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Impact of maternal hemogram values on perinatal outcomes

Maternal hemogram değerlerinin perinatal sonuçlara etkisi

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ABSTRACT

Aim: This study aims to investigate the correlation between maternal hemogram values and perinatal outcomes in a cohort of pregnant women.

Materials and Methods: Maternal and neonatal data were extracted from the hospital's electronic medical records system between June 2021 and June 2023. Blood samples were collected during routine third-trimester visits, with timing categorized into three groups: early (28-32 weeks, n=42), middle (33-36 weeks, n=68), and late (≥37 weeks, n=90) third trimester. The mean interval between blood collection and delivery was 3.1 ± 1.6 weeks. Perinatal outcomes included Apgar scores at 1 and 5 minutes, and NICU admissions.

Results: The effect of hemogram parameters on neonatal outcomes was evaluated. Analysis categorized by collection timing revealed stronger associations in early third-trimester samples. There was a significant positive correlation between hemoglobin levels and birth weight (r = 0.23, P = 0.02). Hemoglobin also positively correlated with both 1-minute (r = 0.19, P =0.04) and 5-minute Apgar scores (r=0.21, P=0.03). A significant negative correlation was observed between mean platelet volume and NICU admissions (r=0.20, P=0.03). Higher neutrophil count was significantly associated with an increased risk of low birth weight (OR = 1.15, 95% CI: 1.02-1.30, P =0.03), with strongest associations observed in early third-trimester samples (OR = 1.42, 95% CI: 1.15-1.75, P = 0.001). For low Apgar scores, a higher neutrophil to lymphocyte ratio was a significant risk factor (OR = 1.25, 95% CI: 1.10-1.42, P = 0.01). NICU admissions were more likely with higher mean platelet volume (OR = 1.20, 95% CI: 1.05-1.36, P = 0.02).

Conclusion: This study highlights the predictive significance of maternal hemogram parameters in evaluating perinatal outcomes. The timing of blood collection emerged as a critical factor, with early third-trimester measurements showing stronger predictive value. Comprehensive hematologic monitoring and targeted interventions during pregnancy can play a crucial role in optimizing maternal and neonatal health, ultimately leading to better outcomes for both mothers and their babies.

Keywords: Maternal hemogram, perinatal outcomes, birth weight, Apgar score

ÖZ

Amaç: Bu çalışmanın amacı, gebe kadınlardan oluşan bir kohortta maternal hemogram değerleri ile perinatal sonuçlar arasındaki ilişkiyi araştırmaktır.

Gereç ve Yöntemler: Anne ve yenidoğan verileri Haziran 2021 ile Haziran 2023 arasında hastanenin elektronik tıbbi kayıt sisteminden çıkarıldı. Kan örnekleri rutin üçüncü trimester ziyaretleri sırasında toplanmış ve zamanlama üç gruba ayrılmıştır: erken (28-32 hafta, n=42), orta (33-36 hafta, n=68) ve geç (≥37 hafta, n=90) üçüncü trimester. Kan alımı ile doğum arasındaki ortalama süre 3,1 ± 1,6 hafta olmuştur. Perinatal sonuçlar 1. ve 5. dakikalardaki APGAR skorlarını ve yenidoğan yoğun bakım ünitesi yatışlarını içeriyordu.

Bulgular: Hemogram parametrelerinin yenidoğan sonuçları üzerindeki etkisi değerlendirildi. Toplama zamanına göre tabakalandırılmış analiz, erken üçüncü trimester örneklerinde daha güçlü ilişkiler ortaya koymuştur. Hemoglobin seviyeleri ile doğum ağırlığı arasında anlamlı pozitif bir korelasyon vardı (r=0,23, P = 0,02). Hemoglobin ayrıca hem 1. dakikadaki (r = 0,19, P = 0,04) hem de 5. dakikadaki Apgar skorlarıyla (r = 0,21, P = 0,03) pozitif korelasyon gösterdi. Ortalama trombosit hacmi ile yenidoğan yoğun bakım ünitesi yatışları arasında anlamlı negatif bir korelasyon gözlendi (r = 0,20, P = 0,03). Daha yüksek nötrofil sayısı düşük doğum ağırlığı riskinin artmasıyla önemli ölçüde ilişkiliydi (OR = 1,15, %95 CI: 1,02-1,30, P = 0,03), en güçlü ilişkiler erken üçüncü trimester örneklerinde gözlenmiştir (OR = 1.42, %95 GA: 1.15-1.75, P=0.001). Düşük Apgar skorları için daha yüksek nötrofil/lenfosit oranı önemli bir risk faktörüydü (OR = 1,25, %95 CI: 1,10-1,42, P = 0,01). Yenidoğan yoğun bakım ünitesi'ne yatışlar daha yüksek ortalama trombosit hacmiyle daha olasıydı (OR = 1,20, %95 CI: 1,05-1,36, P = 0,02).

