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Original Research Article

Association of hematological parameters of cord blood and birth weight of newborns in relation to maternal hemoglobin: a cross-sectional study from eastern Nepal

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ABSTRACT

Background: Maternal anemia is a global public health problem and is common in developing countries. It may influence neonatal hematological parameters and birth weight. The objectives of the present study were to evaluate the relationship between maternal and cord-blood haemoglobin concentrations and the association of maternal anemia with neonatal birth weight in a tertiary-care centre in Nepal.
Methods: It was a qualitative cross-sectional study conducted over one year at the department of pathology, department of obstetrics and gynecology, and department of pediatrics, B. P. Koirala Institute of Health Sciences, Dharan, Nepal.
Results: Among the total 125 participants (pregnant women), 46 (36.80%) were anemic, with corresponding newborns' mean cord blood hemoglobin of 13.81±1.32 gm/dl, whereas 79 (63.20%) were non-anemic, with corresponding newborns' mean cord blood hemoglobin of 15.27±1.31 gm/dl. The p value was 0.00, indicating a significant difference between cord blood hemoglobin and maternal hemoglobin status, and the findings showed that a decrease in cord blood hemoglobin was associated with a decrease in maternal hemoglobin level. However, birth weight and other hematological parameters were not found to be associated (except for hematocrit) with mild and moderate degrees of maternal anemia.
Conclusions: A linear relationship was observed between maternal and cord blood hemoglobin, but not with birth weight. Maternal anemia, which is still a common complication of pregnancy, can be detected by simple and cheap screening tests, and if managed early, decreases neonatal hematological derangement.

Keywords: Birth weight, Hematological parameters, Maternal anemia, Newborn, Umbilical cord blood

INTRODUCTION

Anemia in pregnancy remains a significant global public-health concern, with the World Health Organization estimating a prevalence of approximately 38 % among pregnant women worldwide.[1] The burden is particularly high in South Asia, where studies in Nepal have reported prevalence rates of 42.6 % and 63 % among pregnant women.[2,3] Maternal anemia has been linked to adverse perinatal outcomes, including fetal anemia and low birth weight. Several investigations have demonstrated a significant positive correlation between maternal and cord-

blood hemoglobin levels.[4-6] For example, Al-Hilli et al found that cord-blood hemoglobin decreased linearly with maternal hemoglobin levels.[4] Conversely, some studies have reported inconsistent associations, particularly regarding neonatal hematological indices other than hemoglobin.[7] Given the high prevalence of maternal anaemia in Nepal and the paucity of region-specific data examining maternal-cord haemoglobin relationships and neonatal outcomes, the present study aimed to evaluate: (1) the relationship between maternal and cord-blood haemoglobin concentrations, and (2) the association of maternal anaemia with neonatal birth weight in a tertiary-care centre in Nepal.

METHODS

This was a qualitative cross-sectional study conducted at the department of pathology, department of obstetrics and gynecology, and department of pediatrics, B. P. Koirala Institute of Health Sciences, Dharan. The duration of the study was 1 year (July 2017 to July 2018). Data were compared using SPSS (version 11.5) with Student's t-test, and $p \leq 0.05$ was considered statistically significant.

Inclusion criteria

Pregnant women aged 18-45 years with normal vaginal term delivery (37-42 weeks) of a single child.

Exclusion criteria

Women with multiple pregnancies (e.g., twins), preterm delivery, or cesarean section delivery.

Maternal complications like eclampsia and preeclampsia, placenta previa, antepartum hemorrhage, etc., during pregnancy or with medical conditions like heart disease, diabetes mellitus, hypertension, kidney disease, autoimmune disease, etc.

The study involved mothers and newborn babies delivered in the maternity ward of B. P. Koirala Institute of Health Sciences, Dharan, Nepal.

Expected sample size was calculated using:

As reported in a study by Dapper DV and Didia BC.[8]

Mean ± standard deviation of hemoglobin concentration (gm/dl) on umbilical cord blood and maternal blood was reported as (13.7±3.16) and (10.6±1.5), respectively.

Considering the minimum difference of average blood hemoglobin (d) = 1 gm/dl.

