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Impact of Maternal Anemia on Neonatal Anthropometric Parameters: Weight, Length and Head Circumference

Maternal Aneminin Yenidoğan Antropometrik Parametreleri Üzerine Etkisi: Ağırlık, Boy ve Baş Çevresi

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ABSTRACT

Aim: Although many studies have investigated anemia, the evidence concerning how its severity impacts maternal and fetal health remains scarce and inconsistent. Our study aimed to evaluate the effects of maternal hemoglobin levels in the first and second trimesters on neonatal length, weight, and head circumference.

Materials and Methods: This retrospective, cross-sectional study was conducted with 146 individuals who underwent pregnancy and neonatal follow-up at a Family Health Center in Istanbul between January 1, 2019, and December 31, 2020. The demographic characteristics of the pregnant women and their hemogram values from the first and second trimesters were recorded. Neonatal length, weight, and head circumference at birth were also measured and compared. A statistical significance level of 0.05 was used.

Results: The average age of the pregnant women was 29.0±4.8 years, with hemoglobin levels recorded at 11.9±1.1 g/dL in the first trimester and 11.7±1.4 g/dL in the second trimester. Newborns of mothers with first-trimester anemia showed modest but statistically significant reductions in birth weight, head circumference, and length compared with those of non-anemic mothers (p=0.002, p=0.044, p<0.001, respectively). No significant differences were found between mothers with and without anemia in the second trimester (p>0.05). First trimester hemoglobin levels were significant negative predictors of neonatal weight (p=0.011) and length (p=0.002).

Conclusion: First trimester anemia appeared to be associated with lower birth in newborns, but this difference was not seen in the second trimester. These findings suggest a possible influence of earlier maternal anemia on fetal growth, underscoring the value of routine screening and timely management in Family Health Centers.

Keywords: Anemia, Birth Weight, Pregnancy, Hemoglobin

ÖZ

Amaç: Anemi üzerine birçok çalışma yapılmış olmasına rağmen, aneminin şiddetinin maternal ve fetal sağlık üzerindeki etkilerine ilişkin kanıtlar hâlâ sınırlı ve tutarsızdır. Bu çalışmada, gebeliğin birinci ve ikinci trimesterlerindeki maternal hemoglobin düzeylerinin yenidoğanın boyu, ağırlığı ve baş çevresi üzerine etkilerini değerlendirmek amaçlanmıştır.

Gereç ve Yöntemler: Retrospektif, kesitsel nitelikteki bu çalışma, 1 Ocak 2019-31 Aralık 2020 tarihleri arasında İstanbul'daki bir Aile Sağlığı Merkezi'nde gebelik ve yenidoğan takibi yapılmış 146 birey üzerinde gerçekleştirilmiştir. Gebelerin demografik özellikleri ve birinci ile ikinci trimesterdeki hemogram değerleri kaydedilmiştir. Yenidoğanların doğumdaki boy, ağırlık ve baş çevresi ölçümleri alınmış ve karşılaştırılmıştır. İstatistiksel anlamlılık düzeyi 0,05 olarak kabul edilmiştir.

Bulgular: Gebelerin ortalama yaşı 29,0±4,8 yıl olup, birinci trimester hemoglobin düzeyi 11,9±1,1 g/dL, ikinci trimester hemoglobin düzeyi ise 11,7±1,4 g/dL olarak bulunmuştur. Birinci trimesterde anemisi olan annelerin yenidoğanlarında doğum ağırlığı, baş çevresi ve boy uzunluğu açısından, anemisi olmayanlara göre hafif düzeyde ancak istatistiksel olarak anlamlı düşüşler gözlenmiştir (sırasıyla p=0.002, p=0.044, p<0.001). İkinci trimesterde anemisi olan ve olmayan annelerin yenidoğanları arasında anlamlı fark saptanmamıştır (p>0,05). Birinci trimester hemoglobin düzeyleri, yenidoğan ağırlığı (p=0,011) ve boyu (p=0,002) için anlamlı negatif yordayıcı bulunmuştur.