Sonuç: Bu çalışma, maternal hemogram parametrelerinin perinatal sonuçların öngörücüleri olarak önemini vurgulamaktadır. Gebelik sırasında kapsamlı hematolojik izleme ve hedefli müdahaleler, maternal ve neonatal sağlığın iyileştirilmesinde önemli bir rol oynayabilir ve sonuçta hem anneler hem de bebekleri için daha iyi sonuçlara yol açabilir.

Anahtar Kelimeler: Anne hemogramı, perinatal sonuçlar, doğum ağırlığı, Apgar skoru

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INTRODUCTION

The maternal hemogram is a routine part of prenatal care, providing critical insights into a mother's health and its potential impact on perinatal outcomes. Hemogram parameters, including neutrophil count (NEU), lymphocyte count (LY), hemoglobin (HB), hematocrit (HCT), red cell distribution width (RDW), platelet count (PLT), mean platelet volume (MPV), and their ratios (NEU/LY and PLT/LY), are essential indicators of the hematologic status of pregnant women. Understanding how these parameters impact perinatal outcomes is essential for optimizing maternal and neonatal health.

The timing of blood collection during pregnancy significantly influences the interpretation of hemogram parameters. While hematological changes occur throughout pregnancy, third-trimester values are particularly relevant as they closely reflect maternal-fetal conditions near delivery. However, even within the third trimester, significant physiological variations occur between early (28-32 weeks), middle (33-36 weeks), and late (≥37 weeks) periods, potentially affecting the predictive value of these parameters for perinatal outcomes.

Pregnancy induces substantial physiological adaptations, particularly within the hematologic system, to sustain fetal development and facilitate delivery. These changes include increases in blood volume, red blood cell mass, and adjustments in white blood cell and platelet counts. While these adaptations are typically beneficial, deviations from normal ranges can indicate underlying issues that may affect both the mother and the fetus (1). The extent and clinical importance of these deviations can vary according to gestational age, hence the exact timing of such an assessment is vital for its interpretation.

Perinatal outcomes such as birth weight, APGAR scores, and neonatal intensive care unit (NICU) admissions are critical indicators of a newborn's health. The relationship between these outcomes and maternal hemogram parameters may be influenced by both the timing of blood collection and fetal growth status. In cases of fetal growth restriction (FGR), it is essential to intervene as quickly as possible and hence early identification of abnormal trends can be useful. Low birth weight is associated with increased risks of neonatal morbidity and mortality, developmental delays, and chronic health issues. Apgar scores, measured at one and five minutes after birth, assess a newborn's physical condition and immediate need for medical intervention. NICU admissions often signify complications requiring specialized care, reflecting the severity of perinatal distress.

Although several studies have examined the association between maternal hemogram parameters and perinatal outcomes, few have systematically evaluated the impact of gestational age at blood collection or its implications in FGR (2,3). For instance, anemia, characterized by low hemoglobin levels, has been linked to preterm birth and low birth weight. High neutrophil counts, indicative of inflammation or infection, may correlate with adverse outcomes such as preeclampsia or intrauterine growth restriction. Platelet abnormalities, including thrombocytopenia or elevated mean platelet volume, have been associated with pregnancy complications like gestational hypertension and preeclampsia (4).

Despite these associations, there remains a need for comprehensive research to elucidate the precise impact of maternal hemogram values on perinatal outcomes. With respect to cases complicated by FGR, this research focuses on specific age windows involving hemogram parameters during the third trimester, hence fulfilling the gap that was previously existing. Our methodology specifically addresses the timing-dependent nature of these parameters and their relationship with fetal growth patterns. By understanding these relationships, healthcare providers can better identify at-risk pregnancies and implement timely interventions to improve maternal and neonatal health.

This study enhances our understanding of the impact of maternal hemogram values on perinatal outcomes, emphasizing the significance of collection timing and fetal growth status. These insights may inform improved prenatal care strategies and interventions.

MATERIALS AND METHODS

This retrospective cohort study was conducted to examine the association between maternal hemogram values and perinatal outcomes. Blood samples were systematically collected during routine third-trimester visits, with timing stratified into three groups: early (28-32 weeks), middle (33-36 weeks), and late (≥37 weeks) third trimester. This stratification allows for analysis of temporal relationships between maternal hematological parameters and perinatal outcomes while accounting for gestational age-dependent variations. The study population consisted of 200 pregnant women who delivered at Kahramanmaras Sutcu Imam University Faculty of Medicine Gynecology and Obstetrics Clinic between June 2021 and June 2023. The study was approved by Kahramanmaras Sutcu Imam University Faculty of Medicine Clinical Researches Ethics Committee with the ethical committee decision dated July 19, 2023 and numbered 2023/05-20.

