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Original Article

# Comparison of the umbilical artery blood gas, nucleated red blood cell, C-reactive protein, and white blood cell differential counts between neonates of diabetic and nondiabetic mothers

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**Abstract**

*Objective*: The aim of this study was to compare the neonatal umbilical artery blood gas values, C-reactive protein (CRP) levels, nucleated red blood cells (NRBCs), and white blood cells (WBCs) differential counts between offspring's of the diabetic mothers who needed insulin during pregnancy and normal mothers after cesarean delivery.
*Materials and Methods*: A prospective study was performed involving 68 pregnant diabetic women who needed insulin during pregnancy and 410 healthy pregnant women and their neonates with gestational ages between 35 weeks and 41 weeks. Arterial blood was analyzed for pH and blood gas values and venous blood was analyzed for CRP level, NRBC, and WBC differential counts.
*Results*: The mean NRBC count in the neonates of diabetic mothers and healthy mothers was $560 \pm 985/\mu L$ and $202 \pm 281/\mu L$, respectively ($p < 0.001$). The umbilical arterial blood gas showed a lower pH ($7.22 \pm 0.07$ *vs.* $7.24 \pm 0.04$, $p = 0.004$) and a higher $pCO_2$ ($49.33 \pm 10.08$ *vs.* $47 \pm 8.67$, $p = 0.045$) in neonates of diabetic mothers compared with the controls. Values of $pO_2$, $HCO_3^-$, base excess, WBC differential counts, and CRP levels were almost similar in the two groups.
*Conclusion*: Lower pH, higher $pCO_2$, and elevated NRBC counts were found in the neonates of diabetic mothers that may be suggestive of chronic intrauterine acidosis.


*Keywords:* C-reactive protein; Diabetes; Nucleated red blood cells; Pregnancy; Umbilical arterial blood gas; White blood cell counts

## Introduction

The increasing prevalence of Type 2 diabetes in general, and in younger people in particular, has led to an increasing number of pregnancies with this complication [1]. Diabetic women in pregnancy can be separated in two groups: those who were known to have diabetes before pregnancy (pre-gestational or overt) and those diagnosed during pregnancy (gestational) [2]. The fetus of a diabetic mother is exposed to unexplained fetal death. It has been suggested that hypoxia and acidosis may at least partially account for the increased incidence of intrauterine fetal deaths in diabetic pregnancies [2]. During the past decade, umbilical cord blood gas analysis has increasingly been recognized as the most reliable indication of fetal oxygenation and acid-base condition at birth. Umbilical arterial blood most accurately reflects fetal status because it flows directly from the fetus [3]. In the neonates, increasing of circulating nucleated red blood cells (NRBC) is reported in states, such as hemolysis [4]; intrauterine growth restriction; and preeclampsia [5]. Few studies with small sample sizes reported NRBC values and hematological data in the neonates of diabetic mothers who were born by different routes of delivery [5,6].

On the other hand inflammation may play a role in the pathogenesis of hypoxia-related neonatal complications. Moderately raised C-reactive protein (CRP) levels have been

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found in the subjects at risk of developing cardiovascular diseases [7] and Type 2 diabetes [8]. Total white blood cell (WBC) counts and lymphocyte counts have been suggested to be as possible markers of fetal hypoxic injury [9]. The levels of hemoglobin A1c (HbA1c) is positively correlated with the long-term variations in maternal blood glucose levels in the preceding 2 months [10].

The aim of this study was to compare CRP levels, WBC, and NRBC counts in the umbilical vein and umbilical arterial blood gas values between the neonates of the diabetic mothers who needed insulin and neonates of normal mothers who were born by cesarean delivery. Also HbA1c levels were measured in the diabetic mothers at delivery to evaluate the long-term maternal control of blood sugars.

## Materials and methods

Sixty-eight diabetic mothers who needed insulin therapy and cesarean deliveries were selected as the study group and 410 normal pregnant women who had elective cesarean deliveries because of previous cesarean sections were selected as the control group.

