemoly-

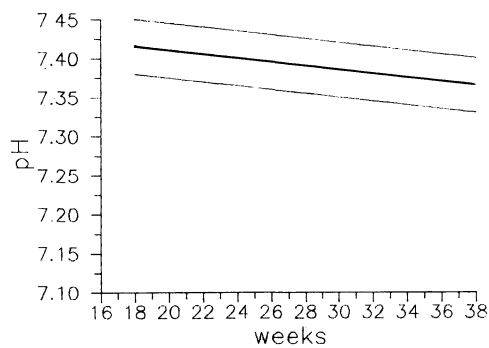


Fig. 1.

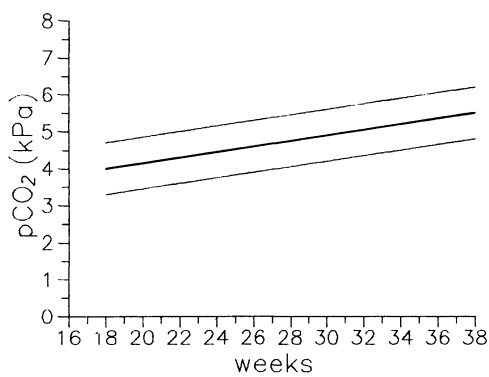
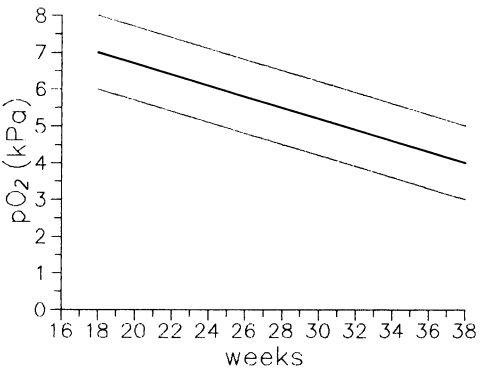


Fig. 2.



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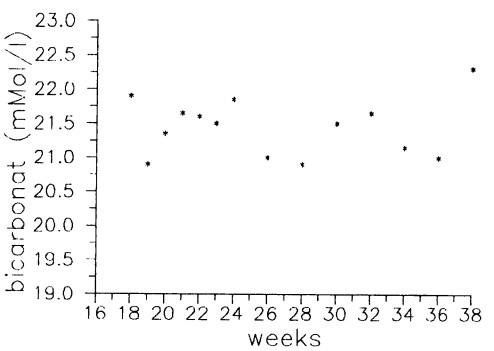

Fig. 4.

ticus and their comparison with the standard values of pCO_2. The mean value of partial pressure of CO_2 is 6.36 kPa, while SD is 0.31 kPa; in the control group the values were as follows: pCO_2 — 4.98 kPa and SD 0.31 kPa. This difference is statistically significant at the level of $p<0.005$; ($t=72.564$).

Chart no. 3 presents O_2 partial pressure in the fetuses affected by morbus hemolyticus, which are compared to standard values of pO_2. The mean value of O_2 partial pressure is 2.65 kPa and SD is 0.89 kPa. In the control group the value of pO_2 is 4.96 kPa and of SD it is 0.90 kPa. The results obtained from the fetuses affected by erythroblastosis are statistically significantly lower than those obtained from the control group at the level of $p<0.005$; ($t=59.575$).

Chart no. 4 presents the values of base excess in the fetuses affected by morbus hemolyticus. These values are shown in reference to standard values. The mean value of base excess is −2.72 mMol/l, while SD is 2.66 mMol/l and it is lower that the measured base excess in the control group (BE −2.30 mMol/l; SD-0.90 mMol/l). This differences is not statistically significant ($t=0.12$; $p>0.05$).