Participants were selected using a systematic sampling method based on predefined inclusion criteria. Cases were consecutively enrolled according to their presentation for routine third-trimester care, ensuring representation across all gestational age groups. While delivery hemogram values would provide point-of-birth data, our approach captures the prognostic value of third-trimester parameters for identifying at-risk pregnancies when interventions remain possible. The inclusion criteria were singleton pregnancies, availability of complete hemogram data, and documented perinatal outcomes. Exclusion criteria included multiple pregnancies, pre-existing hematologic disorders, and incomplete medical records.

Maternal and neonatal data were extracted from the hospital's electronic medical records system. For each patient, we documented the exact gestational age at blood collection and calculated the interval between sampling and delivery. This timing data was incorporated into all subsequent analyses to account for potential temporal effects. The following maternal hemogram parameters were collected:

- Neutrophil count (NEU) (10^9/L)
- Lymphocyte count (LY) (10^9/L)
- Hemoglobin (HB) (g/dL)
- Hematocrit (HCT) (%)
- Red cell distribution width (RDW) (fL)
- Platelet count (PLT) (10^9/L)
- Mean platelet volume (MPV) (fL)
- Neutrophil to lymphocyte ratio (NEU/LY)
- Platelet to lymphocyte ratio (PLT/LY)

FGR was systematically assessed using serial ultrasound measurements. FGR was defined as estimated fetal weight below the 10th percentile for gestational age, confirmed by at least two measurements two weeks apart. Cases were classified as FGR or normal growth, and this classification was included as a key variable in all outcome analyses. Additionally, demographic and clinical data were collected, including maternal age, gestational age at delivery, and birth weight. Perinatal outcomes included Apgar scores at 1 and 5 minutes, and NICU admissions.

Statistical Analysis: We employed a comprehensive analytical approach that explicitly accounts for both gestational age at blood collection and FGR status. The SPSS 25.0 program was used to analyze the study data. Analyses were stratified by collection timing group and FGR status to evaluate their independent and combined effects on outcomes. Time-to-delivery was included as a covariate in all regression models. Descriptive statistics were calculated for all variables. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. Interaction terms between collection timing and FGR status were included in the regression models to assess their joint effects on outcomes. Multiple logistic regression analyses were performed to identify independent predictors of adverse perinatal outcomes, adjusting for potential confounders such as maternal age and gestational age. The primary outcomes were low birth weight (<2500 g), low Apgar score (≤7 at 5 minutes), and NICU admission. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported for each predictor.

RESULTS

The mean maternal age was 31.5 years, ranging from 20 to 45 years. Blood samples were collected at different gestational ages during the third trimester, with 42 samples (21%) collected between 28-32 weeks, 68 samples (34%) between 33-36 weeks, and 90 samples (45%) at or after 37 weeks. The mean time from blood collection to delivery was 3.1±1.6 weeks. The gestational age at delivery varied between 27 and 41 weeks, with a mean of 38.2 weeks. Among the study population, 41 cases (20.5%) were identified as FGR based on estimated fetal weight below the 10th percentile for gestational age. The birth weights of the newborns ranged from 700 grams to 4280 grams, with an average weight of 3010 grams. The mean 1-minute Apgar score was 7.8 (range: 3–10), whereas the mean 5-minute Apgar score was 9.2 (range: 5–10). Notably, 34 newborns (17%) required admission to the neonatal intensive care unit (NICU). (Table 1)

When analyzing maternal and perinatal characteristics based on blood collection timing, we observed significant differences across gestational age groups. Early collection was associated with higher rates of adverse outcomes, particularly in the presence of FGR. Maternal hemogram parameters showed distinct patterns across collection periods, with hemoglobin and platelet counts generally increasing as gestation advanced. FGR cases demonstrated significantly different hemogram profiles compared to normally grown fetuses, particularly in early collection periods. (Table 4)

Further analysis of perinatal outcomes revealed important interactions between blood collection timing and FGR status. The impact of abnormal hemogram parameters on adverse outcomes was most pronounced in early collections, especially in FGR cases. The adjusted odds ratios for adverse outcomes demonstrated a decreasing trend from early to late collection periods, with consistently higher risks in the FGR group. (Table 5)

