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Original Research Article

Correlation between maternal and cord blood haematocrit among term singleton deliveries at a tertiary hospital in Sub-Saharan Africa

Ushakuma M. Anenga[1]*, Yakaka M. Tatabe[2], Juliet A. Nkemdeme[3], Oghenetega J. Agbagoro[4]

[1]Department of Obstetrics and Gynaecology, College of Health Sciences, Benue State University, Makurdi, Benue State, Nigeria
[2]Department of Obstetrics and Gynaecology, University of Maiduguri Teaching Hospital, Maiduguri, Borno State, Nigeria
[3]Department of Obstetrics and Gynaecology, Federal Teaching Hospital, Owerri, Imo State, Nigeria
[4]Department of Obstetrics and Gynaecology, Federal Medical Centre, Yenagoa, Bayelsa State, Nigeria

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***Correspondence:**
Dr. Ushakuma M. Anenga,
E-mail: uanenga@yahoo.com

ABSTRACT

Background: Anaemia in pregnancy is a major public health concern in sub-Saharan Africa as it contributes significantly to maternal and neonatal morbidity. Maternal haematocrit reflects the oxygen-carrying capacity of the red blood cells, and its relationship with cord blood haematocrit provides insight into fetoplacental oxygen transfer. The study aims to determine the correlation between maternal and cord blood haematocrit and to identify predictors of neonatal anaemia among term singleton deliveries at a tertiary hospital in sub-Saharan Africa.
Methods: This was an analytical cross-sectional study conducted at Benue State University Teaching Hospital, Makurdi, Nigeria. Ninety-five term pregnant women and their neonates were recruited consecutively. Maternal venous and umbilical cord blood samples were taken and analysed for haematocrit. Spearman's correlation was used to assess the relationship between maternal and cord blood haematocrit, while binary logistic regression was used to identify the predictors of neonatal anaemia. A p value <0.05 was considered statistically significant.
Result: There was a significant positive correlation between maternal and cord blood haematocrit (ρ=0.299, p=0.003). Neonates of non-anaemic mothers had a higher median cord haematocrit [46.0 (44.8–48.0)%] than those of anaemic mothers [43.0 (39.5–47.5)%] (p=0.009). Logistic regression identified maternal anaemia as the only independent predictor of neonatal anaemia (AOR=0.19, 95% CI=0.07–0.50, p=0.001).
Conclusion: Maternal haematocrit showed a significant positive correlation with cord blood haematocrit, confirming maternal anaemia as a key determinant of neonatal anaemia among term singleton deliveries.

Keywords: Maternal anaemia, Cord blood haematocrit, Neonatal anaemia, Term pregnancy, Sub-Saharan Africa

INTRODUCTION

Anaemia in pregnancy is a major public health challenge in sub-Saharan Africa, with an estimated prevalence of 35–75% among pregnant women in developing countries.[1,2] The World Health Organization (WHO) defines anaemia in pregnancy as haemoglobin <11 g/dl or haematocrit <33%.[2] The haematocrit (Hct) level reflects the oxygen-carrying capacity of blood and provides insight into feto-placental oxygen delivery.[1] Cord blood haematocrit is considered a reliable indicator of neonatal haematologic status at birth.[1] The physiological haemodilution of pregnancy, which is often compounded by nutritional deficiencies, infections, and malaria, contributes to reduced maternal haematocrit levels and could adversely affect both maternal and neonatal outcomes such as preterm birth, low birth weight, intrauterine growth restriction, perinatal mortality, and maternal death.[3-5] Despite ongoing interventions such as

iron–folate supplementation and intermittent preventive treatment for malaria, the burden remains high.

Several studies have reported a positive correlation between maternal and cord blood haematocrit or haemoglobin levels. In Uganda, a prevalence of neonatal anaemia of 17% has been reported, with each one-point decrease in maternal haemoglobin corresponding to a 0.14-point decrease in cord haemoglobin.[1] Similarly, a study in Port Harcourt, Nigeria, found a significant linear correlation between maternal and cord haemoglobin concentrations.[2] Conversely, a study in Canada observed that cord blood haemoglobin was inversely related to placental weight and positively related to the birthweight-to-placental weight ratio, suggesting adaptive placental changes in response to oxygen transport demands.[6] Moreover, a study in Washington, USA, demonstrated that anaemic mothers had higher umbilical vein oxygen content, suggesting compensatory increases in placental oxygen transfer.[7]

Despite growing global literature, data from sub-Saharan Africa remain limited, especially the relationship between maternal haematocrit and neonatal anaemia. Understanding this relationship is important in resource-poor settings like ours, where anaemia screening and neonatal follow-up may be inadequate. This study is, therefore, aimed at evaluating the correlation between maternal and cord blood haematocrit among term singleton deliveries in Benue State University Teaching Hospital, a tertiary hospital in sub-Saharan Africa.

