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Original Article

Maternal Anemia as a Determinant of Suboptimal Birth Outcomes: A Cross-Sectional Analysis

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ABSTRACT

Background: Maternal anemia is a prevalent nutritional disorder during pregnancy, with potential implications for fetal well-being and neonatal outcomes. This study aims to investigate the association between maternal anemia diagnosed during pregnancy and two critical neonatal parameters: birth weight and Apgar score.

Methods: A cross-sectional study was conducted involving 110 mother-neonate pairs recruited from the Department of Obstetrics and Gynecology. Pregnant women were screened for anemia (Hemoglobin <11.0 g/dL) during their third trimester. Neonates were assessed for birth weight and 5-minute Apgar score immediately after delivery. Participants were divided into two groups: anemic (n=55) and non-anemic (n=55). Statistical analysis was performed using independent t-tests for birth weight and Chi-square tests for Apgar scores, with a p-value of <0.05 considered significant.

Results: The mean birth weight of neonates born to anemic mothers (2850 ± 310 grams) was significantly lower ($p<0.001$) than that of neonates born to non-anemic mothers (3250 ± 290 grams). Furthermore, a significantly higher proportion of neonates in the anemic group had low Apgar scores (<7) at 5 minutes (16.4% vs. 1.8%, $p=0.009$).

Conclusion: Maternal anemia during pregnancy is significantly associated with adverse neonatal outcomes, including lower birth weight and a higher incidence of depressed Apgar scores. These findings underscore the critical importance of routine antenatal screening for anemia and the implementation of robust nutritional interventions to improve both maternal and neonatal health.

Keywords: *Maternal Anemia, Neonatal Birth Weight, Apgar Score, Pregnancy Outcomes, Fetal Growth Restriction, Neonatal Health.*

INTRODUCTION

Maternal anemia, defined by the World Health Organization (WHO) as a hemoglobin concentration of less than 11.0 g/dL during pregnancy, remains a major global public health concern, particularly in developing nations.[1] It is estimated to affect approximately 40% of pregnant women worldwide, with iron deficiency being the most common etiology.[2] The physiological demands of pregnancy, including expanded plasma volume and increased erythrocyte production, elevate the requirement for iron, folate, and vitamin B12, creating a state of heightened vulnerability to nutritional deficiencies.[3] When these increased demands are not met through diet or supplementation, maternal anemia ensues.[4]

The implications of maternal anemia extend beyond maternal fatigue and increased risk of postpartum hemorrhage[5]. Substantial evidence indicates it adversely affects fetal development through compromised oxygen delivery to the fetoplacental unit.[6] This chronic fetal hypoxia can lead to intrauterine growth restriction (IUGR) and subsequently, low birth weight (LBW), which represents a primary determinant of neonatal morbidity and mortality.[7] Furthermore, inadequate oxygen supply during the critical intrapartum period may compromise the fetal transition to extrauterine life, potentially resulting in a depressed neonatal condition at birth, as reflected by a low Apgar score.[8]

The Apgar score, developed by Dr. Virginia Apgar, provides a rapid assessment of neonatal well-being at 1 and 5 minutes after birth, evaluating heart rate, respiratory effort, muscle tone, reflex irritability, and color.[9] A persistent score below 7 at 5 minutes is indicative of significant neonatal depression and often necessitates immediate medical intervention.[10] While numerous studies have explored the link between maternal anemia and birth weight, the evidence regarding its direct impact on the Apgar score remains less consolidated and sometimes contradictory, with some studies showing a strong association while others report null findings.[11] This study, therefore, aims to contribute to the existing body of knowledge by conducting a cross-specialty analysis to determine the effect of maternal anemia during pregnancy on two crucial neonatal outcomes: birth weight and the 5-minute Apgar score.

METHODOLOGY

Study Design, setting and population

A hospital-based, analytical cross-sectional study design was employed. The study was conducted over a six-month period at the Department of Obstetrics and Gynecology in collaboration with the Department of Neonatology. The target population for this study consisted of all mother-neonate pairs delivering at the study hospital during the data collection period.

Inclusion Criteria:

- Singleton pregnancy.
- Gestational age between 36 and 40 weeks confirmed by first-trimester ultrasonography.
- Planned for delivery (both vaginal and cesarean section) at the study hospital.
- Availability of a documented hemoglobin (Hb) level from the third trimester (28-32 weeks).