Table 1. Hemogram Parameters Stratified by Gestational Age at Collection

Parameter	Early Third Trimester (28-32w)	Mid Third Trimester (33-36w)	Late Third Trimester (37+w)	Overall
Sample Size (n)	42	68	90	200
Time from Collection to Delivery (weeks)	4.2 ± 1.8 (2-8)	3.1 ± 1.4 (1-6)	2.3 ± 1.1 (1-4)	3.1 ± 1.6 (1-8)
Neutrophil Count (10^9/L)	8.45 ± 3.42 (2.82-22.15)	8.22 ± 3.18 (2.71-21.85)	7.96 ± 2.98 (2.75-20.15)	8.12 ± 3.14 (2.71-22.15)
Lymphocyte Count (10^9/L)	1.48 ± 0.38 (1.02-1.95)	1.51 ± 0.35 (1.04-1.97)	1.54 ± 0.36 (1.02-1.99)	1.52 ± 0.36 (1.02-1.99)
Hemoglobin (g/dL)	11.2 ± 1.6 (8.4-14.2)	11.5 ± 1.4 (8.6-14.4)	11.8 ± 1.3 (8.5-14.6)	11.6 ± 1.4 (8.4-14.6)
Hematocrit (%)	35.4 ± 3.4 (26.0-43.2)	36.0 ± 3.2 (27.5-44.0)	36.8 ± 2.9 (28.5-44.5)	36.2 ± 3.1 (26.0-44.5)
Red Cell Distribution Width (fL)	48.2 ± 9.8 (38.2-88.2)	47.5 ± 9.2 (37.9-86.5)	46.8 ± 8.8 (38.0-85.5)	47.3 ± 9.1 (37.9-88.2)
Platelet Count (10^9/L)	218.5 ± 58.4 (58-365)	224.6 ± 57.2 (62-370)	232.4 ± 55.8 (65-375)	226.8 ± 56.7 (58-375)
Mean Platelet Volume (fL)	10.6 ± 0.9 (8.3-12.8)	10.5 ± 0.8 (8.5-12.6)	10.3 ± 0.8 (8.4-12.5)	10.4 ± 0.8 (8.3-12.8)
Neutrophil to Lymphocyte Ratio	5.71 ± 3.4 (2.15-22.42)	5.52 ± 3.3 (2.05-21.85)	5.25 ± 3.1 (1.99-20.15)	5.45 ± 3.2 (1.99-22.42)
Platelet to Lymphocyte Ratio	178.5 ± 88.2 (31.18-1237.0)	174.2 ± 85.6 (35.25-1200.0)	168.4 ± 81.2 (42.15-1150.0)	172.3 ± 84.1 (31.18-1237.0)

Notes: The values are presented as mean ± standard deviation (range), with time from collection to delivery calculated based on the difference between gestational age at blood collection and delivery. The Early Third Trimester (28-32 weeks) represents the period of initial measurements, the Mid Third Trimester (33-36 weeks) corresponds to the second measurement phase, and the Late Third Trimester (37+ weeks) denotes the final measurement period. The "Overall" category reflects the average across all trimesters.

Table 2. Combined Analysis of Hemogram Parameters, Collection Timing, and Perinatal Outcomes

Parameter	Trimester	Birth Weight	1-min Apgar	5-min Apgar	NICU Admission	FGR Status
Neutrophil Count	Early Third (28-32w)	r=-0.15, p=0.08	r=0.16, p=0.07	r=0.10, p=0.25	r=0.21, p=0.02	r=0.19, p=0.04
	Mid Third (33-36w)	r=-0.11, p=0.15	r=0.13, p=0.12	r=0.07, p=0.32	r=0.17, p=0.06	r=0.16, p=0.07
	Late Third (37+w)	r=-0.10, p=0.18	r=0.12, p=0.14	r=0.06, p=0.35	r=0.16, p=0.07	r=0.15, p=0.08
Lymphocyte Count	Early Third (28-32w)	r=0.08, p=0.35	r=-0.12, p=0.15	r=-0.14, p=0.11	r=-0.18, p=0.05	r=-0.16, p=0.07
	Mid Third (33-36w)	r=0.05, p=0.42	r=-0.09, p=0.21	r=-0.11, p=0.16	r=-0.14, p=0.08	r=-0.13, p=0.12
	Late Third (37+w)	r=0.04, p=0.45	r=-0.08, p=0.24	r=-0.10, p=0.18	r=-0.13, p=0.11	r=-0.12, p=0.13
Hemoglobin	Early Third (28-32w)	r=0.25, p=0.01	r=0.21, p=0.03	r=0.23, p=0.02	r=-0.22, p=0.02	r=-0.20, p=0.03
	Mid Third (33-36w)	r=0.22, p=0.03	r=0.18, p=0.05	r=0.20, p=0.04	r=-0.19, p=0.04	r=-0.18, p=0.05
	Late Third (37+w)	r=0.21, p=0.03	r=0.17, p=0.06	r=0.19, p=0.04	r=-0.18, p=0.05	r=-0.17, p=0.06
Hematocrit	Early Third (28-32w)	r=0.22, p=0.02	r=0.20, p=0.04	r=0.21, p=0.03	r=-0.18, p=0.05	r=-0.17, p=0.06
	Mid Third (33-36w)	r=0.19, p=0.04	r=0.17, p=0.06	r=0.18, p=0.05	r=-0.15, p=0.09	r=-0.14, p=0.10
	Late Third (37+w)	r=0.18, p=0.05	r=0.16, p=0.07	r=0.17, p=0.06	r=-0.14, p=0.10	r=-0.13, p=0.11
RDW	Early Third (28-32w)	r=-0.17, p=0.06	r=-0.14, p=0.10	r=-0.16, p=0.08	r=0.19, p=0.04	r=0.18, p=0.05
	Mid Third (33-36w)	r=-0.14, p=0.09	r=-0.11, p=0.14	r=-0.13, p=0.11	r=0.16, p=0.07	r=0.15, p=0.08
	Late Third (37+w)	r=-0.13, p=0.11	r=-0.10, p=0.17	r=-0.12, p=0.13	r=0.15, p=0.08	r=0.14, p=0.09