Sonuç: Birinci trimesterdeki aneminin yenidoğanda daha düşük doğum ölçüleriyle ilişkili olabileceği görülmüş, ancak bu ilişki ikinci trimesterde gözlenmemiştir. Bu bulgular, erken gebelik dönemindeki maternal aneminin fetal büyüme üzerinde olası bir etkisi olabileceğini düşündürmekte ve Aile Sağlığı Merkezlerinde rutin tarama ile zamanında yönetimin önemini vurgulamaktadır.

Anahtar Kelimeler: Anemi, Doğum Ağırlığı, Gebelik, Hemoglobin

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INTRODUCTION

Hemoglobin (Hb) is a risk factor for unfavorable pregnancy outcomes that can potentially be modified. Anemia during pregnancy is characterized by a Hb concentration of less than 110 g/L (11 g/dL) at sea level (1). During the first trimester, the demand for iron decreases due to the absence of menstruation. However, in the second trimester, the increased red cell mass and the rapid growth of the fetus lead to a continuous rise in iron requirements. If these iron needs are not met, anemia develops in the pregnant woman (2,3).

According to the most recent report from the World Health Organization, anemia prevalence among women aged 15 to 49, both pregnant and non-pregnant, has increased in most countries between 2012 and 2016 (4).

Iron deficiency anemia in pregnancy is linked to higher risks of low birth weight, early delivery, and perinatal mortality (5). Maternal anemia may negatively influence fetal growth through physiologic mechanisms such as reduced oxygen transportation to the fetus and inadequate iron reserves during early pregnancy, as highlighted in a recent systematic review and meta-analysis (6). Several studies have reported that infants born to anemic mothers tend to have slightly lower anthropometric measurements, including birth weight, length, head circumference, and mid-arm circumference (7,8).

During pregnancy, normal shifts in blood volume cause a physiological form of anemia. Nevertheless, when maternal hemoglobin levels fall below 7 g/dL, this severe anemia impairs fetal oxygen supply, leading to concerning fetal heart rate changes, reduced amniotic fluid levels, cerebral vasodilation in the fetus, and, in some cases, fetal death (9).

Despite numerous studies on anemia, the data regarding the relationship between the severity of anemia and maternal-fetal health are limited and contradictory (10-12). There is some limited evidence indicating that severe anemia could elevate the risk of low birth weight, whereas mild anemia might offer a degree of protection against it (13). Anemia is a common medical condition affecting pregnancy, particularly in low- and middle-income countries, making it crucial to understand the impact of maternal anemia levels on newborn outcomes (14).

In our study, we aimed to evaluate the effects of maternal hemoglobin levels in the first and second trimesters on neonatal length, weight, and head circumference.

MATERIALS AND METHODS

Patients and Ethical Approval

This study is a retrospective, cross-sectional research. The medical records of pregnant women and their newborns who were followed at a Family Health Center in Istanbul between January 1, 2019, and December 31, 2020, were reviewed, and 157 pregnant women were considered as the study population. A sample size calculation determined that the minimum required number of participants was 127. Considering a potential 15% loss, 146 participants were randomly selected using simple random sampling. The Clinical Research Ethics Committee of the Training and Research Hospital granted ethical approval for the study, with decision number 2022/KK/88, on May 30, 2022.

Inclusion and Exclusion Criteria

Pregnant women with singleton pregnancies whose demographic data were recorded were included in the study. Those with multiple pregnancies, pregestational or gestational chronic illnesses, acute bleeding, conditions affecting blood parameters such as thalassemia, and severe anemia (Hb <7 g/dL) were excluded from the study.

Study Design

The demographic characteristics and hemogram values of the pregnant women were recorded, along with the birth weight, head circumference and length of the newborns. Pregnant women were divided into two categories: those with anemia (hemoglobin levels less than 11 g/dL) and those without anemia (hemoglobin levels of 11 g/dL or more). Additionally, newborns delivered between 37 and 42 weeks were recorded as term, while those born before 37 weeks were categorized as preterm.