Pooled standard deviation (σ)

$\sigma=(\sigma_1+\sigma_2)/2= (3.16 + 1.5)/2=2.33$

Where:

σ_1 = Standard deviation of cord blood hemoglobin
σ_2 = Standard deviation of maternal blood hemoglobin

Thus, pooled standard deviation (σ) = 2.33

Zα at 5% = 1.96

Zβ at 10% = 1.28

Where:

Zα=Type I error, Zβ = type II error

The sample size (n) was calculated using the following formula:

$n=2(Z\alpha+Z\beta)^2\sigma^2/d^2$

$n=2(1.96+1.28)^2(2.33)^2/(1)^2$

n=113.98

Therefore, the required sample size was 114. After adding 10% for non-response, the final sample size was 125.

Sampling technique

Non-probability, convenience sampling method was used.

Ethical consideration

Ethical clearance was obtained from the institutional ethical review board, B. P. Koirala Institute of Health Sciences, Dharan, Nepal (Ref. No. 231/074/075-IRC, Code No.: IRC/1149/017). Informed consent was taken from all the patients.

Methods

The patient was assessed for inclusion into the study as per the aforementioned inclusion criteria. In all cases, the placental cord was clamped immediately after delivery, a syringe was inserted into the umbilical vein, and blood samples were drained into containers with an EDTA anticoagulant-containing vial, and then they were sent to the hematology laboratory. The following hematological variables were analyzed.

Hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were determined using a hematological automated hematology analyzer (Lab Life D5 Supreme).

Reticulocyte count was performed manually using brilliant cresyl blue-stained blood smears.

Maternal hemoglobin and other blood parameters were taken at the time of delivery for the study. Selection of anemic and non-anemic mothers was done according to the WHO classification of anemia in pregnancy, and further sub-classification, or grading, was done as per the ICMR classification.

The available maternal blood hemoglobin level for each trimester was also recorded.

The birth weight was measured, and a comparative cross-sectional study of the result was carried out in the departments of pathology.

Operational definition as per WHO (World Health Organization)[1]

Anemia in pregnancy: hemoglobin levels of less than 11 gm%. Non-anemia: hemoglobin level more than or equal to 11gm %.

Severity or grading of anemia (Indian Council of Medical Research, ICMR)[2]

Mild anemia: hemoglobin level of 9.0-10.9 gm/dl. Moderate anemia: hemoglobin level of 7.0-8.9 gm/dl. Severe anemia: hemoglobin level of less than 7 gm/dl. Very severe anemia: hemoglobin level of less than 4 gm/dl.

RESULTS

Out of the total 125 participants, 63(50.4%) were primigravida, and 62 (49.6%) were multigravida, to whom 62 (49.6%) male and 63 (50.4%) female babies (Figure 1) were delivered by the normal vaginal route.

The mean age of the pregnant women was 24.32±4.45 years, and that of anemic mothers was 24.56±4.49 years.

According to the WHO classification of anemia in pregnant women, 46 (36.8%) pregnant women were found to be anemic with corresponding newborns' mean cord blood hemoglobin of 13.81±1.32 gm/dl, whereas 79 (63.2%) pregnant women were non-anemic with corresponding newborns' mean cord blood hemoglobin of 15.27±1.31 gm/dl (Table 1). The p value of 0.00 when the t-test was applied showed that there was a significant difference between the hemoglobin level of cord blood and maternal hemoglobin status. This result showed that a decrease in cord blood hemoglobin was associated with a decrease in maternal hemoglobin level.

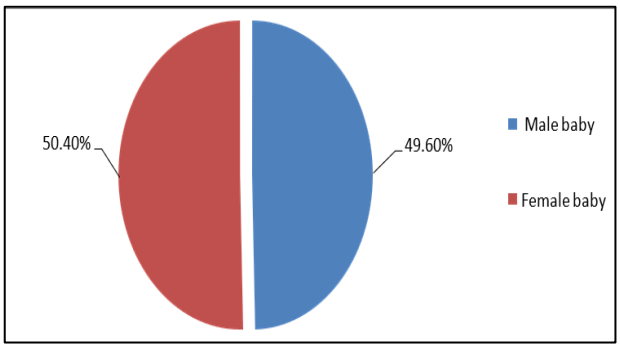

Figure 1: Sex distribution of newborn.