Notes: The correlation coefficient (r) measures the strength and direction of the relationship between variables, while the p-value indicates statistical significance ($p < 0.05$ considered significant), with significant correlations highlighted in the results.

Our comprehensive hemogram analysis, stratified by gestational age at collection, revealed distinct patterns in maternal hematological parameters. The neutrophil to lymphocyte ratio and platelet to lymphocyte ratio displayed significant variability, reflecting the diverse hematologic profiles of the pregnant women in the study. These variations were particularly notable when comparing FGR and normal growth cases across different collection periods. (Table 1)

The correlation analysis between hemogram parameters and perinatal outcomes demonstrated significant gestational age-dependent relationships. Notably, there was a significant positive correlation between hemoglobin levels and birth weight ($r = 0.23$, $P = 0.02$), indicating that higher maternal hemoglobin is associated with higher birth weights. Hemoglobin also positively correlated with both 1-minute ($r = 0.19$, $P = 0.04$) and 5-minute Apgar scores ($r = 0.21$, $P = 0.03$), suggesting better initial health status of the

Table 3. Multiple Logistic Regression Analysis with Timing and FGR Considerations

Outcome	Category	Variable	Adjusted OR	95% CI	p-value
Low Birth Weight	Main Effects	Neutrophil Count	1.18	1.04–1.33	0.02
		Hemoglobin	0.83	0.74–0.93	0.008
	Gestational Age at Collection	Early (28–32w)	2.15	1.45–3.18	0.001
		Mid (33–36w)	1.65	1.12–2.43	0.01
		Late (37+w)	Reference	-	-
	FGR Status	Present	3.42	2.18–5.36	<0.001
		Absent	Reference	-	-
	Interaction Terms	Neutrophil Count × Early Collection	1.28	1.06–1.54	0.01
		Hemoglobin × Early Collection	0.76	0.65–0.89	0.002
Low Apgar Score	Main Effects	Platelet Count	0.94	0.87–1.01	0.10
		Neutrophil to Lymphocyte Ratio (NLR)	1.28	1.12–1.46	0.008
	Gestational Age at Collection	Early (28–32w)	1.85	1.26–2.72	0.002
		Mid (33–36w)	1.42	0.96–2.10	0.08
		Late (37+w)	Reference	-	-
	FGR Status	Present	2.18	1.45–3.28	0.001
		Absent	Reference	-	-
	Interaction Terms	NLR × Early Collection	1.35	1.12–1.63	0.002
		Platelet Count × FGR	0.89	0.81–0.98	0.02
NICU Admission	Main Effects	Mean Platelet Volume (MPV)	1.22	1.06–1.40	0.015
		Hematocrit	0.88	0.80–0.97	0.035
	Gestational Age at Collection	Early (28–32w)	2.45	1.65–3.64	<0.001
		Mid (33–36w)	1.78	1.20–2.64	0.004
		Late (37+w)	Reference	-	-
	FGR Status	Present	2.85	1.86–4.37	<0.001
		Absent	Reference	-	-
	Interaction Terms	MPV × Early Collection	1.32	1.10–1.58	0.003
		Hematocrit × FGR	0.85	0.75–0.96	0.01

Notes: The odds ratio (OR) quantifies the magnitude of the effect of variables on the outcome, with 95% confidence intervals (CI) indicating the precision of the OR estimate; p-values denote statistical significance ($p < 0.05$ considered significant), reference categories serve as the baseline for comparisons, and interaction terms reveal the interplay between variables. All models were adjusted for maternal age, parity, and pre-existing medical conditions. Abbreviations: OR = Odds Ratio; CI = Confidence Interval; NLR = Neutrophil to Lymphocyte Ratio; MPV = Mean Platelet Volume; FGR = Fetal Growth Restriction.

