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Original Research

The effect of delivery type on neonatal blood indices in an Iranian population

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ABSTRACT

Background: Generally, there are two methods for childbirth: normal vaginal and cesarean section (C-section). Each method has advantages and complications. In this study, we investigated the effects of type of delivery on hematological parameters in healthy full-term neonates in an Iranian population, from 2016-2017. **Materials**: Three hundred pregnant women, along with their healthy and term babies, were studied. According to the route of delivery, the neonates were divided into two groups: vaginal (n=150) and C-section (n=150). Complete blood count (CBC) and peripheral blood smear (PBS) were performed on the neonates from umbilical cord blood immediately after birth. Data were analyzed by using SPSS v. 22 and statistical analyses were done by student's *t*-test and correlation tests, with P-value < 0.05 set as the lowest limit of significance. **Results**: We observed a significant increase in hematologic parameters, such as red blood cell (RBC) count, hemoglobin, hematocrit, red cell distribution width (RDW), platelets, total leukocyte count and neutrophil count, in full-term neonates who delivered vaginally compared to those delivered by cesarean section (p<0.001). However, there was no significant difference between the delivery types in terms of mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean platelet volume (MPV), platelet distribution width (PDW), eosinophil count, lymphocyte count, or monocyte count. **Conclusion**: According to our study, the mode of delivery influences the hematological parameters in full-term neonates; thrombocytopenia and anemia in neonates were associated with cesarean section delivery. Thus, we recommend that pregnant women do not deliver by C-section unless in emergency situations.

Key words: Blood indices, Delivery type, Iran, Neonate

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INTRODUCTION

Childbirth is one of the divine gifts for procreation and increasing the human population on earth, from the time of Adam and Eve to now. The mechanism of childbirth is a self-sustaining process with no need for external intervention. If the childbirth is dangerous for the fetus or mother, a cesarean section (C-section) can help to save the mother's or baby's life [1,2].

Unfortunately, nowadays, the prevalence of C-section in most of the developed countries has reached more than 50%, and indeed, in many societies childbirth by this method has turned into a cultural trend such that more than half of women voluntarily prefer to have a C-section [3–5]. Thus, in addition to increasing the mother's risk of death after performing this surgery, as well as creating physical and psychological complications, C-section can increase costs for the mother and her family by 2-3 fold. Moreover, mothers who experience disabilities after C-section are prone to inattention, less care, and incorrect breastfeeding after the birth of the newborn [6,7].

C-sections are typically limited to special, emergency cases in which childbirth through the natural channel isn't possible or when serious dangers are posed for mother and fetus. Thus, the use of C-section surgery is restrictive. It is not the preferred method for childbirth since like other surgeries, it is accompanied with risks and complications for mother and fetus [8,9], in comparison to vaginal childbirth. Indeed, the rate of mortality from C-section is 7-fold greater than that for natural childbirth [10]. Owing to the complications C-section poses to mother and fetus, in recent years, international organizations such as the World Health Organization have emphasized that this type of childbirth delivery should only be performed based on the clinical dangers for the mother [11,12].

When vaginal birth occurs naturally, without use of instruments and medications, the newborn immediately has skin contact with the mother, and this can increase the possibility of breastfeeding [13]. The pain of natural childbirth causes the production of oxytocin, epinephrine, and adrenaline which have important roles in facilitating responses between mother and newborn, as well as in early breastfeeding post-delivery [14–16]. On the other hand, the breastfeeding period is the most sensitive period for growth and

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evolution in the human life and, thus, correct infant feeding plays an important role in this period. Breast milk is the most complete food for infants in the first few months after birth [17,18].

