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Original Article

Paediatrics Section

Effect of Maternal Haemoglobin on Neonatal Anthropometry: A Prospective Observational Study

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ABSTRACT

Introduction: Anaemia during pregnancy is highly prevalent especially in developing nations (65-75% in India). The causes are multifactorial, nutritional anaemia being the most common cause. Maternal anaemia is known to have adverse neonatal outcomes, including anthropometric measurements.

Aim: To study the correlation between maternal haemoglobin level and neonatal birth weight, length and head circumference.

Materials and Methods: It was a prospective observational study carried out at DY Patil University School of Medicine and Hospital, Nerul, Navi Mumbai, Maharashtra, India done over two years between November 2018-November 2020. Maternal history, blood samples and neonatal birth weight, length and head circumference were taken. Results were recorded, and qualitative data was presented using frequency, percentage while quantitative data was presented using descriptive statistics. Further statistical analysis was carried out with the help of tests such as Wilcoxon Mann-whitney U test, Kruskal Walis test and Spearman's correlation test for association.

Results: A total of 550 anaemic mothers fulfilling the inclusion criteria were enrolled in the study. Neonatal birth weight, length and head circumference were negatively affected by the severity of maternal anaemia which was statistically significant. Higher Body Mass Index (BMI), compliance with Iron Folic Acid (IFA) supplementation, adequate interpregnancy interval between pregnancies and adequate calorie intake during pregnancy resulted in significant differences in birth weight and length.

Conclusion: Maternal anaemia, malnutrition, irregular IFA supplementation, inadequate spacing and inadequate calorie intake significantly hampers neonatal anthropometry.

Keywords: Anaemia in pregnancy, Birth weight, Head circumference, Length

INTRODUCTION

Anaemia is the most common nutritional deficiency in the world. According to World Health Organisation (WHO) the estimated prevalence of anaemia in pregnancy is 14% in developed nations whereas in India alone the prevalence is 65-75% [1]. Nutritional deficiency accounts for >90% of the causes, other causes being chronic blood loss due to infection, anaemia before pregnancy, early, multiple and recurrent pregnancies, lower socio-economic status, etc., [2]. Neonates born to their anaemic mothers have adverse perinatal outcome in the form of preterm and Small for Gestational Age (SGA) babies, Intrauterine Growth Restriction (IUGR) and Intrauterine Death (IUD) due to severe placental insufficiency and increased perinatal mortality rates. These babies have little or no iron stores and are at risk of infection and poor growth [3,4]. Longterm consequences of these babies are reduced cognitive skills, impaired schooling and behavioural abnormalities. They also have poor performance in the Bayley scale of infant development and increased incidence of hypertension and cardiovascular disease in adult life [5,6]. This is due to the deficiency of chemical mediators in foetal brain as a result of maternal iron deficiency. All these complications are aggravated in preterm. In view of importance attached to such high prevalence of maternal anaemia and adverse maternal and foetal complications associated with it, the present study was carried out with an aim to study the correlation between maternal haemoglobin level and neonatal birth weight, length and head circumference.

MATERIALS AND METHODS

The present prospective observational study was conducted in Department of Paediatrics and Obstetrics in the Post Natal Care (PNC) ward at DY Patil University School of Medicine & Hospital, Nerul, Navi Mumbai, Maharashtra, India between November 2018 to November 2020. Institutional Ethical Committee (IEC) approval was taken (IEC REF NO. DYP/IEC/02-092/2019). Informed consent was taken from the mothers.

Inclusion criteria: Mothers between age group 18-35 years with low maternal haemoglobin in 2nd or 3rd trimester of pregnancy with singleton gestation and full term babies were included.

Exclusion criteria: Mothers with medical conditions except anaemia like TORCH (T)oxoplasmosis, (O)ther Agents, (R)ubella, (C)ytomegalovirus, and (H)erpes Simplex infection or smokers or alcoholics or known diabetes mellitus and hypertension before pregnancy, diagnosed renal or heart disease, connective tissue disease, Haemoglobinopathies (e.g. Thalassemia) and those who received drugs were excluded. Babies born preterm, with skeletal deformities or any other congenital malformations at birth or born of multiple gestations were excluded.

Sample size calculation: Sample size calculation was performed based on a similar study conducted, as their demographics were relatable to the Indian study population [7]. The sample size was fixed by determining the effect size (d=0.44), significance level (α=0.05), 90% power and approximately 216 subjects were required to conduct the study. The sample size was calibrated to account for the study's dropout rate.

Study Procedure

Detailed history was recorded. Enrolled mothers gravida and interpregnancy interval was asked. They were divided into primigravida and multigravida, and a child spacing of 18 months was considered adequate. Mother's daily calorie intake was counted with Calorie Calculator. Mother's height, weight and BMI was calculated and divided into four groups as underweight (<18.5 kg/m^2), normal BMI (18.5-22.9 kg/m^2), over weight (23-24.9 kg/m^2), obese (>25 kg/m^2) [8]. IFA supplementation was asked and divided into two groups, IFA taken and IFA not taken.