As per ICMR classification of anemia in pregnancy, 38 (30.4%), 8 (6.4%), and 79 (63.2%) pregnant women fell into mild, moderate, and non-anemic categories of anemia, respectively.

The mean cord blood hemoglobin of newborns was 13.86±1.19 gm/dl (p=0.000) in mild anemia, 13.53±1.90 gm/dl (p=0.002) in moderate anemia, and 15.27±1.31 gm/dl in non-anemia. The result showed that a positive correlation of cord blood hemoglobin in mild and moderate degrees of maternal anemia (Table 2).

The mean birth weight of newborns delivered to anemic mothers (as per ICMR) was 3.10±0.40 kg (p=1.00) in mild anemia, 2.95±0.30 kg (p=1.00) in moderate anemia, and 3.07±0.46 kg in non-anemia. The result showed that the birth weight of newborns was not associated with mild and moderate degrees of maternal anemia (Table 3).

Cord blood parameters like WBC, MCV, MCH, MCHC, platelets, and reticulocyte count showed no significant differences in anemic and non-anemic mothers (as per WHO), except for HCT, which was found to be statistically significant (Table 4).

Maternal peripheral blood smear picture showed microcytes, occasional elliptocytes, and teardrop cells with normocytic normochromic to microcytic hypochromic RBC morphology in anemic mothers.

Table 1: Cord blood hemoglobin level in relation to maternal hemoglobin status.

Categorization of maternal Hb level as per WHO (gm/dl)	Number of patients (125)	Percentage	Mean cord blood hemoglobin (gm/dl)	P value
<11 (anemic)	46	36.8	13.81±1.32	0.00
≥11 (non- anemic)	79	63.2	15.27±1.31	0.00

Table 2: Relation of cord blood hemoglobin in maternal anemia.

Maternal anemia	Number of patients (125)	Mean cord blood hemoglobin (gm/dl)	P value
Mild	38	13.86±1.19	0.000
Moderate	8	13.53±1.90	0.002
Non-anemia	79	15.27±1.31	1.000

Table 3: Relation of birth weight in anemic and non-anemic mothers.

Maternal anemia	Number of patients (125)	Mean newborn birth weight (kg)	P value
Mild	38	3.10±0.40	1.00
Moderate	8	2.95±0.30	1.00
Severe	0	0	0
Very severe	0	0	0
Non-anemic	79	3.07±0.46	1.0

Table 4: Correlation of cord blood hematological parameters between anemic and non-anemic mothers.

Hematological parameters	Mean value in cord blood of anemic mother (46 cases)	P value	Mean value in cord blood of non-anemic mother (79 cases)	P value
White blood cells (WBC)				
Total leucocyte count (per mm^3) (TLC)	15391.30±5336.40	0.75	15687.34±4930.99	0.75
Differential leucocyte count (DLC)				
Neutrophil (%) (N)	62.10±12.94	0.22	59.70±9.02	0.27
Lymphocyte (%) (L)	25.67±9.58	0.64	28.74±8.41	0.07
Monocyte (%) (M)	9.13±7.49	0.56	8.60±2.37	0.64
Eosinophil (%) (E)	2.72±1.39	0.33	3.00±1.47	0.32
Hematocrit (%) (HCT)	43.33±5.21	0.00	47.80±4.24	0.00
Mean corpuscular volume (fl) (MCV)	102.34±9.01	0.05	105.19±7.41	0.07
Mean corpuscular hemoglobin (pg) (MCH)	32.88±3.53	0.19	33.72±3.47	0.19
Mean corpuscular hemoglobin concentration (gm/dl) (MCHC)	31.82±1.78	0.22	32.29±2.18	0.19
Platelets (per mm^3) (PLT)	275982.60±120860.30	0.10	243189.87±99759.72	0.12
Reticulocyte count % (Retics)	3.23±1.66	0.07	3.78±1.63	0.07

DISCUSSION

In this study of 125 pregnant women, the prevalence of maternal anemia was found to be 36.8 %, which is consistent with the global estimate of 38 % by the WHO.[1] Previous Nepalese studies reported higher rates (e.g., 42.6 % and 63 %), possibly reflecting differences in study populations, exclusion criteria, and regional nutritional or health-care contexts.[2,3] In our study, women with severe anemia (Hb<7 gm/dl) were not included, in accordance with our exclusion criteria; this may partly explain the slightly lower prevalence.