Breast milk includes different protective immunological substances, such as immunoglobulins and growth factors. Human milk contains antibodies produced against the mother's peripheral antigens, such as *E. coli*. As a result, infants fed by breast milk are less susceptible to intestinal infections [19–22], and are more protected against rotavirus which can cause infantile gastroenteritis [23]. Furthermore, breastfeeding can decrease the risk of atopic dermatitis and respiratory infections [24]. A mother's milk contains both T and B lymphocytes. T lymphocytes in breast milk are different from those found in the blood; T cells in breast milk particularly present specific antigens. It is suggested an infant benefits from the mother's immunological experiences via the memory T lymphocytes in the milk [25–27]. For the first newborn, the hematological indexes (such as leukocytes, hematocrit, platelets, and hemoglobin) were higher than those for the second and third newborn.

In women with high parity due to frequent childbirth and menstrual cycles, iron deficiency is greater than in nulliparous women [28–30]. Iron deficiency increases the risk of preterm childbirth and low weight in newborns. In fact, in low weight and premature infants, hematocrit levels are decreased [31]. On the other hand, in women with high parity, natural childbirth or C-section is accompanied by less stress, in comparison to nulliparous women, because of previous childbirth experience and short deliveries. Moreover, the leukocyte and neutrophil counts in nulliparous women are higher because of the high rate of cortisol [32,33].

Sexual hormones (like testosterone) are one of the reasons of why hematocrit levels are increased in males during puberty. Various studies have reported that levels of testosterone among male infants are higher than among female ones [34]. According to the studies, the level of umbilical vein testosterone in male newborns is significantly higher than that in female newborns. It seems that one of the reasons for high hematocrit in male infants is the higher level of testosterone in males versus female infants [35,36]. During puberty, sexual steroids such as estrogen and progesterone will increase; these hormones impress hematopoiesis and play a role in the reduction of hemoglobin in the pregnancy period. The levels of the steroid hormones (estrogen and progesterone) are high, while the mother's hemoglobin concentration is reduced during the pregnancy period [37].

It has been hypothesized that female infants may have the sexual hormones as those in the puberty period, as well as lower levels of hemoglobin than male infants [38]. The infant levels of hemoglobin and hematocrit depend on various factors. The delayed close of the umbilical cord can increase infant hemoglobin levels up to 20%. Also, if the placenta is cut off and interrupted, and/or one of the fetus vessels is pierced or torn and the infant is kept significantly above the level of the placenta before closing the cord, the hemoglobin concentration may be decreased after childbirth [39]. Factors such as early birth, anemia during pregnancy, and C-section can also decrease levels of hemoglobin at the beginning of birth and can be followed by accelerated or intensified anemia [40–42]. Accordingly, the type of childbirth can have different effects on various infant hematological factors. Thus, it is also important to determine and understand the neonatal blood indices as it relates to childbirth effects. In this study, an Iranian population was evaluated with the purpose of surveying and comparing the effects of natural childbirth versus C-section on infant hematological factors.

METHODS

Study population

Patients included in this study consisted of healthy male newborns born by normal delivery or non-emergency C-section, whose mothers were at gestational age greater than 38 weeks, with positive RH and non-O blood type, without underlying illness and anemia, and referred to the Aslian Hospital (Khorramabad) or Imam Khomeini Hospital (Aleshtar) in 2017. Due to the exclusion of all possible interactions, we only selected male neonates. To prevent possible ABO and Rh HDN (hemolytic disease of the newborns), mothers with O blood group and Rh negative were excluded from the study. Any underlying disease and anemia may affect the blood indices so we excluded all mothers (and her babies) with these conditions.

Research and information gathering

In this cross-sectional study, 300 umbilical cord blood samples were taken from 300 neonates, including 150 neonates delivered naturally and 150 cases of neonates delivered by C-section. All of the newborns were of male gender and had not shown any abnormal findings in the primary examination. Subsequently, accurate records were gathered for the mothers such as maternal hospital records, information about the number of pregnancies, underlying illnesses, and

hemoglobin levels. Only those mothers and infants who had met these criteria or parameters were included in the study; any mother and infant who did not have the above conditions were excluded.