Exclusion Criteria:

- Multiple pregnancies (twins, triplets, etc.).
- Known major congenital fetal anomalies detected on antenatal ultrasound.
- Maternal chronic diseases known to affect fetal growth or oxygenation (e.g., pre-gestational diabetes, chronic hypertension, cardiac disease, renal disease).
- Pregnancy-related complications (e.g., pre-eclampsia, gestational diabetes, placental abruption, placenta previa).
- History of active smoking, alcohol, or substance abuse during pregnancy.
- Incomplete medical records.

Sample Size Calculation

Sample size was calculated using the formula for comparing two means, $n = \frac{2(Z_{\alpha/2}+Z_{\beta})^2\sigma^2}{\Delta^2}$, with a significance level (α) of 0.05 (Z_{α/2}=1.96), a power (1-β) of 90% (Z_β=1.28), an estimated standard deviation (σ) of 300 grams for birth weight based on previous literature, and a clinically important mean difference (Δ) of 300 grams to detect between the anemic and non-anemic groups. This calculation yielded a minimum requirement of 21 participants per group. To enhance the study's robustness, account for potential data incompleteness, and ensure adequate power for analyzing the secondary Apgar score outcome, the sample size was increased to 55 per group, resulting in a total sample of 110 mother-neonate pairs.

Procedure for Data Collection

1. **Screening and Recruitment:** Potential participants meeting the inclusion criteria were identified from the antenatal ward and labor room registers.
2. **Maternal Data Extraction:** Demographic data (age, parity) and the most recent third-trimester hemoglobin (Hb) value (recorded between 28-32 weeks gestation) were extracted from the antenatal care records. This Hb value was used to classify participants into the anemic or non-anemic group.

3. **Neonatal Assessment:**

- **Birth Weight:** Immediately after delivery and initial drying, the neonate's weight was measured using a calibrated digital electronic scale (to the nearest 5 grams).
- **Apgar Score:** The 5-minute Apgar score was assigned by a qualified pediatrician or neonatologist who was blinded to the maternal anemia status of the participant. The assessment was based on the standard evaluation of heart rate, respiratory effort, muscle tone, reflex irritability, and color.

4. **Data Recording:** All data were recorded in a pre-designed, structured proforma.

Statistical analysis

- All data from the proforma were entered into a Microsoft Excel spreadsheet. Data entry was double-checked for accuracy. The dataset was then imported into the Statistical Package for the Social Sciences (SPSS) version 26.0 for statistical analysis.

Table 1: Baseline Maternal and Gestational Characteristics of the Study Participants

Characteristic	Anemic Group (n=55)	Non-Anemic Group (n=55)	p-value
Maternal Age (years), Mean ± SD	26.4 ± 4.1	27.1 ± 3.8	0.351
Parity, n (%)			0.840
Primigravida	24 (43.6%)	26 (47.3%)	
Multigravida	31 (56.4%)	29 (52.7%)	
Gestational Age at Delivery (weeks), Mean ± SD	38.5 ± 1.1	38.7 ± 0.9	0.283
Hemoglobin Level (g/dL), Mean ± SD	10.2 ± 0.6	11.8 ± 0.5	**<0.001**

As illustrated in Table 1, there were no statistically significant differences in maternal age (26.4 ± 4.1 vs. 27.1 ± 3.8 years, p=0.351), parity, or gestational age at delivery (38.5 ± 1.1 vs. 38.7 ± 0.9 weeks, p=0.283), confirming the successful matching of the cohorts. The mean hemoglobin level, as expected, was significantly lower in the anemic group (10.2 ± 0.6 g/dL) compared to the non-anemic group (11.8 ± 0.5 g/dL, p<0.001).

Table 2: Comparison of Primary Neonatal Outcomes between the Anemic and Non-Anemic Groups

Neonatal Outcome	Anemic Group (n=55)	Non-Anemic Group (n=55)	p-value
Birth Weight (grams)			
Mean ± SD	2850 ± 310	3250 ± 290	**<0.001**
Range	2200 – 3450	2750 – 3780	
Low Birth Weight (<2500 g), n (%)	8 (14.5%)	1 (1.8%)	**0.015**

As shown in Table 2, the mean birth weight of neonates born to anemic mothers (2850 ± 310 grams) was substantially and significantly lower than that of neonates born to non-anemic mothers (3250 ± 290 grams), with a mean difference of 400 grams (p<0.001). Consequently, the incidence of low birth weight (<2500 g) was significantly higher in the anemic group (14.5%) compared to the non-anemic group (1.8%, p=0.015).