Chart no. 5 presents the bicarbonate values in the fetuses affected by the Rh isoimmunization, which are compared to the values found in the control group. The mean value of bicarbonate is 23.84 mMol/l and SD is 3.02 mMol/l, which

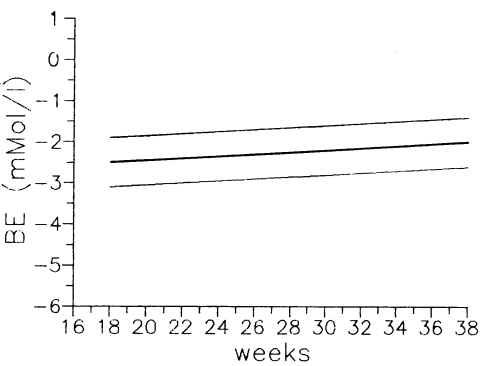

Fig. 5.

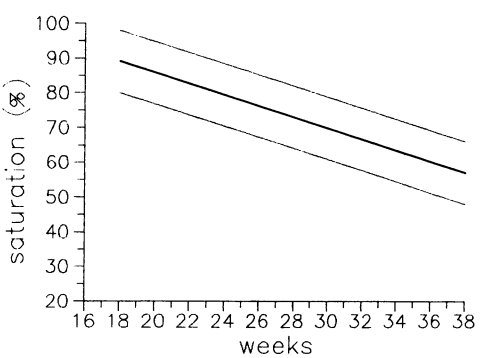

Fig. 6.

is higher than the bicarbonate values in the control group ($HCO_3 = 21.56$ mMol/l; SD = 0.27 mMol/l). This difference too, is not statistically significant ($t = 5.76$; $p < 0.1$).

Chart no. 6 presents saturation values of the fetuses afflicted by morbus hemolyticus, as compared to those of the control group. The mean value of saturation is 28.26%; the value of SD is 15.56%. In the control group the saturation values were 67.23; and of SD-11.60%. This is a statistically significant difference at the level of $p < 0.005$ ($t = 85.056$).

DISCUSSION

The possibility of safe fetal blood sampling and the introduction of percutaneous intrauterine intravascular transfusion represents important progress in the diagnosis and therapy of fetal hemolytic disease ([3]). In pregnancies complicated by isoimmunization the fetuses are affected by anemic hypoxia of various degrees.

By comparing gases and acid base parameters of the fetuses affected by isoimmunization with the values of the control group, it was possible to conclude that 10 fetuses, or 83.33% of cases, with erythroblastosis were afflicted with severe hypoxia accompanied by hypercapnia and excessive base. Two fetuses, or 16.67% of cases, were affected by a mixed respiratory metabolic acidosis with hypercapnia, by a lack of bases and by markedly adverse values of base excess.

The explanation for this disorder is to be found in the prolonged intrauterine hypoxia which is the result of a long-lasting anemia, due to the permanent hemolysis of fetal erythrocytes.

In the beginning, the fetus is capable of compensating anemia by cardiovascular adaptation and gradual promoting of erythropoiesis.

As the oxygen content decreases, so the blood supply to all organs increases up to certain critical values of hemoglobin (40 gr/l), after which blood is redistributed to all vital organs (heart, brain, suprarenal gland). The decreased blood flow towards other organs induces the onset of tissue hypoxia with a reduced buffer capacity of fetal blood and lack of base. If, however, hemoglobin drops below the 40 g/l level greater quantities of lactate are produced, which the placenta cannot "purify" in the course of one passage. Thus, fetal hypoxemia becomes more severe and anaerobic glycosis and metabolic acidosis are on the rebound ([4, 5]). Therefore, the fetus is capable of compensating anemia by means of functional adjustment mechanism as long as hemoglobin does not fall below 1/3 of its normal value. After such a situation has occurred, these mechanisms collapse with the onset of fetal hydrops – the most severe degree of fetal disorder – caused by the hemolytic disease, which does not rule out death ([6]).

Even though ultrasound and CTG apparatuses do offer great possibilities, the above data indicate that in risk pregnancies (Rh isoimmunization, Diabetes mellitus, hypertensive forms of gestosis) fetal blood sampling represents the most precise method for evaluation of fetal anemia and of the nature of its hypoxia. The values of acid base parameters and blood gases allow us to clarify whether we are dealing with respiratory, respiratory-metabolic or metabolic acidosis.

Such possibilities of prenatal diagnostics will doubtless contribute to a significant decrease of perinatal mortality.

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