Two mL blood samples from the umbilical cord were taken immediately after closing the umbilical cord and were poured in a special test tube, which contains an anti-coagulant ethylenediaminetetraacetic acid (EDTA), and slowly shaken to prevent clotting. Peripheral blood slides were immediately prepared and used for morphological examination of blood cells. Samples were analyzed by a calibrated counter (Sysmex KX 21N) in three hours. For samples that were left for more than three hours (maximum 6 hours), it was not possible to test them that day and they were placed in the refrigerator at 4°C. It should be noted that all mothers were satisfied verbally and were told that there was no danger to the baby and mother during the umbilical cord blood sampling. Blood samples were collected after clamping the umbilical cord at a site of the umbilical cord still attached to the infant.

Data Analysis

The statistical software used to analyze the data was SPSS version 11.5. Independent t-test and Mann-Whitney test were used to compare the indices between the two groups. Chi-square test was also used to measure the relationship between two qualitative variables.

Ethical Statements

This study is licensed with code LUMS.REC.1396.229 from the Ethics Committee of Lorestan University of Medical Sciences, Iran.

RESULTS

The blood cell parameters of the 150 neonates of C-section and 150 neonates of normal delivery by mothers who were referred to Asalian Hospital (Khorramabad) and Imam Khomeini Hospital (Aleshtar), from February 19, 2017 to September 22, 2017, were examined. The mean age of the mothers was 25.9±2.65 in the vaginal delivery group and 26.4±3.45 in the cesarean group; there was no underlying disease in both groups. All mothers had RH blood+ type and were pregnant for the second time. Mothers with blood group O were excluded from the study in order to prevent possible immune interference between mother and fetus. The average maternal hemoglobin in normal delivery was 12.9±0.89 and in the C-section was 13.04±0.77. There was no significant difference between the two groups (P = 0.649).

The mean neonatal hemoglobin, hematocrit, red blood cell (RBC) count, and RDW in normal delivery were 14.9±1.3 g/dL, 44±1.4%, 5.05±0.007 x 10^{12}/L, and 17.94±4.1%, respectively; the corresponding parameters for delivery by C-section were 14.09±1.2 g/dL, 42±3.7%, 4.4±0.008 x 10^{12}/L, and 16.3±3.2%, respectively (**Table 1**). There was a significant difference between all groups (p<0.001). There were no significant differences in other RBC indices, such as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) (P>0.05). The mean white blood cell (WBC), neutrophil count, and lymphocyte count of neonates in normal delivery were 18.3±8 x 10^{9}/L, 58±7%, and 34±7 %, respectively; in C-section, they were 7.78±3 x 10^{9}/L, 38±8% and 57±8%, respectively. Notably, a p-value of P <0.001 indicated that there was a significant difference between the two groups in all parameters The mean percentage of the infant's monocytes and eosinophils in normal delivery were 4.0±0.85% and 7.1±0.36%, respectively; in cesarean delivery those values were 4±0.81 % and 1.7±0.27%, respectively (**Table 2**). There were no significant differences between the two groups (p=0.836).

The average platelet count, mean platelet volume (MPV), and PDW of neonates of normal delivery were 305±82 x 10^{9}/L, 9.84±0.64 femtoliter (fL), and 12.18±2.03%, respectively. In those delivered by C-section, the corresponding parameters were 242±92 x 10^{9}/L, 9.87±0.65 fL, and 11.88±1.7%, respectively. There was a significant difference between all groups (P<0.001; **Table 3**).

The anemia rate of infants in normal delivery versus C-section was 34% versus 53%, respectively. There was significant relationship between the type of delivery and anemia (P<0.001). Also, the rate of thrombocytopenia in infants was 1% in normal delivery and 7% in C-section. Since P<0.001, this indicated a significant relationship between the type of delivery and anemia (**Table 4**).