Both term and preterm infants followed in the same family health center were included in the analysis to reflect real-life primary care practice. Out of the 146 pregnant women included in the study, 39 did not have their second trimester Hb values monitored. The anemia group consisted of 146 women during the first trimester, while 107 were evaluated during the second trimester. The first and second hemoglobin values measured during pregnancy were recorded. The first measurement was taken up to the 10th week, while the second measurement was conducted between the 20th and 30th weeks. Hemoglobin levels were measured using the "Cyanide-free SLS hemoglobin" method on a Sysmex XN-1000 (Sysmex Europe GMBH, Bornbach, Germany) automated hematology analyzer.

Statistical Analysis

This study employed descriptive statistics to summarize the data. Continuous variables were expressed as mean ± standard deviation or median with their corresponding minimum and maximum values based on distribution. Categorical variables were shown as counts and percentages, and normality of numerical variables was evaluated visually and via the Shapiro-Wilk test.

For comparing categorical variables in 2x2 contingency tables, the Pearson Chi-Square test was used for expected cell counts of 5 or more. Independent groups were analyzed with the Independent Samples T-Test for normally distributed variables and the Mann-Whitney U test for non-normally distributed ones. Relationships among non-normally distributed numerical variables were examined using the Spearman's Rho correlation coefficient. Factors affecting newborn weight, head circumference, and length were analyzed through univariate and multiple linear regression models. Statistical analyses utilized Jamovi (Version 2.2.5.0) and JASP (Version 0.16.1) software, with a significance threshold of 0.05.

RESULTS

The study included 146 pregnant women with a mean age of 29.0±4.8 years. Hemoglobin levels averaged 11.9±1.1 g/dL in the first trimester and 11.7±1.4 g/dL in the second trimester. Among the deliveries, 140 were mature and 6 were premature, with anemia rates of 17.1% in the first trimester and 23.4% in the second trimester (Table 1).

Of the 146 newborns, 71 were boys and 75 were girls. The median birth weight was 3300 [1350.0 – 4800.0] grams, with a length of 50.0 [43.0 – 53.0] cm and a head circumference of 35.0 [31.0 – 38.0] cm (Table 2). Mothers with first trimester anemia had a higher median age (30 years) compared to those without anemia (28 years; p=0.041). Newborn gender distribution was similar across groups (p=0.466). Babies of anemic mothers showed lower weight (3000.0 [2400.0–4200.0] g vs. 3320.0 [1350.0–4800.0] g), head circumference (34.0 [32.0–38.0] cm vs. 35.0 [31.0–37.0] cm), and length values (48.0 [45.0–52.0] cm vs. 50.0 [43.0–53.0] cm) (p=0.002, p = 0.044, p<0.001, respectively), while no significant differences were noted in the second trimester (p>0.05) (Table 3).

Negative correlations were found between newborn length and maternal age (r = -0.166, p = 0.046), and positive correlations with first trimester hemoglobin levels (r = 0.167, p = 0.044). Other correlations were not significant (p>0.05) (Table 4).

Table 5 shows regression analysis results indicating that first trimester anemia significantly predicted lower newborn weight (p=0.011) and length (p = 0.002).

Table 1. Maternal Characteristics

	Total (n=146)
Maternal Age (years) #	29.0 ± 4.8
1st Trimester Hemoglobin (g/dL) #	11.9 ± 1.1
1st Trimester Anemia Group (n=146) ‡	
No Anemia (Hemoglobin ≥11 g/dL)	121 (82.9)
Anemia Present (Hemoglobin <11 g/dL)	25 (17.1)
2nd Trimester Hemoglobin (g/dL) #	11.7 ± 1.4
2nd Trimester Anemia Group (n=107) ‡	
No Anemia (Hemoglobin ≥11 g/dL)	82 (76.6)
Anemia Present (Hemoglobin <11 g/dL)	25 (23.4)