METHODS

Study design and setting

This was an analytical cross-sectional study conducted from 01 October 2021 to 31 May 2022 at the Benue State University Teaching Hospital (BSUTH), Makurdi, Nigeria. The hospital is a tertiary health institution and the main referral centre for Benue State and neighbouring states, providing specialised care in obstetrics, gynaecology, paediatrics, and internal medicine. It also serves as a major training site for medical students and resident doctors. The hospital conducts an average of 1,500 deliveries per annum.

Study population

The study population comprised women who had singleton live births at term (≥37 weeks) at BSUTH during the study period. Inclusion criteria were: confirmed term gestation based on the last menstrual period or early ultrasound, singleton pregnancy, and willingness to participate in the study. Exclusion criteria included multiple pregnancies, antepartum haemorrhage, chronic systemic diseases such as sickle cell anaemia, hypertension, diabetes mellitus, or renal disease, as well as mothers who received blood transfusions within three months prior to delivery. Neonates with gross congenital anomalies were also excluded.

Sample size determination

The sample size estimation was done using the statistical formula for correlation studies to detect a minimum correlation coefficient (r) of 0.3 between maternal and cord blood haematocrit at a 95% confidence level (α=0.05) and 80% power.[8] This resulted in a minimum sample size of 85 mother-neonate pairs. Allowing for a 10% attrition rate, the total sample size was 95 pairs.

Sampling technique

A consecutive sampling technique was used, such that all eligible and consenting women who met the inclusion criteria were recruited consecutively until the desired sample size was achieved.

Data collection

Data were collected by trained resident doctors using structured proformas. After obtaining informed consent, 2 ml of maternal venous blood was collected in ethylenediaminetetraacetic acid (EDTA) bottles during the first stage of labour or immediately prior to delivery. Umbilical cord blood samples (2 ml) were drawn from the placental end of the cord immediately after clamping and cutting, before the expulsion of the placenta. Both samples were transported promptly to the departmental side laboratory for analysis. Blood was drawn into two capillary tubes by capillary action, and each tube was sealed at one end with plasticine. The paired tubes were placed opposite each other in a Micro Haematocrit Centrifuge (Hawksley and Sons Ltd., Lancing, United Kingdom) to maintain balance. Centrifugation was performed for five minutes at 1500 revolutions per minute (rpm). After centrifugation, the blood column was visibly separated into packed erythrocytes, a thin buffy coat, and clear plasma. The tubes were then kept horizontally on a micro-haematocrit capillary tube centrifuge reader (Hawksley and Sons Ltd., Lancing, United Kingdom) to determine haematocrit values in percentage. The mean values of haematocrit read from the two capillary tubes were recorded. Neonatal anaemia was defined as cord blood haematocrit <45% or haemoglobin concentration <13 g/dl, while maternal anaemia in pregnancy was defined as haematocrit <33%.[1,2] Socio-demographic and clinical variables, including maternal age, parity, booking status, and socioeconomic class classified using the Olusanya criteria, were obtained and verified against the women's antenatal case notes.[9]

Data analysis

Data were analyzed using statistical package for the social sciences (SPSS) version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized using means and standard deviations or medians and

interquartile ranges, while categorical variables were presented as frequencies and percentages. Spearman's rank correlation assessed the relationship between maternal and cord haematocrit, and the Mann–Whitney U test was used to compare cord blood haematocrit between anaemic and non-anaemic mothers. Binary logistic regression was used to identify predictors of neonatal anaemia, with results presented as adjusted odds ratios (AOR) and 95% confidence intervals (CI). A p value <0.05 was considered statistically significant.

Ethical considerations

Ethical approval for the study was obtained from the Health Research Ethics Committee of Benue State University Teaching Hospital, Makurdi, with reference number BSUTH/MKD/HREC/2021/154. Written informed consent was obtained from each participant after explanation of the study objectives and procedures, in accordance with the ethical principles of research involving human participants.

RESULTS

A total of 95 women and their neonates were included in the analysis. The participants' ages ranged from 18 to 42 years, with a mean age of 29.3±4.8 years. Most participants (37.9%) were between 25 and 29 years. About half (48.4%) of the women belonged to the lower socio-economic class, and 78.9% were booked for antenatal care. The majority (82.1%) were multiparous (parity 1–4), while 3.2% had parity ≥5. The mean gestational age at delivery was 38.8±1.6 weeks, while the mean birth weight was 3.0±0.5 kg (Table 1).