DISCUSSION

For a long time, there has been discussion about the advantages and disadvantages of the types of childbirth on mothers and infants. Many studies have been conducted to evaluate the effects of childbirth, in various aspects, on both mother and infant. In the study herein, we evaluated 300 male term neonates for their cord blood indexes; these neonates were born from mothers who had come to Imam Khomeini Hospital (Aleshtar city) and Asalian Hospital (Khorramabad city) for selective natural childbirth or C-section,

Table 1: Comparison of red blood cell-related neonatal blood factors in normal delivery versus cesarean section

Row	Blood parameter	Delivery type		P-value
		C-section Mean±SD	Normal delivery Mean±SD	
1	Hemoglobin (gram/dL)	14.09±1.2	14.9±1.3	<0.001
2	Hematocrit (%)	42±3.7	44±1.4	<0.001
3	RBC (x 10^{12}/L)	4.4±0.008	5.05±0.007	<0.001
4	MCV (femtoliter)	106±5.7	107±5.9	0.524
5	MCH (picogram)	34.4±3.3	34.6±3.2	0.591
6	MCHC (gram/dL)	34.15±1.15	34.41±1.19	0.452
7	RDW (%)	16.3±3.2	17.94±4.1	<0.001

RBC: red blood cell; **MCV**: mean cell volume; **MCH**: mean cell hemoglobin; **MCHC**: mean cell hemoglobin concentration; **RDW**: red cell distribution width

Table 2: Comparison of white blood cell-related neonatal blood in normal delivery versus cesarean section

Row	Blood parameter	Delivery type		P-value
		C-section Mean±SD	Normal delivery Mean±SD	
1	Mean neutrophil (%)	38±8	58±7	<0.001
2	Lymphocyte (%)	57±8	34±7	<0.001
3	Monocyte (%)	4±0.81	4±0.85	0.836
4	Eosinophil (%)	1.7±0.27	1.7±0.36	0.822
5	WBC count (x 10^9/L)	7.78±3	18.3±8	<0.001

WBC: white blood cell

Table 3: Comparison of platelet-related neonatal blood factors in normal delivery versus cesarean section

Row	Blood factor	Delivery type		P-value
		C-section Mean±SD	Normal delivery Mean±SD	
1	Platelet average (x 10^9/L)	242±92	305±82	<0.001
2	MPV (fL)	9.87±0.65	9.84±0.64	0.684
3	PDW (%)	11.88±1.7	12.18±2.03	0.637

MPV: mean platelet volume; **PDW**: platelet distribution width

from March to September 2017. All of the selected newborns were term neonates who did not show any abnormalities in their first examination. Their mothers did not indicate any background diseases, and all of them were gravida 2 with A, B, AB or RH positive blood type. Due to the probable immunological incompatibilities between the mother and the embryo, mothers with blood type O (related to ABO hemolytic disease of the newborn, *i.e.* ABO HDN)[43] were excluded from the study, as were those mothers who were Rh negative.

Among the 300 neonates studied, 150 neonates were born by natural (vaginal) delivery while 150 neonates were born by selective C-section. According to the results of this study, which are based on complete blood count and peripheral blood smear taken from newborns at the beginning of birth, blood indexes such as hemoglobin, hematocrit, RBC, WBC, neutrophil count, platelet count, and RDW were higher in those newborns delivered naturally than in those delivered by C-section. Other blood indexes such as MCV, MCH, MCHC, MPV, PDW, eosinophils, and mono-

Table 4: Prevalence of anemia and thrombocytopenia in neonates with normal delivery versus cesarean section

	p(.51480000000000004)	Delivery type		
		Normal delivery	C-section	P-value
Anemia	Hemoglobin above 13.7 (g/dL)	125 (83.3%)	25 (16.7%)	<0.001
	Hemoglobin below 13.7 (g/dL)	92 (61.3%)	58 (38.7%)	
Thrombocytopenia	Platelet over 150 (x 10^9/L)	149 (0.99)	1 (0.01)	<0.001
	Platelet over 150 (x 10^9/L)	139 (0.93)	11 (0.07)	

cytes showed no differences between the two kinds of childbirth. The lymphocytes index did not show a significantly different count between the two types of childbirth. However, babies born by caesarean showed a higher percentage of relative abundance of lymphocytes than those babies born vaginally.