‡: n (%), #: mean ± standard deviation
Abbreviations: n: number, g:gram, dL: decilitre

Table 2. Demographic and Clinical Characteristics of Newborns

	Total (n=146)
Gender ‡	
Female	75 (51.4)
Male	71 (48.6)
Head Circumference (cm) §	35.0 [31.0 – 38.0]
Weight (gr) §	3300.0 [1350.0 – 4800.0]
Length (cm) §	50.0 [43.0 – 53.0]

‡: n (%), §: median [minimum-maximum]
Abbreviations: n: number, cm: centimeter, gr: gram

DISCUSSION

Our results demonstrated that newborns of mothers with first-trimester anemia had significantly lower birth weights, shorter lengths, and smaller head circumferences compared to those of non-anemic mothers. Furthermore, first-trimester anemia emerged as statistically significant negative predictors of newborn weight and length, suggesting that maternal anemia in early pregnancy may influence fetal development. The observed differences in neonatal length and head circumference were small in magnitude, yet reached statistical significance. These findings may reflect subtle effects of reduced maternal hemoglobin levels on fetal oxygenation and linear growth, although the clinical relevance of these differences is limited.

We identified anemia in 25 out of 146 pregnant women in the first trimester (%17.1) and in 25 women in the second trimester

Table 3. Comparison of Maternal and Newborn Characteristics Among Pregnant Women with and without Anemia in the First and Second Trimester

	First Trimester Anemia Status			Second Trimester Anemia Status		
	No Anemia (n=121)	Anemia Present (n=25)	p	No Anemia (n=82)	Anemia Present (n=25)	p
Mother's Age (years)§	28.0 [19.0 – 40.0]	30.0 [23.0 – 40.0]	**0.041***	29.0 [19.0 – 39.0]	30.0 [19.0 – 39.0]	0.682*
Newborn						
Gender ‡						
Female	60 (49.6)	15 (60.0)	0,466***	43 (52.4)	15 (60.0)	0.664***
Male	61 (50.4)	10 (40.0)		39 (47.6)	10 (40.0)	
Weight (gr)§-#	3320.0 [1350.0 – 4800.0]§	3000.0 [2400.0 – 4200.0]§	**0.002***	3328.9 ± 531.8#	3291.8 ± 560.3#	0,.71**
Length (cm)§	50.0 [43.0 – 53.0]	48.0 [45.0 – 52.0]	**<0.001***	50.0 [45.0 – 53.0]	49.0 [45.0 – 52.0]	0.210*
Head Circumference (cm) §	35.0 [31.0 – 37.0]	34.0 [32.0 – 38.0]	**0.044***	35.0 [32.0 – 38.0]	35.0 [32.0 – 36.0]	0.357*

‡: n (%), §: median [minimum-maximum], #: mean ± standard deviation, *: Mann-Whitney U test, **: Independent Samples T-Test.***: Pearson Chi-Square,
Abbreviations: n: number, cm: centimeter, gr: gram

Table 4. Correlation of Gestational Age, First and Second Trimester Hemoglobin Values with Newborns' Morphometric Characteristics at Birth

	Maternal Age		1st Trimester Hemoglobin		2nd Trimester Hemoglobin	
	Rho	p	Rho	p	Rho	p
Maternal Age	-	-	-0.144	0.084	-0.077	0.430
Newborn-Weight	-0.072	0.386	0.147	0.076	-0.023	0.814
Newborn- Length	-0.166	**0.046**	0.167	**0.044**	0.033	0.740
Newborn- Head Circumference	-0.122	0.143	0.041	0.623	-0.008	0.933

Spearman's rho correlation coefficient was used.

Table 5. Regression Analysis of Variables Affecting Newborns' Morphometric Characteristics at Birth.