The mean maternal haematocrit was 33.6±3.3%, and 38.9% of the women were anaemic. The mean cord blood haematocrit was 44.9±4.8%, with 36.8% of neonates being anaemic (Table 2).

A significant positive correlation was observed between maternal and cord blood haematocrit levels (ρ=0.299, p=0.003) (Table 3).

Furthermore, neonates of non-anaemic mothers had a higher median cord haematocrit [46.0 (44.8–48.0)%] than those of anaemic mothers [43.0 (39.5–47.5)%], and this difference was statistically significant (U=729.5, p=0.009) (Figure 1).

Binary logistic regression revealed maternal anaemia as the only significant independent predictor of neonatal anaemia. Neonates born to anaemic mothers were 82% less likely to have normal haematocrit compared to those born to non-anaemic mothers (AOR=0.19, 95% CI: 0.07–0.50, p=0.001). Although maternal age showed a marginal association (AOR=0.90, 95% CI: 0.80–1.00, p=0.058), it was not statistically significant. Other maternal factors, including socio-economic status, booking status, parity, and gestational age, were not significantly associated with neonatal anaemia (Table 4).

Table 1: Socio-demographic and obstetric characteristics of participants (N=95).

Variables	N	%
Age (years)	Mean=29.3	SD=4.8
<20	1	1.1
20–24	14	14.7
25–29	36	37.9
30–34	28	29.5
35–39	15	15.8
40–44	1	1.1
Socio-economic status		
Upper	19	20.0
Middle	30	31.6
Lower	46	48.4
Booking status		
Booked	75	78.9
Unbooked	20	21.1
Parity		
0 (primi)	14	14.7
1-4	78	82.1
≥5	3	3.2
Gestational age (weeks)	Mean=38.8	SD=1.6
Birth weight (kg)	Mean=3.0	SD=0.5
Low	14	14.7
Normal	81	85.3

SD=Standard deviation

Table 2: Maternal and neonatal anaemia (N=95).

Variable and category	N	%
Maternal anaemia	Mean=33.6	SD=3.3
Yes	37	38.9
No	58	61.1
Neonatal anaemia	Mean=44.9	SD=4.8
Yes	35	36.8
No	60	63.2

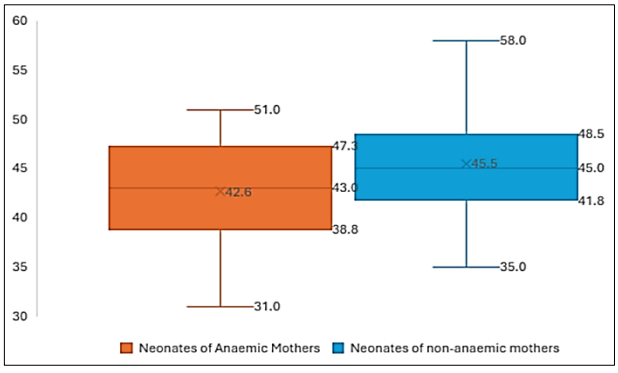

Figure 1: Box plot comparing cord blood haematocrit between neonates of anaemic and non-anaemic mothers (n=95).

Mann–Whitney U=729.5; p value=0.009

Table 3: Correlation between maternal and cord blood haematocrit (n=95).

Variables	Correlation coefficient (ρ)	P value
Maternal haematocrit versus cord blood haematocrit	0.299	0.003

ρ=Spearman's rank correlation coefficient

Table 4: Binary logistic regression predicting neonatal anaemia (n=95).

Predictor variables	AOR	95% CI for AOR	P value
Age (years)	0.90	0.80–1.00	0.058
Socio-economic status (ref: lower)			
Upper	2.64	0.65–10.72	0.175
Middle	0.72	0.21–2.43	0.594
Booking status (unbooked)	0.52	0.15–1.77	0.293
Parity (ref: primigravida)			
1–4	1.33	0.34–5.29	0.683
≥5	1.85	0.08–44.97	0.706
Gestational age (weeks)	1.08	0.81–1.45	0.606
Maternal anaemia (yes)	0.19	0.07–0.50	0.001