Under aseptic precautions, peripheral vein-puncture blood samples were collected from the pregnant subjects for the determination of haemoglobin levels before delivery by Cyanmethaemoglobin method. The principle of this method lies in conversion of haemoglobin to Cyanmethaemoglobin by the addition of Potassium cyanide and ferricyanide whose absorbance is measured at 540 nm in a photoelectric calorimeter against a standard solution [9]. Anaemia in pregnancy is defined by WHO criteria as presence of haemoglobin concentration of <11 g/dL. Thus, the pregnant anaemic women are divided into three categories as per the maternal haemoglobin levels, (a) 10.9-9.0 g/dL- mild anaemia (b) 8.9-7.0 g/dL- moderate anaemia (c) <7 g/dL- severe anaemia [10]. All the singleton live born babies included in the study were examined within 48 hours of birth. Birth weight was measured by electronic digital weighing scale with accuracy of 10 grams, and weight more than 2.5 kg was considered normal. Length was measured by infantometer and head circumference was measured using a non stretchable tape. All the parameters were documented in the proforma.

STATISTICAL ANALYSIS

Results were recorded and qualitative data was presented using frequency, percentage while quantitative data was presented using descriptive statistics such as Mean, Standard Deviation (SD), and Structural Equation Modelling (SEM). Further statistical analysis was carried out with the help of tests such as Wilcoxon Mann-whitney U test, Kruskal-Walis test and Spearman's correlation for test for association. Level of significance was set at 5%. All p-values <0.05 were taken as significant.

RESULTS

A total of 550 anaemic mothers fulfilling the inclusion criteria were enrolled in the study. Mean maternal age was 25 years and there were 277 (50.4%) male and 273 (49.6%) female neonates. The mean baby birth weight was 2496 gms, mean baby length was 47 cm, mean baby head circumference was 34 cm and gestational age was 38 weeks [Table/Fig-1].

A positive association was noted between maternal haemoglobin and birth weight, length and head circumference of the baby (better maternal haemoglobin resulted in improved neonatal anthropometry) and was statistically significant (p<0.001). No statistically significant difference was found on comparing gravida with newborn birth weight, length and head circumference (p>0.001). On comparing the maternal BMI with anthropometry of newborns, it was found that underweight mothers had statistically significant negative effect on the birth weight and length when compared to mothers with normal weight. The difference between the four groups in terms of birth weight and length was statistically significant (p<0.001), but head circumference was not affected significantly (p-0.063). Compliance of IFA supplementation resulted in higher neonatal anthropometric measures, and these differences were statistically significant (p<0.001) [Table/Fig-2].

Spearman correlation is a non parametric measure of the strength and direction of association that exists between two variables measured on atleast an ordinal scale.

Maternal factors		Mean±SD	Frequency (%)
Maternal age (years)		25.69±3.87	
Gestational age (weeks)		38.97±1.32	
Gravida/Parity	Primigravida	-	268 (48.7)
	Multigravida	-	282 (51.3)
Spacing from previous pregnancy (years)		2.02±0.91	
Severity of anaemia	Mild	-	345 (62.7)
	Moderate	-	192 (34.9)
	Severe	-	13 (2.4)
IFA suplementation	Not taken	-	219 (39.8)
	Taken		331 (60.2)
Maternal daily calorie intake (Kcal)		2059.31±315.64	
Maternal BMI (kg/m^2)	<18.5	-	32 (5.8)
	18.5-22.9	-	427 (77.6)
	23.0-24.9	-	90 (16.4)
	25.0-29.9	-	1 (0.2)
Neonatal parameters			
Birth weight (gm)		2496.33±339.88	-
Baby length (cm)		47.45±2.65	-
Head circumference (cm)		34.47±1.01	-

[Table/Fig-1]: Demographics of maternal and neonatal history.

