

To Study Profile of Hemoglobin and Red Blood Cell Indices during First Week of Life in Normal Term Neonates

Bipin Rathod¹, Neha Muda²

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Abstract

Background: During transition from fetal to neonatal life is related with major changes in hemogram due to homeostatic control. There are very extensive ranges of hemogram levels that seem to be abnormally high or low in healthy term neonate at birth and during first week of life. Those were actually normal for that neonatal period depending upon gestational and post-natal age.

Method: Hemogram was studied in 100 normal term neonates born in our Tertiary centre during June 2023 to Dec 2023.

Results: The ranges of various hemogram indices at birth, 24 hours, 48 hours and 7 days are as follows: Hemoglobin 18.1 ± 2.62 gm%, 17.2 ± 2.62 gm%, 16.6 ± 2.37 gm% and 16.1 ± 2.28 gm% respectively. Hematocrit $52.3 \pm 6.2\%$, $50.1 \pm 6.2\%$, $49.4 \pm 6.3\%$ and $47.3 \pm 6.1\%$ respectively. Mean corpuscular volume (MCV) 100.3 ± 7.20 fl, 98.5 ± 7.2 fl, 98.9 ± 7.3 fl and 99.2 ± 7.3 respectively. Mean corpuscular hemoglobin (MCH) 34.1 ± 2.69 pg, 33.4 ± 2.71 pg, 33.6 ± 2.73 pg and 33.8 ± 2.75 pg respectively. MCH concentration (MCHC) 34.8 ± 1.61 g/dl, 33.8 ± 1.57 g/dl, 34.1 ± 1.56 g/dl and 34.6 ± 1.61 g/dl respectively.

Conclusions: Hemoglobin levels naturally decrease in healthy term neonates during early life. Additionally, there is significant variation in red blood cell parameters among healthy term neonates. Notably, normal hemogram values for neonates differ from other age groups and change with postnatal and gestational age. To accurately interpret neonatal hemograms, reference ranges derived from large datasets spanning various gestational and postnatal ages should be consulted, such as those provided here for healthy term neonates.

Keywords: Hemogram; Term neonates; Cord blood; Foetal transition; Hematocrit; MCV; MCH; MCHC; TRBC.

INTRODUCTION

The postnatal changes in tissue oxygenation and erythropoietin production result in a physiologic anemia of infancy with a mean minimal hemoglobin concentration in healthy term infants. Infant growth and development are likely affected by hemoglobin levels, but current evidence is inconclusive regarding optimal target levels of hemoglobin and RBC indices.¹ The importance and difficulty of assessment and management of hemoglobin and RBC indices during the neonatal period can be as great as ever encountered in medicine.² One reason

Author's Affiliation: ¹Associate Professor, Department of Paediatrics, Dr. Panjabrao Deshmukh Memorial Medical College, Amravati 444603, Maharashtra, ²Senior Resident, Department of Pathology, Jawaharlal Nehru Medical College, Wardha 442005, Maharashtra, India.

Corresponding Author: Bipin Rathod, Associate Professor, Department of Paediatrics, Dr. Panjabrao Deshmukh Memorial Medical College, Amravati 444603, Maharashtra, India.

E-mail: bipinrathodamt@gmail.com

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is that the transition from foetal to neonatal life is associated with major changes in RBC mass and transition of fetal hemoglobin to mature hemoglobin A.³ The average Hb at birth is relatively unchanged; however, 48 hours later, after redistribution of plasma volume, Hb values will reflect the lower or higher red cell mass.

The normal reference ranges of hemogram quoted in various textbooks have a very wide range and seem to be abnormal. The normal reference range of these parameters in a term neonate quoted in Rennie textbook of neonatology and Nelson textbook of pediatrics is as follows: hemoglobin: mean-16.8g/dl (14.5-22.5g/dl), Hematocrit: mean-53%, TRBC: mean 5.2×10^{12} /litre.^{3,6} The laboratory value obtained at extreme of these ranges or outside these ranges seems to be abnormal and pathological and may need to be treated accordingly. In neonatal period there are hematological changes in an attempt to maintain homeostasis after transition from foetal to neonatal period. These high hemoglobin levels are common during this period & are a part of that physiological process of transition from foetal to neonatal period.