Table 3: Comparison of Secondary Neonatal Outcome (5-minute Apgar Score) between the Groups

5-minute Apgar Score	Anemic Group (n=55)	Non-Anemic Group (n=55)	p-value
Score, Mean ± SD	7.5 ± 1.2	8.4 ± 0.7	**<0.001**
Categorization, n (%)			**0.009**
Normal (Apgar ≥ 7)	46 (83.6%)	54 (98.2%)	
Low (Apgar < 7)	9 (16.4%)	1 (1.8%)	

A significant association was found between maternal anemia and the condition of the neonate at birth, assessed by the 5-minute Apgar score. The mean Apgar score was significantly lower in the anemic group (7.5 ± 1.2) compared to the non-anemic group (8.4 ± 0.7, p<0.001). More critically, as detailed in Table 3, the proportion of neonates with a low Apgar score (<7) was 16.4% (9 out of 55) in the anemic group, which was markedly higher than the 1.8% (1 out of 55) observed in the non-anemic group (p=0.009).

DISCUSSION

This cross-sectional study demonstrates a significant association between maternal anemia during the third trimester and adverse neonatal outcomes, specifically lower birth weight and depressed Apgar scores at 5 minutes. Our findings underscore the critical role of maternal hematological status in influencing fetal well-being and the neonatal transition to extrauterine life, adding to the growing body of literature on this important clinical issue.[12]

The most pronounced finding of our study was the substantial reduction in mean birth weight among neonates born to anemic mothers. The 400-gram difference observed is not only statistically significant but also clinically relevant, as it pushed a significantly larger proportion of these neonates into the low birth weight (LBW) category. This result aligns coherently with the established pathophysiological pathway of maternal anemia. Iron deficiency, the most common cause of anemia, compromises the oxygen-carrying capacity of maternal blood, leading to chronic fetal hypoxia and altered placental function.[13] This hypoxic state can impair trophoblast invasion and angiogenesis, ultimately restricting the transfer of essential nutrients and oxygen required for optimal fetal growth, a condition known as intrauterine growth restriction (IUGR).[14] Our results are consistent with a large body of evidence, including a comprehensive meta-analysis by Rahman et al., which confirmed a significant increase in the risk of LBW among infants of anemic mothers[7].

Furthermore, our study provides compelling evidence linking maternal anemia to a higher incidence of low 5-minute Apgar scores. A low score at this critical juncture is a reliable marker of neonatal depression and often signifies difficulty in

adapting to extrauterine life, potentially due to intrapartum hypoxia and metabolic acidosis.[15] The plausible mechanism is that anemic mothers have a diminished physiological reserve to withstand the repetitive stresses of labor, particularly the uterine contractions which transiently reduce uteroplacental blood flow.[16] This compromised reserve can precipitate fetal distress and acidosis, manifesting clinically as respiratory depression, bradycardia, and poor tone in the newborn—the very components comprising the Apgar score.[9] While some previous studies have reported inconsistent findings on this association, our results, showing a nine-fold higher incidence of low Apgar scores in the anemic group, strongly suggest that maternal anemia is a significant risk factor for suboptimal neonatal condition at birth.[17]

The implications of these findings are substantial for clinical practice and public health policy. Both low birth weight and neonatal depression are well-established predictors of immediate morbidity, increased risk of infections, and long-term neurodevelopmental challenges.[18] Therefore, the identification and management of maternal anemia must transcend the goal of merely improving maternal symptoms; it represents a crucial intervention for safeguarding neonatal health and ensuring optimal developmental trajectories.[19] The high prevalence of anemia in our study population, even within a hospital setting, highlights a persistent gap in current antenatal care protocols regarding the effectiveness of iron supplementation programs, patient education, and adherence strategies.[20]

Several limitations of this study must be acknowledged. Its cross-sectional design allows for the establishment of association but not causation. While we controlled for several major confounders through strict exclusion criteria, the influence of unmeasured factors such as precise socioeconomic status, maternal body mass index, and dietary habits cannot be entirely ruled out. The sample size, though adequate, was recruited from a single center, which may limit the generalizability of the findings. Finally, we defined anemia based on a single hemoglobin measurement and did not differentiate based on the severity or specific etiology of the anemia.

CONCLUSION

In conclusion, this study adds robust evidence that maternal anemia is a significant determinant of poor neonatal outcomes, manifesting as reduced birth weight and an increased likelihood of neonatal depression. These results reinforce the critical importance of routine and vigilant screening for anemia throughout pregnancy. Future public health initiatives should focus not only on providing iron supplements but also on enhancing patient education and counseling to ensure adherence. For mothers diagnosed with anemia, a heightened level of vigilance during intrapartum monitoring may be warranted to promptly identify and manage fetal distress, thereby improving the chances of a healthy start to life for the newborn.

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