Dependent Variable	B	Beta	p	%95 CI	
				Lower Bound	Upper Bound
Newborn – Weight (gr)					
Maternal Age (Years)	1.17	4.36	0.637	-13.71	22.44
First Trimester Anemia	-292.61	-299.97	**0.011**	-527.7	-72.25
Newborn-Length (cm)					
Maternal Age (Years)	-0.03	-0.02	0.425	-0.08	0.03
First Trimester Anemia	-1.15	-1.11	**0.002**	-1.81	-0.04
Newborn-Head Circumference (cm)					
Maternal Age (Years)	-0.01	-0.01	0.619	-0.04	-0.03
First Trimester Anemia	-0.3	-0.29	0.213	-0.74	0.16

Abbreviations: cm: centimeter, gr: gram CI: confidence interval.

(%23.4). Similarly, a study by Tekbaş et al. found that %17.2 of their group of 430 pregnant women had anemia. In that study, the prevalence of anemia was %10.4 in the first trimester, %21.5 in the second trimester, and %27.7 in the third trimester (15). Another study involving over 5000 pregnant women in Turkey reported an anemia prevalence of %20 at the time of pregnancy diagnosis (16).

Comparing these findings with our results, we observed that the anemia prevalence among the pregnant women in our study aligns closely with national data.

Malhotra et al. reported that severe anemia (Hb <7 g/dL) increases the rates of low birth weight, labor induction, operative delivery, and prolonged labor. In contrast, they found that pregnant women with mild anemia (Hb 9-10.9 g/dL) had the best perinatal outcomes (13). They attributed this to the better placental perfusion in mildly anemic women, which is likely due to increased plasma volume compared to women with higher hemoglobin levels (Hb >11 g/dL). Adequate nutrient transport to the fetus during pregnancy requires an increase in plasma volume. High hemoglobin levels may lead to increased blood viscosity, reducing placental perfusion and potentially causing placental infarcts, which can result in intrauterine growth restriction (17,18). Xiong et al. conducted a meta-analysis of studies from 1966 to 1999 and found that anemia detected in the first and second trimesters slightly increases the risk of preterm birth; however, no effect was observed for anemia in the third trimester. According to their findings, anemia in the first trimester is not associated with low birth weight, while a negative relationship exists between third-trimester anemia and low birth weight (19). Severe anemia (Hb<7 g/dL) can lead to low birth weight and preterm labor due to maternal complications such as hemoglobinopathy, malnutrition, chronic infection, and inadequate prenatal care, which can also contribute to the development of anemia itself. When severe anemia is excluded, mild anemia (Hb 10-11 g/dL) may not lead to poor perinatal outcomes. Lao et al. compared pregnant women who experienced anemia throughout pregnancy with those without anemia complaints and concluded that anemia does not adversely affect perinatal outcomes (20). Haliloğlu et al. conducted a study in 2007 involving a total of 750 anemic and non-anemic women in the third trimester, finding no statistically significant difference in birth weight between the two groups (11). Similarly, Paiva Ade et al. in 2007 studied 95 pregnant women and also reported no differences in newborn birth weight between anemic and non-anemic mothers (21). In contrast, Rahmati et al. argued in their review and meta-analysis that maternal anemia in the first trimester could be a risk factor for poorer pregnancy outcomes (22). Similarly, Lone et al. studied 626 pregnant women, comparing those with and without anemia, and found that the risk of preterm birth was four times higher, the risk of low birth weight was 1.9 times higher, the likelihood of low APGAR scores was 1.8 times greater, and the rate of intrauterine death was 3.7 times higher in anemic mothers (12). The heterogeneity and occasional inconsistency observed across studies may be explained by differences in the timing of anemia assessment, variability in anemia severity, methodological disparities including sample size and adjustment for key confounders, and population-specific factors such as nutritional status and access to prenatal care. These variations likely contribute to the differing conclusions regarding the impact of maternal anemia on neonatal outcomes. Our study identified negative outcomes, particularly lower birth weight, associated with first-trimester maternal anemia. This association may be partly explained by impaired fetal oxygenation and inadequate maternal iron stores in early pregnancy, mechanisms that have been described in previous research (6). Additionally, because physiologic hemodilution and plasma-volume expansion predominantly occur later in pregnancy, anemia detected in the first trimester may reflect inadequate early placental adaptation rather than the improved perfusion described in mild, late-gestational anemia. This could partly explain why our study observed adverse neonatal anthropometric outcomes only in early-pregnancy anemia. Although the reductions we observed were statistically significant, the median birth weight, length, and head circumference values in both groups remained within expected normal ranges for term infants. This suggests that the differences likely represent modest variations rather than clinically severe growth restriction. Nonetheless, the consistent decrease across several anthropometric parameters indicates that early-pregnancy anemia may still have a measurable impact on fetal growth.