Study objectives

To approximate normal physiological values of haemoglobin and red blood indices values during first week of life.

To suspect early Haemoglobinopathies and to plan there management.

This study will help to establish trend and changes in values in early neonatal period.

METHODS

This hospital based observational study was conducted at our tertiary institute during January 2023 to June 2023. Total 80 term neonates delivered during the stated study period were randomly selected as per inclusion criteria defined below.

Inclusion criteria

Normal healthy term neonates delivered vaginally or by caesarean section with gestational age ≥ 37 weeks and birth weight > 2500 gm were included in the study.

Exclusion criteria

Gestational age < 37 weeks, birth weight < 2500 gms; neonates with history of birth asphyxia (Apgar score < 5 at 5 min); meconium aspiration syndrome; clinical signs and symptoms of neonatal sepsis or any other neonatal illness; any evidence of any gross congenital or chromosomal malformation; presence of maternal risk factors.

After inclusion of patient in the study a detailed antenatal, natal, postnatal history noted, clinical examination of neonate at birth, 24 hours, 48 hours, 72 hours and 7 days of life. Assessment of gestational age using new Ballard scoring system.⁷ complete hemogram at birth, at 24 hours, 48 hours and 7 days of life using standard method. Complete blood count/hemogram was performed on automated analyser-Sysmex XT-2000i (5 Part analyzer). Collection of cord blood done using the bag method. Venous blood was drawn under strict aseptic precaution from fresh venepuncture site using 24 gauge or 22-gauge needle.

Ethical considerations

Permission of in Written informed consent was obtained from parents/representatives before enrolling to this study.

Statistical analysis

All the data was collected in predesigned format. This data was entered to Microsoft office excels which was used for various calculations. Statistical analyses were performed using the software statistical package for the social sciences (SPSS) version 10.0 for MS-windows. Descriptive frequencies were expressed using mean $\pm$ standard deviation (SD) and median (range).

RESULTS

In this study 55 (55%) cases were male, 45 (45%) cases were female. The 48 (48%) cases were of 37-38 weeks of gestation, 36 (36%) cases were of 39-40 weeks gestation and 16 (16%) were of 41-42 weeks of gestational age (Fig. 1). The mean, median and standard deviation of gestational age of neonates in the study were 39.4

Table 1: Levels of mean, standard deviation and range of hemoglobin

Time of sample	Mean Hb (gm%)	SD (gm%)	Range (gm%)
Cord blood at birth	18.1	2.62	13.6- 24.1
24 hours of life	17.2	2.46	12.3-23.7

Table cont...

48 hours of life	16.6	2.37	12.1-21.9
72 hours of life	16.4	2.31	11.8-21.4
7 days of life	16.1	2.28	11.3-21.1

Table 2: Levels of mean, standard deviation and range of hematocrit

Time of sample	Hematocrit (gm%)	SD (gm%)	Range (gm%)
Cord blood at birth	52.3	6.2	37.7-65.6
24 hours of life	50.1	6.2	36.2-62.3
48 hours of life	49.4	6.3	35.7-61.6
72 hours of life	48.5	6.2	33.5-60.8
7 days of life	47.3	6.1	32.2-60.1

Table 3: Levels of mean, standard deviation and range of MCV

Time of sample	MCV	SD (gm%)	Range (gm%)
Cord blood at birth	100.3	7.2	82.2-126.5
24 hours of life	98.5	7.2	82.5-126.1
48 hours of life	98.9	7.3	82.1-126.3
72 hours of life	99.5	7.2	82.3-126.
7 days of life	99.2	7.3	80.5-126.4

Table 4: Levels of mean, standard deviation and range of MCH

Time of sample	MCH	SD (gm%)	Range (gm%)
Cord blood at birth	34.1	2.69	26.2-40.9
24 hours of life	33.4	2.71	26-39.7
48 hours of life	33.6	2.73	26.1-40.1
7 days of life	33.8	2.75	26.3-41.5

Table 5: Levels of mean, standard deviation and range of MCHC

Time of sample	Mean MCHC (g/dl)	SD (gm%)	Range (gm%)
Cord blood at birth	34.8	1.61	30.1-38.2
24 hours of life	33.8	1.57	28.5-37.7
48 hours of life	34.1	1.56	28.6-38.9
7 days of life	34.6	1.61	29.4-38.5

In this study, highest number of neonates (52%) had birth weight in the range of 2500-2999 grams and the least number of neonates (6%) had a birth weight ≥ 3500 grams. The mean, median and standard deviation of birth weight in this study was 2808 gm, 2780 gm and 306 gm, respectively. The range of birth weight in this study was 2210 to 3900 gm.

