

Original Research Article

Study of hemoglobin and red blood cell indices during first week of life in normal term neonates

Mohammad Asif¹, Nishant Dangi¹, Vijay Rajak², Suresh Goyal¹, Manoj K. Garg^{1*}

¹Department of Paediatrics, ²Department of Pathology, RNT Medical College, Udaipur, Rajasthan, India

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*Correspondence:

Dr. Manoj K. Garg,

E-mail: drgargmanoj@gmail.com

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ABSTRACT

Background: Transition from foetal to neonatal life is associated with major changes in hemogram due to homeostatic control. There are very wide ranges of hemogram levels that seem to be abnormally high or low in healthy term neonate at birth and during first week of life but these 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 RNT medical college during June 2009 to Dec 2009.

Results: The ranges of various hemogram indices at birth, 24 hours, 48 hours and 7 days are as follows: Hemoglobin 12.2-23.2 gm/dl, 11.6-22.8 gm/dl, 11.5-21.3 gm/dl and 11.3-21.3 gm/dl respectively. Hematocrit 36.8-64.3%, 35.2-61.3%, 34.4-60.6% and 32.2-60.1% respectively. Mean corpuscular volume (MCV) 82.2-126.5 fl, 82.5-126.1 fl, 82.1-126.3 fl and 80.5-126.4 fl respectively. Mean corpuscular hemoglobin (MCH) 26.2-40.9 pg, 26.0-39.7 pg, 26-40.5 pg and 25.4-39.4 pg respectively. MCH concentration (MCHC) 29.6-38 g/dl, 28.5-37.7 g/dl, 28.4-38.6 g/dl and 28.4-38.5 g/dl respectively. Total red blood cell count (TRBC) $3.7-6.9 \times 10^6/\mu\text{l}$, $3.3-6.9 \times 10^6/\mu\text{l}$, $3.3-6.7 \times 10^6/\mu\text{l}$ and $3.3-6.3 \times 10^6/\mu\text{l}$ respectively.

Conclusions: Hemoglobin level falls in early life in healthy term neonate. Also, there is wide range of RBC parameters in healthy term neonates. The normal values of hemogram in neonates are different from other age groups and it varies with postnatal age and gestational age. A reference range derived from large neonatal datasets of varied gestational and postnatal age should be used such as those presented here for healthy term neonates.

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

INTRODUCTION

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 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 Before birth, the fetal aortic oxygen saturation is 45%, erythropoietin levels are high and RBC

production is rapid. High levels of hemoglobin are required to cope up the situation. After birth oxygen saturation is 95% and erythropoietin is undetectable.⁴ RBC production by day 7 is $<1/10^{\text{th}}$ the level in utero. Moreover, for reasons that are not understood, the transition from foetal to neonatal life is associated with what have come to be accepted as normal changes in hemogram.⁵

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-16.8 g/dl (14.5-22.5 g/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

The study objectives were to estimate normal physiological values of hemogram during first week of life which will help in better diagnosis and management of hematological disorders during first week of life. This study will help to establish that these extreme and abnormal values of hemoglobin do not have any clinicopathological effects on neonate and are normal for that neonatal period and will also help establish a normal reference range of hemogram during first week of life.

METHODS

This hospital based observational study was conducted at RNT medical college, Udaipur, Rajasthan, India during June to November 2009 with approval of institutional ethics committee. Total 100 term neonates delivered at Mahila Chikitsalaya 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 >2100 gm ($\geq 10^{\text{th}}$ percentile for term neonates) were included in the study.

Exclusion criteria

Gestational age <37 weeks, birth weight $<10^{\text{th}}$ percentile of that gestational age; 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 like: use of oxytocin during labour, use of hypotonic fluid given to mother during labour, history of PIH in mother and taken antihypertensive medications like ACE inhibitors, Prolonged and difficult labour/instrumentation, foul smelling liquor or meconium stained liquor, Evidence of chorioamnionitis or PROM, Poorly controlled maternal diabetes mellitus, any chronic illness in mother, history of oligohydramnios or polyhydramnios and evidence of antenatal steroids given to mother were exclude from the study.