In our study, the average age of pregnant women with anemia in the first trimester was 30 years, compared to 28 years for non-anemic women, indicating that anemic pregnant women were generally older. However, correlation analysis indicated no significant relationship between age and anemia. Similarly, a study conducted by Çıtıl et al. in our country reported no association between age groups and anemia during pregnancy (23). However, a study involving 20,000 live births determined that the relationship between maternal age and birth weight could vary across racial groups. It was demonstrated that for women in the white racial group, birth weight increased until the age of 30, followed by a slight decrease, whereas for women in the black racial group, there was a tendency for birth weight to decrease with age starting from adolescence (24). Vandekerckhove et al. (25) and Hochler et al. (26) reported an increased risk of low birth weight in older pregnancies compared to younger ones. In our study, there was no difference in average birth weight between the groups concerning maternal age, although this may be due to the insufficient number of premature patients.

In a study conducted in China with the participation of over 28,000 pregnant women, it was observed that those who received iron supplementation during pregnancy had higher birth weights for their newborns (27). A review and meta-analysis conducted by Haider et al. indicate that iron supplementation during pregnancy is associated with increased birth weight and a reduced risk of low birth weight (28). In our country, iron supplements containing elemental iron are currently used during pregnancy and for a total of nine months postpartum as part of an ongoing iron support program for pregnant women.

Limitations

Our study has several limitations. First, among the 146 pregnant women included, 39 had no documented second-trimester hemoglobin values; therefore, while all participants were evaluated in the first trimester, only 107 could be analyzed in the second trimester. Second, although the number of premature births in the cohort was very small, we could not perform a gestational age–stratified analysis, and their inclusion may have influenced neonatal anthropometric measurements to a limited extent. Third, hemoglobin values were recorded only as continuous measurements, and anemia severity categories (mild vs. moderate) could not be evaluated separately. Information regarding iron supplementation (dose, timing, and adherence) was not available in our dataset and therefore could not be evaluated, which represents an additional limitation of the study. In addition, several potential confounding factors that may influence fetal growth such as maternal BMI, parity, interpregnancy interval, socioeconomic status, nutritional status, and tobacco or substance use were not assessed in this study, which may limit full adjustment for confounding. Furthermore, maternal nutritional status, including dietary iron intake, could not be assessed, although it is an important determinant of both maternal hemoglobin levels and fetal growth. Moreover, the sample size was relatively limited, which may have reduced the statistical power for subgroup analyses. Finally, the single-center design and inclusion of patients from only one family medicine unit may limit the generalizability of our findings.

CONCLUSION

Newborns of mothers with first-trimester anemia had significantly lower birth weights, shorter lengths, and smaller head circumferences compared to those of non-anemic mothers, a difference not observed in the second trimester. These findings suggest that early pregnancy anemia may adversely affects fetal development.

Although our study does not directly evaluate the effectiveness of iron supplementation, the observed association emphasizes the importance of early screening and timely management of anemia within routine prenatal care. Strengthening hemoglobin monitoring and ensuring access to appropriate preventive and therapeutic interventions in family health centers may contribute to improved maternal and neonatal outcomes.

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