DISCUSSION

At birth, term newborns exhibit significantly different hemoglobin values and red blood

cell (RBC) parameters compared to older children and adults. Newborns have relative polycythemia, characterized by macrocytosis (high mean corpuscular volume, MCV) and marked polychromasia with nucleated RBCs. Following birth, dramatic changes in oxygenation occur during the first few days, leading to a rapid decline in erythropoietin levels. Consequently, RBC production decreases by a factor of 2-3 during the first few days and by a factor of approximately 10 during the first week of life. This results in a transient "physiologic" anemia developing at the end of the neonatal period.

At birth, newborns exhibit polycythemia and macrocytosis, followed by a gradual decrease in RBC count, hemoglobin concentration, and MCV during the postnatal period. Although RBC, hemoglobin, and MCV values are higher in newborns, the mean corpuscular hemoglobin concentration (MCHC) is relatively low compared to adult standards.

While the erythrocytes are bigger and contain more hemoglobin relative to their increased size, the hemoglobin within the cells is neither more nor less concentrated than for adults.^{4,5}

In this study the mean $\pm$ SD hemoglobin at birth, at 24 hours, 48 hours and 7 days was 18.1 $\pm$ 2.62 gm%, 17.2 $\pm$ 2.62 gm%, 16.6 $\pm$ 2.37 gm% and 16.1 $\pm$ 2.28 gm% respectively. The corresponding figures in other studies were as follows: in study of preterm infants by Thomas *et al.* mean Hb was 17.8 $\pm$ 2.7 gm% at 7 days of life.⁷ In study done by Abdurrahman *et al.* mean Hb was 14 gm%.⁸ In study done by Ozyurek *et al.* mean hemoglobin at day 1 and 7 days was 17.0 $\pm$ 0.4 gm% and 16.2 $\pm$ 0.4 gm% respectively.⁹ The mean Hb values showed a decreasing trend with the postnatal age, it decreased to 1.5 gm% in first 7 days of life in this study as compared to 1 gm% decrement from day 1 Hb to day 7 Hb in study by Ozyurek *et al.*⁹ The range of hemoglobin in our study at birth, at 24 hours, 48 hours and 7 days was 12.2-23.2 gm%, 11.6-22.8 gm%, 11.5-21.3 gm% and 11.3-21.1 gm% respectively. The corresponding figures in other studies were as follows: in study of preterm infants by Thomas *et al.* range of Hb was 11.4-24.8 gm% at 7 days of life.⁷ In study done by Ozyurek *et al.* range of hemoglobin at day 1 and 7 days of life was 13.1-23.0 gm% and 10.3-20.0 gm% respectively.⁹

In this study the mean $\pm$ SD hematocrit at birth, at 24 hours, 48 hours and 7 days was 52.3 $\pm$ 6.2%, 50.1 $\pm$ 6.2%, 49.4 $\pm$ 6.3% and 47.3 $\pm$ 6.1% respectively. The corresponding figures in other studies were as follows: in study done by Acharya and Payne the mean $\pm$ SD hematocrit at birth, at 24 hours and 48 hours was 54.17 $\pm$ 6.32%, 53.09 $\pm$ 7.91% and 49.18 $\pm$ 5.94% respectively.⁵ In study done by Abdurrahman *et al.* mean hematocrit was 42%.⁸ In study done by Ozyurek *et al.* mean hematocrit at 1 day and 7 days was 47.0 $\pm$ 1.0% and 44.6 $\pm$ 1.0% respectively.⁹ The mean hematocrit values showed a decreasing trend with the postnatal age, it decreased to 4.2 % in first 7 days of life in this study as compared to 2.9% decrement from day 1 hematocrit to day 7 hematocrit in study by Ozyurek *et al.*⁹ The range of hematocrit at birth, at 24 hours, 48 hours and 7 days was 36.8-64.3%, 35.2-61.3%, 34.4-60.6% and 32.2-60.1% respectively,

the corresponding figures in other studies were as follows: in study done by Acharya *et al.* the range of hematocrit at birth, at 24 hours and 48 hours was 43-62.0%, 42-64.0% and 36-59.0% respectively.⁵ In study done by Ozyurek *et al.* range of hematocrit at day 1 and 7 days of life was 36.7-62.8% and 28.5-54.7% respectively.