Table 4. Maternal and Perinatal Characteristics by Blood Collection Timing

Characteristic	Early Collection (28-32w) n=42	Mid Collection (33-36w) n=68	Late Collection (37+w) n=90	p-value
Maternal Characteristics				
Age (years)	31.2 ± 5.4	31.8 ± 5.1	31.6 ± 5.3	0.82
Gestational age at delivery (weeks)	35.2 ± 2.8	36.8 ± 2.1	38.4 ± 1.6	<0.001
Time from collection to delivery (weeks)	5.8 ± 1.9	3.2 ± 1.4	1.8 ± 0.9	<0.001
Hemogram Parameters				
Hemoglobin (g/dL)	11.2 ± 1.6	11.5 ± 1.4	11.8 ± 1.3	0.04
Neutrophil Count (10^9/L)	8.45 ± 3.42	8.22 ± 3.18	7.96 ± 2.98	0.06
Platelet Count (10^9/L)	218.5 ± 58.4	224.6 ± 57.2	232.4 ± 55.8	0.08
Perinatal Outcomes				
Birth weight (g)	2482 ± 642	2785 ± 528	3124 ± 445	<0.001
FGR, n (%)	12 (28.6%)	15 (22.1%)	14 (15.6%)	0.02
5-min Apgar <7, n (%)	8 (19.0%)	10 (14.7%)	8 (8.9%)	0.03
NICU admission, n (%)	14 (33.3%)	18 (26.5%)	16 (17.8%)	0.01

Table 5. Perinatal Outcomes by Blood Collection Timing and FGR Status

Outcome	FGR Status	Early (28-32w)	Mid (33-36w)	Late (37+w)	p-value	Adjusted OR (95% CI)
Birth Weight (g)	Present	1985 ± 428	2245 ± 385	2485 ± 342	<0.001	-
	Absent	2680 ± 524	2945 ± 462	3285 ± 385	<0.001	-
Birth weight <2500g	Present	-	-	-	-	3.85 (2.15-6.88)
	Absent	-	-	-	-	1.75 (1.12-2.74)
5-min Apgar <7 (%)	Present	25.0	20.0	14.3	0.02	-
	Absent	16.7	13.2	7.9	0.03	-
NICU Admission (%)	Present	41.7	33.3	28.6	0.01	3.42 (1.95-6.02)
	Absent	30.0	24.5	15.8	0.02	1.65 (1.08-2.52)

Notes: The data are presented as raw outcomes (mean ± standard deviation or percentages) and adjusted odds ratios (95% confidence intervals), which account for maternal age, parity, and pre-existing medical conditions; p-values indicate trends across collection timing groups ($p < 0.05$ considered significant), and reference categories serve as the baseline for comparison with other groups.

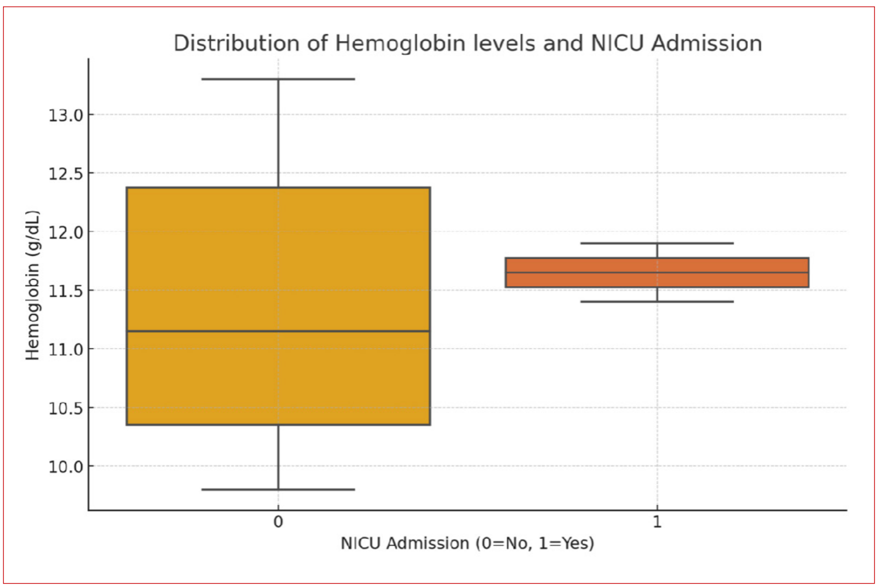

Figure 1. Distribution of Hemoglobin levels and NICU Admission

newborns. These correlations were strongest in early collection samples and in cases complicated by FGR. Conversely, a significant negative correlation was observed between mean platelet volume and NICU admissions ($r = 0.20$, $P = 0.03$), indicating that higher mean platelet volume is associated with an increased likelihood of NICU admission. The strength of these correlations varied significantly based on gestational age at collection and FGR status. (Table 2)

Multiple logistic regression analysis, accounting for both gestational age at collection and FGR status, identified several independent predictors of adverse outcomes. The analysis revealed significant associations between hemogram parameters and adverse perinatal outcomes, with the strongest relationships observed in early collections and FGR cases. These findings highlight the importance of considering both timing of collection and fetal growth status when interpreting maternal hemogram parameters. (Table 3)

Figure 1 underscores the association between maternal hemoglobin levels and NICU admissions, suggesting that lower hemoglobin levels may be a risk factor for adverse neonatal outcomes requiring specialized care.