After inclusion of patient in the study a detailed antenatal, natal, postnatal history noted, clinical examination of neonate at birth, 24 hours, 48 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 methods used in the institute and was analysed at Aravali Path labs pvt. Ltd. (under Rajasthan Medicare relief society) in the hospital. Complete blood count/hemogram was performed on automated analyser-Sysmex XT-2000i (5 Part analyzer). Collection of cord blood done using the bag method.⁸ Venous blood was drawn under strict aseptic precaution from fresh venepuncture site using 24 gauge or 22-gauge needle.

Ethical considerations

Permission of institute ethical committee (IEC) was taken. 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 excel 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 (Figure 1). The mean, median and standard deviation of gestational age of neonates in the study were 39.4 weeks, 40 weeks and 1.3 weeks, respectively.

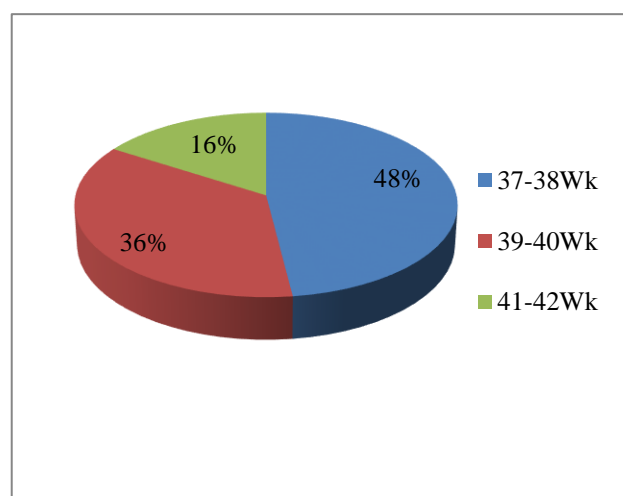


Figure 1: Distribution of cases according to gestational age.

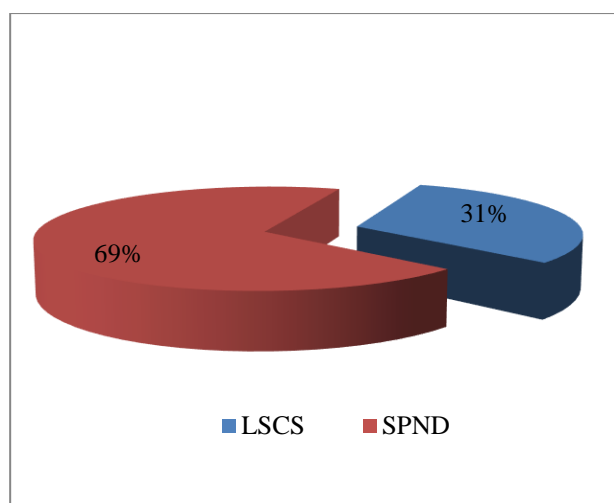


Figure 2: Distribution of cases according to mode of delivery.

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.

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	17.6	2.40	12.2-23.2
24 hours of life	16.6	2.46	11.6-22.8
48 hours of life	16.4	2.37	11.5-21.3
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	Mean hematocrit (%)	SD (%)	Range (%)
Cord blood at birth	51.5	6.2	36.8-64.3
24 hours of life	49.2	6.2	35.2-61.3
48 hours of life	48.4	6.1	34.4-60.6
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	Mean MCV (fl)	SD (fl)	Range (fl)
24 hours of life	100.3	7.2	82.2-126.5
48 hours of life	98.5	7.2	82.5-126.1
7 days of life	98.9	7.3	82.1-126.3
24 hours of life	99.2	7.3	80.5-126.4

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

Time of sample	Mean MCH (pg)	SD (pg)	Range (pg)
24 hours of life	34.3	2.71	26.2-40.9
48 hours of life	33.2	2.70	26-39.7
7 days of life	33.5	2.67	26-40.5
24 hours of life	33.7	2.61	25.4-39.4

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

Time since birth	Mean MCHC (g/dl)	SD (g/dl)	Range (g/dl)
24 hours of life	34.2	1.59	29.6-38.0
48 hours of life	33.8	1.57	28.5-37.7
7 days of life	33.9	1.51	28.4-38.6
24 hours of life	34.0	1.52	28.4-38.5

Table 6: Levels of mean, standard deviation and range of TRBC (total red blood cells).