Past studies by others have also investigated the relationship of mode of childbirth delivery and blood indexes. For instance, in 2011, Chang *et al.* demonstrated that there is no meaningful relationship between the kind of delivery and blood indexes (such as MCV, MCHC and MCH)[44], which is in agreement with our study. Qaiser *et al.* showed in a cross-sectional study, in 2006, that there was no change in MCV, MCHC, or MCH in the two kinds of childbirth delivery[45], which is, again, in agreement with our current study. Moreover, Nikischin *et al.*, in 1997, studied the impact of type of childbirth on the healthy and term newborn's blood indexes. Their study was based in Germany and they demonstrated that there is no relevance between MCV, MCHC, and MCH with the type of delivery[46], which is consistent, too, with the findings of our study.

According to our study, the average hemoglobin in cord blood of babies born by natural delivery is 14.9±1.3 g/dL, and in cesarean babies is 14.09±0.2 g/dL. Therefore, infants born by normal delivery show about 0.8% higher mean hemoglobin. The hematocrit index in newborns born vaginally is 44±4.1% and in cesarean newborns is 42±3.7%; thus, the newborn hematocrit level from neonates of natural birth is approximately 2% higher than that for cesarean birth. Moreover, the RBC count in vaginal newborns was 5.05 x $10^6/\mu$L, whereas the count in cesarean newborns was 4.4 x $10^6/\mu$L (thus vaginal newborns have 600,000 RBC/μL more than cesarean newborns).

Generally, our results were aligned with study results from Hajia Borna *et al.* in Tehran in 2004[47], Shahla Vaziri *et al.* in Ahvaz in 2003[48], Zibdad *et al.* at Bahman Gonabad Hospital in 2011[49], Hemmatyar *et al.* at Najmieh Tehran Hospital in 2005[50], Marwaha *et al.* in 1992[51], Sheffer *et al.* in 2003[52], Zhou *et al.*[53], Chang *et al.* in Taiwan in 2011[54], Wu J.H. *et al.* in Taiwan in 2009[55], Fady *et al.* in Egypt in 2013[56], Lee *et al.* in Korea in 1998[57], Acharya *et al.* in 2009[58], Eskola *et al.* in 2011[59], and Nogurea *et al.* in Bono Siro in 1999[60].

In conclusion, the mean of hematological indexes (*e.g.* hemoglobin, hematocrit, RBC, WBC, neutrophil count, platelet count, and RDW) were higher in neonates who were born by natural childbirth versus those born by cesarean delivery. Other blood indices such as MCV, MCH, MCHC, MPV, PDW, eosinophils, and monocytes did not show any significant difference between the two methods of delivery. On the other hand, 16.7% of normal birth infants and 38.7% of C-section birth infants had hemoglobin below 13.7 g/dL, and approximately 1% of normal birth infants and 7% of C-section birth infants had platelet counts below 150,000 platelets/μL. Platelets below 100,000/μL and hemoglobin < 10 g/dL were not seen in any of the newborns. The umbilical cord blood hemoglobin of the studied infants was significantly lower than the hemoglobin listed in the Nelson textbook of pediatrics (16.5±1.5). According to the results of our study, there were higher levels of beneficial blood parameters (such as hemoglobin and hematocrit) in normal birth neonates, but a higher percentage of anemia and thrombocytopenia in cesarean birth neonates.

CONCLUSIONS

In the current study, although there were some limitations, such as low sample size and few analysis techniques, the findings demonstrate that it is necessary to raise the awareness of parents about the benefits of

normal delivery and to refrain them from making selective and unnecessary cesareans inasmuch as possible.

COMPETING INTERESTS

The authors declare no conflict of interest in this investigation.

AUTHORS' CONTRIBUTIONS

Ali Asghar Kiani: Study design, data collection
Majid Fathi: data collection, doing experiments
Hossein Eliyasy: data collection, doing experiments
Mehdi Birhjandi: data analysis
Babak Abdolkarimi: data collection
Parastoo Baharvand: study design, writing

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