In this study the mean $\pm$ SD MCV at birth, at 24 hours, 48 hours and 7 days was 100.3 $\pm$ 7.20 fl, 98.5 $\pm$ 7.2fl, 98.9 $\pm$ 7.3fl and 99.2 $\pm$ 7.3 respectively whereas mean MCV in study done by Ozyurek *et al.* at 1 day and 7 days of life was 101.1 $\pm$ 0.5 fl and 98.7 $\pm$ 0.5 fl respectively. The mean MCV values showed a decreasing trend from cord blood to 7 days of life with slight rise at 48 hours as compared to 24 hours MCV. The range of MCV at birth, at 24 hours, 48 hours and 7 days was 82.2-126.5 fl, 82.5-126.1 fl, 82.1-126.3 fl and 80.5-126.4 fl respectively whereas in study done by Ozyurek *et al.* range of MCV at day 1 and 7 days of life was 94-107 fl and 92.6-105.0 fl respectively.⁹

In this study the mean $\pm$ SD MCH at birth, at 24 hours, 48 hours and 7 days was 34.1 $\pm$ 2.69pg, 33.4 $\pm$ 2.71pg, 33.6 $\pm$ 2.73pg and 33.8 $\pm$ 2.75pg respectively whereas mean MCH in study done by Ozyurek *et al.* at 1 day and 7 days of life was 36.5 $\pm$ 0.2 pg and 35.8 $\pm$ 0.2 pg respectively.⁹ The mean MCH showed a trend of initial fall at 24 hours to rise again till 7 days of life. The range of MCH at birth, at 24 hours, 48 hours and 7 days was 26.2-40.9 pg, 26-39.7 pg, 26-40.5 pg and 25.4-39.4 pg respectively whereas in study done by Ozyurek *et al.* range of MCH at day 1 and 7 days of life was 33.9-39.2 pg and 32.9-38.4 pg respectively.⁹

In this study the mean $\pm$ SD MCHC at birth, at 24 hours, 48 hours and 7 days was 34.8 $\pm$ 1.61 g/dl, 33.8 $\pm$ 1.57 g/dl, 34.1 $\pm$ 1.56 g/dl and 34.6 $\pm$ 1.61 g/dl respectively whereas mean MCHC in study done by Ozyurek *et al.* at 1 day and 7 days of life was 36.2 $\pm$ 0.1 g/dl and 36.2 $\pm$ 0.1 g/dl respectively.⁹ The mean MCHC showed a trend of initial fall at 24 hours to rise again till 7 days of life but the rise is not more than cord blood value. The range of MCHC at birth, at 24 hours, 48 hours and 7 days was 29.6-38.0 g/dl, 28.5-37.7 g/dl, 28.4-38.6 g/dl and 28.4-38.5 g/dl respectively whereas in study done by Ozyurek *et al.* range of MCHC at day 1 and 7 days of life was 35-37 g/dl and 35-37.4 g/dl respectively.⁹

CONCLUSION

The normal hemoglobin and RBC indices values in healthy term neonates observed in this study showed a very wide range and seem to

be abnormal, but are actually normal for that neonatal period depending upon the postnatal age. Recognizing that any value abnormally high or low can influence many clinical decisions in our day-to-day practice but unfortunately the reference ranges for the various hemoglobin and RBC indices during the neonatal period are not simple, but change considerably with advancing gestational and postnatal age. Any result in neonates must be interpreted according to data for baby's gestational and postnatal age. If this is not done, results may be misinterpreted and diagnosis of many conditions like infection, anemia, polycythemia and others may be missed, over diagnosed or delayed.

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