A key finding is the significant positive correlation between maternal and cord-blood hemoglobin concentrations: the mean cord-blood hemoglobin among neonates of anemic mothers was 13.81±1.32 gm/dl versus 15.27±1.31 gm/dl among neonates of non-anemic mothers. This finding aligns with prior studies conducted in Nepal (e.g., Timilsina et al) and internationally (Al-Hilli et al, Debbarma et al).[4-6]

The biological plausibility lies in maternal iron status influencing placental iron transfer and fetal erythropoiesis. In contrast, Akhter et al found no statistical correlation between maternal and cord hemoglobin, suggesting that population differences (iron supplementation, maternal disease, gestational age, etc.) may modulate this relationship.[7]

Regarding neonatal birth weight, our findings showed no significant difference between neonates of mildly (3.10±0.40 kg) and moderately (2.95±0.30 kg) anemic mothers. This is consistent with Al-Hilli et al and Debbarma et al, who found low birth weights mainly in association with severe maternal anemia (which our study did not include).[4,5] In contrast, Kaur and Singla et al reported significant reductions in birth and placental

weights among severely anemic mothers.[9,10] Thus, our results suggest that mild to moderate maternal anemia (as in our cohort) may not significantly impair birth weight, but caution is warranted given the exclusion of severe cases.

In the analysis of maternal hematological indices, anemic mothers demonstrated significantly lower hematocrit, MCV, MCH, and MCHC, consistent with findings by Ahenkorah et al and Abdulqadir et al.[11,12] No significant differences were seen in WBC count, differential count, platelet count, or reticulocyte count, mirroring results from Abdulqadir et al.[12] In cord-blood parameters, only hematocrit differed significantly between neonates of anemic and non-anemic mothers; other parameters (WBC, MCV, MCH, MCHC, platelet, reticulocyte count) did not. These findings align with Elgari et al, who reported similar patterns except for a higher reticulocyte count in neonates of anemic mothers.[7] The mean cord-blood values in our study were comparable to reference values reported by Qaiser et al.[13]

Red-cell indices such as MCV, MCH, and MCHC are known to be poor early indicators of iron-deficiency anemia during pregnancy, since significant changes in red-cell morphology often occur only in advanced stages.[14,15] Our peripheral-smear findings (normocytic-normochromic to microcytic-hypochromic patterns) are consistent with mild to moderate anemia and echo Abdelrahman et al's observations.[15]

Implications

These findings underscore the value of routine hemoglobin screening in pregnancy and suggest that maternal hemoglobin levels do affect neonatal cord-blood hemoglobin. While we did not observe birth-weight impact in mild to moderate anemia, the absence of severely anemic subjects suggests that the effect threshold may lie in more advanced maternal anemia. Given the high prevalence of maternal anemia in Nepal, strengthening antenatal iron supplementation and monitoring may help improve neonatal hematologic status.

This study has some limitations. This study was conducted at a single tertiary-care centre, with a moderate sample size and absence of severely anemic mothers due to exclusion criteria, limiting generalizability to all pregnant populations in Nepal. Future multicentric studies with larger sample sizes and inclusion of severe anemia cases are recommended to confirm and extend these findings.

CONCLUSION

There was a positive correlation of cord blood hemoglobin in mild and moderate degrees of maternal anemia. However, fetal weight and other hematological parameters were not found to be associated (except for hematocrit) with mild and moderate degrees of maternal anemia. Detection of maternal anemia facilitates early prevention and management of newborn hematological parameters, thereby optimizing neonatal hematologic outcomes.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee B. P. Koirala Institute of Health Sciences, Dharan, Nepal (Ref. No. 231/074/075-IRC, Code No. IRC/1149/017).

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