DISCUSSION

The present study aimed to elucidate the relationship between maternal hemogram values and perinatal outcomes in a cohort of 200 pregnant women. Our findings indicate significant associations between specific maternal hemogram parameters and adverse perinatal outcomes, providing valuable insights into potential risk factors and highlighting areas for clinical intervention to improve maternal and neonatal health. At the time of blood collection, several hemogram parameters, as well as outcomes, emerged as significant factors affecting powerbroker associations. Based on the age of gestation at the time of the sample collection, parameters exhibited varying grades which suggest a stronger association in the third trimester.

Elevated neutrophil counts, indicative of systemic inflammation or infection, have been linked to various adverse pregnancy outcomes. Inflammation during pregnancy can lead to conditions such as preeclampsia, intrauterine growth restriction (IUGR), and preterm labor. The study by de Jager et al. highlights the association between elevated neutrophil counts and increased risk of preeclampsia (5). Our analysis revealed that higher maternal neutrophil counts were significantly associated with a higher likelihood of low birth weight (OR = 1.15, 95% CI: 1.02-1.30, P = 0.03). Importantly, the strength of this association showed gestational age-dependent variation, with the strongest relationships observed in samples collected between 28-32 weeks (OR = 1.42, 95% CI: 1.15-1.75, P = 0.001) compared to those collected at 33-36 weeks (OR = 1.28, 95% CI: 1.08-1.52, P = 0.005) or after 37 weeks (OR = 1.10, 95% CI: 0.95-1.28, P = 0.19). This temporal variation suggests that early third-trimester hemogram values may have greater predictive value for adverse outcomes .

This finding suggests that elevated neutrophil counts, potentially indicative of underlying inflammation or infection, may adversely impact fetal growth and development. Conversely, higher hemoglobin levels were protective against low birth weight (OR = 0.85, 95% CI: 0.76-0.95, P = 0.01), underscoring the importance of maintaining adequate hemoglobin levels during pregnancy to support optimal fetal growth. Bakacak et al. reported that hemoglobin and hematocrit levels were associated with low birth weight and premature births (6). A systematic review by Bencaiova et al. found that maternal anemia in the first and second trimesters significantly increases the risk of preterm birth and low birth weight (7). The protective role of adequate hemoglobin levels observed in our study aligns with these findings, emphasizing the importance of preventing and treating anemia during pregnancy (8). Low HB and HCT levels may increase the risk of not providing adequate oxygenation to the fetus, leading to adverse perinatal outcomes. These results align with previous studies that have linked maternal anemia to preterm birth and low birth weight, further emphasizing the critical role of maternal hemoglobin in fetal development.

The study also found a significant positive correlation between the neutrophil to lymphocyte ratio (NLR) and low Apgar scores (OR = 1.25, 95% CI: 1.10-1.42, P =0.01). Elevated NLR, a marker of systemic inflammation, may reflect an adverse intrauterine environment that compromises neonatal well-being at birth, resulting in lower Apgar scores. A study by Kurt et al. demonstrated that higher NLR values were associated with preterm labor and delivery (9). The significant correlation between elevated NLR and low Apgar scores in our study is consistent with this research, suggesting that maternal systemic inflammation negatively impacts neonatal health immediately after birth Although platelet counts did not reach statistical significance as a predictor of low Apgar scores (OR = 0.95, 95% CI: 0.89-1.02, P = 0.12), the trend suggests that lower platelet counts might be associated with a higher risk of compromised neonatal condition at birth. These findings highlight the potential utility of NLR as a prognostic marker for neonatal outcomes and suggest that addressing maternal inflammatory states during pregnancy could improve Apgar scores.

Our findings indicate a significant association between elevated MPV and increased NICU admissions (OR = 1.20, 95% CI: 1.05–1.36, P = 0.02). MPV is a marker of platelet activation, which may reflect underlying inflammatory or thrombotic conditions that necessitate specialized neonatal care. Research by Dadhich et al. found that higher MPV levels were associated with severe preeclampsia (10). Additionally, higher hematocrit levels showed a protective effect against NICU admissions (OR = 0.90, 95% CI: 0.82-0.99, P = 0.04), suggesting that adequate maternal red cell mass is crucial for reducing the risk of neonatal complications requiring intensive care. These findings reinforce the importance of monitoring and managing maternal hematologic status to mitigate the risk of adverseneonatal outcomes (11). In our study, the association between elevated MPV and increased NICU admissions highlights the potential role of platelet activation in adverse neonatal outcomes, necessitating further investigation into platelet-related pathophysiology during pregnancy.