Parameters	Categories n (% of mothers)	Mean birth weight in grams ±SD	Mean baby length in cm ±SD	Mean baby head circumference in cm ±SD
Haemoglobin (gm/dL)	Mild 345 (62.7%)	2638.15±275.63	48.68±2.00	34.77±0.58
	Moderate 192 (34.9%)	2285.07±289.06	45.60±2.16	34.05±1.24
	Severe 13 (2.4%)	1853.08±191.70	42.15±2.03	32.85±1.91
	p-value (Kruskal-wallis test)	<0.001	<0.001	<0.001
Gravida	Primigravida 268 (48.7%)	2510.23±342.94	47.5±2.68	34.51±0.98
	Multigravida 282 (51.3%)	2483.13±337.03	47.4±2.62	34.4±1.03
	p-value (Wilcoxon Mann-whitney U test)	0.518	0.548	0.345
BMI (kg/m^2)	Underweight 32 (5.8%)	2129.28±366.92	44.62±3.03	34.12±1.41
	Normal 427 (77.6%)	2489.97±326.16	47.44±2.56	34.45±1.00
	Overweight 90 (16.4%)	2656.1±286.31	48.47±2.17	34.69±0.83
	Obese 1 (0.2%)	2580±0	49±0	35±0
	p-value (Kruskal wallis test)	<0.001	<0.001	0.063
IFA supplementation	Not taken 219 (39.8%)	2280.32±310.39	45.59±2.35	34.04±1.28
	Taken 331 (60.2%)	2686.17±268.97	49.06±1.78	34.77±0.62
	p-value (Kruskal-wallis test)	<0.001	<0.001	<0.001

[Table/Fig-2]: Comparison of maternal haemoglobin, gravida, BMI, Iron folic supplementation with neonatal birth weight, length and head circumference.

The mean maternal daily calorie intake was 2059 kcal. There was a strong positive correlation between maternal daily calorie intake with birth weight and length and were found statistically significant (p≤0.001). There was a weak positive correlation with head circumference and this was also significant (p≤0.005). There was a moderate positive correlation between spacing from previous pregnancy and birth weight (p<0.001), while a weak positive correlation was found between spacing and length (p<0.001) and head circumference (p<0.001), which were all statistically significant [Table/Fig-3].

Correlation	Spearman correlation coefficient	p-value
Maternal daily calorie intake (kcal) vs. birth weight (gm)	0.520	<0.001
Maternal daily calorie intake (kcal) vs. baby length (cm)	0.500	<0.001
Maternal daily calorie intake (kcal) vs. head circumference (cm)	0.120	<0.005
Spacing from previous pregnancy (years) vs. birth weight (gm)	0.330	<0.001
Spacing from previous pregnancy (years) vs. baby length (cm)	0.260	<0.001
Spacing from previous pregnancy (years) vs. head circumference (cm)	0.170	<0.005

[Table/Fig-3]: Spearman correlation between maternal daily calorie intake and spacing from previous pregnancy vs baby's birth weight, length and head circumference.

DISCUSSION

Anaemia in pregnant women can be both physiological and pathological. Nutritional anaemia is the most common cause and can range from mild to severe. In present study cohort of 550 anaemic mothers, majority (62.7%) of them had mild anaemia. In similar studies done by Desalegn S and Lokare PO et al., the majority had moderate anaemia (74.3% and 54.4% respectively) [11,12]. The possible reasons for this variation may be because of improved nutrition over period and better intake of supplements in the metropolitan city where present study was conducted.

Low haemoglobin levels in mother restrict oxygen circulation in the body, creating an environment of oxidative stress or chronic hypoxia, which can cause foetal growth restriction thereby decrease in neonatal anthropometric measurements [13]. Present study results indicated inverse correlation between severity of anaemia and mean neonatal birth weight, length and head circumference which was statistically significant.

In present study, mean birth weight was found to be 2638 gm in mild anaemia, 2285 gm in moderate anaemia and 1853 gm in severe anaemic mothers. In similar studies done by Behal M et al., Al-Hilli NM, Kumar NP and Pabbati J, the mean birth weight was 2560 gm, 3100 gm, and 2844 gm in mild anaemia cases respectively; the mean birth weight was 2536 gm, 2700 gm and 2670 gm in moderately anaemic mothers; and in severely anaemic mothers the birth weight was 2261 gm, 2200 gm, 2227 gm respectively [14-16]. These results also showed a statistically significant correlation between maternal Haemoglobin and birth weight which were in accordance with present study.

In present study, the mean baby length was 48.6 cm, 45.6 cm, and 42.15 cm in mild, moderate and severe anaemic mothers respectively. Similar study done by Behal M et al., found mean baby length to be 49 cm, 48 cm, and 45 cm in mild, moderate and severe anaemic mothers [14]. In another study done by Paramahamsa RRK and Chakravarthi GK, baby length between anaemic and non anaemic mothers was compared and it was found that 74.1% of babies with low crown heel length were born to anaemic mothers [17]. All these results were statistically significant and in accordance to present study.

The mean baby head circumference in mild, moderate and severe anaemic mothers were 34.77 cm, 34.05 cm and 32.85 cm respectively in our study and in the study done by Behal et al., it was 34 cm, 33 cm and 32 cm respectively [14]. In the study done by Paramahamsa RRK and Chakravarthi GK, 67.9% of babies were born to anaemic mothers had low head circumference [17]. These results were also statistically significant and in congruence with present study. It was documented in all the previous studies as well that as severity of anaemia increased, the mean baby length and head circumference at birth decreased significantly, which was in congruence to present study.