AOR=Adjusted odds ratio; CI=confidence interval; ref=reference category

DISCUSSION

This was an analytical cross-sectional study conducted at the Benue State University Teaching Hospital, Makurdi, to investigate the correlation between maternal and cord blood haematocrit among term singleton deliveries. The mean maternal age (29.3±4.8 years) and predominance of multiparity (82.1%) align with findings from other sub-Saharan studies, including Ngonzi et al in Uganda, who reported a mean age of 28 years among mothers delivering at term.[1] The maternal anaemia prevalence of 38.9% in this study falls within WHO estimates for sub-Saharan Africa (35–75%).[1,2] Comparable results were found by Timilsina et al in Nepal.[10] Our neonatal anaemia rate (36.8%) is higher than that reported in Uganda (17%), likely reflecting regional nutritional and malaria burdens, lower antenatal supplementation adherence, and socioeconomic disparities.[1] The observed mean birth weight of 3.0 kg, with 14.7% low birth weight (LBW), confirms recent meta-analyses linking maternal anaemia to increased LBW risk.[11] The sociodemographic patterns reinforce the persistent public health challenge of maternal anaemia in Sub-Saharan Africa.

The mean maternal haematocrit of 33.6% and neonatal haematocrit of 44.9% confirm the physiological expectation that cord blood haematocrit exceeds maternal values due to active placental iron transfer and fetal erythropoietic adaptation.[6] A significant positive correlation between maternal and cord blood haematocrit was observed in our study. This supports the hypothesis that maternal haematologic status directly influences neonatal haematologic indices, as corroborated by a study in Uganda, which found that a 1 g/dl decrease in maternal haemoglobin corresponded to a 0.14 g/dl fall in cord haemoglobin (p=0.02).[1] Comparable results were also observed by a study in Nepal and Port Harcourt.[2,10] Conversely, a study in Pakistan reported negligible correlations between maternal and neonatal haematocrit, concluding that foetal indices are largely independent of maternal blood values.[12] These disparities could be due to the exclusion of women with haemoglobin <10 g/dl, which may have influenced the results. Another author conducted a meta-analysis and reported only negligible pooled correlations between maternal and cord blood haematocrit indices.[13] However, the study pooled many heterogeneous studies with wide variation in gestational age, assay methods, timing of maternal sampling, inflammatory status, and population characteristics, while our study used strict exclusion criteria, uniform timing of blood sampling, and a single standardized micro-haematocrit technique. Generally, the consistent positive correlations across several studies affirm maternal haematocrit as a predictor of neonatal haematologic status.

Regression analysis established maternal anaemia as the only independent predictor of neonatal anaemia. This is consistent with findings in Uganda, which also reported that maternal anaemia significantly predicted neonatal anaemia.[1] Similarly, it was observed in another study that maternal anaemia was associated sex-specifically with neonatal anaemia independent of maternal race and ethnicity.[14] Studies conducted at various times in Nepal and India confirmed the same relationship.[10,15] In contrast, Gragasin et al found no direct relationship between maternal haemoglobin and cord blood levels among Canadian mother-baby pairs.[6] This discrepancy may be explained by placental adaptations that might offset moderate maternal anaemia.[16] Also, Gragasin et al's cohort comprised women in high-income settings, whereas our study was in a low-resource, infection-endemic region with limited nutritional supplementation. The strong predictive link between maternal and cord blood shows the need for targeted interventions, such as iron and folate supplementation, malaria control, and improved antenatal follow-up, to prevent maternal anaemia.

Although our study found socioeconomic status, booking status, parity, and gestational age to be of no significant predictive value for neonatal anaemia, other studies conducted using data from across Sub-Saharan Africa identified maternal education and antenatal attendance as predictors of adverse birth outcomes.[5,11] Hence, while maternal anaemia exerts the strongest independent effect, other determinants, such as socioeconomic empowerment and antenatal care, remain important factors in improving perinatal outcomes.

Limitations

The limitations of this study include its single-centre cross-sectional design, which precludes establishing causal relationships. Also, nutritional deficiencies and infections that cause anaemia in pregnancy, such as malaria parasitaemia, were not evaluated.

CONCLUSION

In conclusion, the study found a significant positive correlation between maternal and cord blood haematocrit, establishing maternal anaemia as a major determinant of neonatal anaemia among term singleton deliveries in a sub-Saharan African hospital setting.

Recommendations

We recommend that routine and periodic antenatal screening for anaemia should be strengthened. Secondly, cord blood haematocrit assessment should be institutionalized to identify neonates at risk for early anaemia and initiate prompt follow-up. Lastly, future studies should be conducted to explore the longitudinal effects of maternal anaemia on neonatal iron status and developmental milestones.

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