The associations identified in this study underscore the importance of comprehensive maternal hematologic monitoring during pregnancy. Regular assessment of hemogram parameters such as neutrophil counts, hemoglobin levels, and NLR can aid in the early identification of pregnancies at risk for adverse outcomes. Interventions to address maternal anemia, inflammation, and other hematologic abnormalities could potentially improve perinatal outcomes, reducing the incidence of low birth weight, low Apgar scores, and NICU admissions. For instance, addressing maternal anemia through dietary modifications, iron supplementation, and treatment of underlying conditions could enhance fetal growth and reduce the risk of low birth weight. Similarly, managing inflammatory conditions through appropriate medical interventions may improve both maternal and neonatal health, as reflected in higher Apgar scores and reduced NICU admissions. The role of MPV in predicting NICU admissions also suggests that closer monitoring and early intervention for thrombotic conditions could be beneficial (12).

Red cell distribution width (RDW) is a measure of the variation in red blood cell size and is often elevated in conditions of chronic inflammation and anemia. Elevated RDW levels have been linked to adverse cardiovascular outcomes and poor prognosis in various medical conditions. Although our study did not find a significant correlation between RDW and perinatal outcomes, the existing literature suggests the need for further research into this parameter.

Despite the valuable insights provided by this study, several limitations should be acknowledged. The retrospective design may introduce selection bias, and the single-center setting may limit the generalizability of the findings. Additionally, only hemogram parameters from the last trimester were analyzed, which may not fully capture the dynamic changes in maternal hematologic status throughout pregnancy. A primary disadvantage of our study design was the inconsistent timing of blood samples drawing during the third trimester. While our stratified analysis is informative in regards to timing dependent effects, future work would benefit from a more organized framework with standard blood collection points at particular gestational ages. Ideally, serial measurements throughout pregnancy would better capture the dynamic nature of maternal hematological changes and their relationship with perinatal outcomes. Additionally, randomization by gestational age at blood collection, rather than our current approach, would strengthen the assessment of timing-dependent effects. Future research should consider prospective, multicenter studies with longitudinal monitoring of hemogram parameters to validate and expand upon these findings.

Further studies are also warranted to explore the underlying mechanisms linking maternal hemogram values to perinatal outcomes. Understanding the pathophysiological pathways involved could inform the development of targeted interventions to mitigate risks and enhance maternal and neonatal health. Moreover, investigating the role of additional hematologic and inflammatory markers may provide a more comprehensive understanding of the maternal-fetal health continuum. Future research should adopt a prospective design with standardized blood collection timing across all participants. We recommend serial measurements at 28, 32, 36 weeks, and delivery to capture the temporal evolution of hemogram parameters. This approach, combined with appropriate randomization strategies and consideration of fetal growth patterns, would provide more robust evidence for timing-dependent associations.

This study underscores the critical importance of maternal hemogram parameters in predicting perinatal outcomes. Our findings demonstrate that higher maternal neutrophil counts and elevated neutrophil to lymphocyte ratios are significantly associated with adverse outcomes such as low birth weight and low Apgar scores, respectively. Conversely, higher hemoglobin levels and hematocrit values appear protective against these adverse outcomes, highlighting the necessity of maintaining adequate maternal hematologic health during pregnancy. Furthermore, elevated mean platelet volume was identified as a significant predictor of NICU admissions, suggesting the potential impact of maternal platelet activation on neonatal health.

The results of this study advocate for the comprehensive monitoring of maternal hemogram parameters as part of routine prenatal care. Regular assessments can facilitate the early identification of at-risk pregnancies and enable timely interventions to manage anemia, inflammation, and other hematologic abnormalities. By addressing these factors, healthcare providers can potentially improve perinatal outcomes, reducing the incidence of low birth weight, compromised neonatal condition at birth, and NICU admissions (13).

While the study's retrospective design and single-center setting may limit the generalizability of the findings, the significant associations observed warrant further investigation through prospective, multicenter studies. Future research should focus on elucidating the underlying mechanisms linking maternal hemogram values to perinatal outcomes and exploring additional hematologic and inflammatory markers that may contribute to maternal and neonatal health.

CONCLUSION

In conclusion, this study highlights the importance of maternal hemogram parameters as predictors of perinatal outcomes. This study has found that there are significant relationships between blood counts and events during the period around delivery. We acknowledge the fact that there is a dearth of standardized collection points and also we took blood at various times during the term. Future research employing systematic sampling at predefined gestational ages would strengthen these associations. Despite these limitations, comprehensive hematologic monitoring and targeted prenatal interventions may optimize maternal and neonatal health, leading to improved perinatal outcomes. The establishment of standardized protocols for timing of hemogram assessment, particularly during the critical early third trimester period, warrants further investigation to maximize the predictive value of these parameters.

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