On comparing the gravida of mothers with neonatal anthropometry, no significant effect was demonstrated. Tiwari N and Mishra V studied the relation between birth order and neonatal anthropometry using Pearson Correlation coefficient and failed to demonstrate any significant correlation between order of birth and birth weight (p-value=0.853), length (p-value=0.705), and head circumference (p-value=0.030), which was in correspondence to present study [18]. Woman may offer, through remodelling of maternal vasculature in their previous pregnancies, a more favourable environment for placental development, its function and foetal nutrition in the next pregnancies [19].

Maternal malnutrition has a significant impact on maternal haemoglobin and foetal anthropometry. It was observed in present study that mothers with low BMI were more anaemic, which was also seen in a study done by Singhal A and Kochar S, their study also found that mean haemoglobin of underweight women was 8.64 g% and of normal weight women was 9.73 g%, suggesting a highly significant correlation between haemoglobin and BMI [20].

Present study noted that as the BMI improved, the mean birth weight and length also increased, and the difference was statistically significant. Similar results were observed in studies done by Chowdhary et al., and Kalk P et al., [21,22]. In studies done by Chowdhary et al., and Kalk P et al., mean birth weight was 1.66 kg and 2.66 kg respectively in low BMI group, 2.82 kg and 3.05 kg respectively in normal BMI group, 3.11 kg and 3.22 kg respectively in overweight group, 3.2 kg and 3.66 kg respectively in obese group. These results were statistically significant and corresponds to results of present study as well. Kalk P et al., also compared maternal BMI with newborn length and head circumference. In low BMI mothers, the mean length was 47±5 cm and head circumference was 33±3 cm. In normal weight mothers, the mean length was 49±4 cm and head circumference was 34±3 cm. In overweight mothers the mean length was 50±4 cm and head circumference was 35±2 cm and in obese mothers, the mean length was 51±3 cm and head circumference was 35±2 cm. All these results were found to be statistically significant. Present study did not document any significant increase in head circumference as the BMI increased, while study done by Kalk P et al., demonstrated a statistically significant increase [22]. Head sparing effect in children with asymmetric IUGR may be the possible reason for non affection of head circumference by Maternal BMI as noted in present study.

In present study, the mothers who were in compliance with IFA supplements demonstrated statistically significant positive effect on all neonatal anthropometric parameters. Similar study done in Malawi showed that pregnant women who self-reported taking supplement taking supplements consistently (atleast two months) lowered the risk of delivering a LBW newborn significantly [23], which was in accordance to present study. This also corroborates the effect of maternal haemoglobin on foetus as well as reiterates the importance of IFA supplementation in pregnancy.

Short birth interval does not give the mother enough time to recuperate from the nutritional burden of the previous pregnancy, therefore, an increased risk for maternal anaemia is expected when the inter-pregnancy interval is very short [24]. Present study found a moderate positive correlation between spacing and birth weight, while length and head circumference had a weak positive correlation. Study done by Saaka M and Aggrey B also suggested that a short birth interval is associated positively with an increased risk of low birth weight [25].

Eating a well-rounded diet with all the right nutrients and adequate calorie intake is important for healthy pregnancy outcome. In present study, Spearman Correlation showed that there was a moderate positive correlation between maternal daily calorie intake and birth weight, length and weak positive correlation with head circumference and these correlations were statistically significant. In a study done by Gopalan C et al., mothers who consumed calories <1500 kcal/day delivered low birth weight (2242.63±324.49 g) newborns [26]. This result shows that the mean birth weight of newborns increased with proportionate increase in the consumption of calories by the mothers ($p<0.05$), which was in congruity with present study.

The strength of present study was that it was a prospective study in which maternal haemoglobin effect was described on all the neonatal anthropometric parameters. Simultaneously authors also compared common maternal factors which affects neonatal anthropometry and established statistically significant correlation.

Limitation(s)

Limitation of current study was that serial samples of haemoglobin could not be taken as per trimester in mother and couldn't do long-term follow-up of the study subjects to see the progress in neonatal anthropomentry.

CONCLUSION(S)

Anaemia in pregnancy had a statistically significant negative impact on the birth weight, length and head circumference of the baby, which was proportionate to the severity of anaemia. Improved maternal nutrition as measured by BMI, compliance with IFA supplementation, adequate spacing between pregnancies and adequate calorie intake during pregnancy resulted in higher differences in birth weight and length, which were statistically significant. Neonatal birth weight and length are significantly affected by maternal parameters like anaemia, malnutrition, regular IFA supplementation, adequate spacing and calorie intake. It further reinforces the need for a robust public health program for females in reproductive age group ensuring adequate micro and macro nutrient sufficiency which is essential for a healthy pregnancy outcome.

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