Gestational ages were calculated by the last menstrual period and confirmed by ultrasound. All participants were screened for diabetes during pregnancy and gestational diabetes was diagnosed according to the guidelines of the American College of Obstetricians and Gynecologists [11]. Blood samples were collected from the diabetic mothers at the time of delivery and HbA1c levels were measured by ion exchange high-performance liquid chromatography (Jamea Co., Tehran, Iran) to evaluate the effect of long-term blood sugar control on the fetal outcomes.

After delivery blood samples were collected from neonatal umbilical veins for hematological analyses. Hematological analysis was performed by an automated cell counts analyzer (Sysmex Kx 21N, Kobe, Japan) and the peripheral smears evaluated by a hematologist. Heparinized blood was taken from the umbilical artery for blood gas analysis (COMPACT 3 Blood Gas Analyser, Roche Diagnostics; Graz, Austria). Respiratory, metabolic, and mixed acidemia were defined according to the guidelines of American College of Obstetricians and Gynecologists [12].

The CRP level was measured by qualitative and semi-quantitative method of latex agglutination test (Kimia Pajouhan, Iran). We followed the maternal and neonatal admission charts and medical records for the information and outcomes. This study was approved by the medical ethics committee of Shiraz University of Medical Sciences, and written consents were provided by all the participants. Statistical analysis was made by SPSS Version 15 software (SPSS Inc., Chicago, IL, USA). Statistical $t$ test and $\chi^2$ test were used to evaluate the significance of differences in individual groups. A $p$ value less than 0.05 was considered significant.

## Results

There were 68 diabetic mothers who needed insulin during pregnancy, whose ages were between 20 years and 43 years (mean $31.13 \pm 5.02$) and 410 normal pregnant women with the age of 15–43 years (mean $27.7 \pm 4.2$). The gestational ages at deliveries were between 35 weeks and 41 weeks in the diabetic group and 38–41 weeks in the control group. The mean gravidity for the diabetic mothers was $2.83 \pm 1.76$ and for the normal group was $2.38 \pm 0.97$ ($p =$ not significant). The mean abortion times for the diabetic mothers and the normal group were $0.58 \pm 0.86$ and $0.25 \pm 0.53$ ($p = 0.001$), respectively.

All of these women had cesarean deliveries. Diabetic patients had cesarean deliveries because of severe preeclampsia, fetal macrosomia, previous cesarean sections, or signs of fetal distress and the control group had elective cesarean deliveries because of previous abdominal deliveries. The characteristics of the neonates of the study groups are shown in Table 1.

Table 2 shows the hematological and umbilical blood gas analyses of the neonates of the diabetic mothers compared with the control mothers. Absolute NRBC count in the neonates of diabetic mothers was significantly higher than neonates of healthy mothers (mean $560 \pm 985/\mu L$ *vs.* $202 \pm 281/\mu L$, $p < 0.001$). CRP levels that were measured in the serum derived from the cords of all neonates of diabetic and control groups were exclusively negative (Table 2). The blood gas analysis showed significantly lower pH and higher $pCO_2$ values in the neonates of the diabetic mothers compared with the control group. However, $HCO_3^-$, $O_2$ saturation, WBC differential counts, and CRP levels were not statistically significant between the two groups.

Diabetic women were divided into two subgroups, namely pregestational diabetics with 21 cases and gestational diabetics with 47 cases. Hematologic parameters and blood gas values were all compared between these two groups but there was no significant statistical difference between them. The maternal and neonatal data of these two groups are compared in Table 3. All of the diabetic women had HbA1c less than 10 mg/dL.

Table 1
Comparison between the characteristics of the neonates born from the diabetic and normal mothers

| Variables | Diabetic mothers ($n = 68$) | Control mothers ($n = 410$) | Significance ($p$) |
|---|---|---|---|
| Birth weight (g) | $3,400 \pm 524$ | $3,190 \pm 393$ | <0.001 |
| Gestational age (wk) | $38.07 \pm 1.05$ | $38.64 \pm 0.65$ | <0.001 |
| First minute Apgar score <7 | 6 | 0 | <0.001 |
| Fifth minute Apgar score <7 | 0 | 0 | NS |
| Birth weight ≥4,000 g, $n$ (%) (range) | 9 (13.23); 4,000–4,500 | 14(3.4); 4,120–4,350 | 0.002 |

Data are mean values ± SD.
NS = not significant; SD = standard deviation.