Time since birth	Mean TRBC (μL)	SD (μL)	Range (μL)
24 hours of life	5.2×10^6	0.72×10^6	$3.7-6.9 \times 10^6$
48 hours of life	5.0×10^6	0.74×10^6	$3.3-6.9 \times 10^6$
7 days of life	4.9×10^6	0.73×10^6	$3.3-6.7 \times 10^6$
24 hours of life	4.8×10^6	0.72×10^6	$3.3-6.3 \times 10^6$

DISCUSSION

At birth, term newborns have significantly different hemoglobin values and RBC parameters from those in older children and adults. There is relative polycythemia with macrocytosis (high MCV) and marked polychromasia with nucleated RBCs. Birth brings dramatic changes in oxygenation during the first few days after birth and the erythropoietin level virtually disappears. There is a marked decline in RBC production by a factor of 2 to 3 during the first few days of life and by a factor of about 10 during the first week of life as a result, a transient "physiologic" anemia develops at the end of the neonatal period. At birth, polycythemia and macrocytosis are present. During the postnatal period, there is a gradual decrease in the RBC count, hemoglobin concentration, and MCV. The mean RBC count drops steadily and hemoglobin concentration follows. While RBC, hemoglobin, and MCV values are higher in newborns, the MCHC is relatively low by adult standards. Thus, 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.

In this study the mean \pm SD hemoglobin at birth, at 24 hours, 48 hours and 7 days was 17.6 ± 2.40 gm%, 16.6 ± 2.45 gm%, 16.4 ± 2.36 gm% and 16.1 ± 2.27 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 ± 2.7 gm% at 7 days of life.⁹ In study done by Abdurrahman et al mean Hb was 14 gm%.¹⁰ In study done by Ozyurek et al mean hemoglobin at day 1 and 7 days was 17.0 ± 0.4 gm% and 16.2 ± 0.4 gm% respectively.¹¹ 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.¹¹ 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.⁹ 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.¹¹

In this study the mean \pm SD hematocrit at birth, at 24 hours, 48 hours and 7 days was $51.5 \pm 6.15\%$, $49.2 \pm 6.19\%$, $48.4 \pm 6.09\%$ and $47.3 \pm 6.04\%$ 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%.¹⁰ 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.¹¹ 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.¹¹ 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.¹¹

In this study the mean \pm SD MCV at birth, at 24 hours, 48 hours and 7 days was 100.3 ± 7.20 fl, 98.5 ± 7.15 fl, 98.9 ± 7.27 fl and 99.2 ± 7.28 fl respectively whereas mean MCV in study done by Ozyurek et al at 1 day and 7 days of life was 101.1 ± 0.5 fl and 98.7 ± 0.5 fl respectively.¹¹ 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.¹¹

In this study the mean \pm SD MCH at birth, at 24 hours, 48 hours and 7 days was 34.3 ± 2.71 pg, 33.2 ± 2.70 pg, 33.5 ± 2.67 pg and 33.7 ± 2.61 pg respectively whereas mean MCH in study done by Ozyurek et al at 1 day and 7 days of life was 36.5 ± 0.2 pg and 35.8 ± 0.2 pg respectively.¹¹ 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.¹¹

In this study the mean \pm SD MCHC at birth, at 24 hours, 48 hours and 7 days was 34.2 ± 1.59 g/dl, 33.8 ± 1.57 g/dl, 33.9 ± 1.51 g/dl and 34.0 ± 1.52 g/dl respectively whereas mean MCHC in study done by Ozyurek et al at 1 day and 7 days of life was 36.2 ± 0.1 g/dl and 36.2 ± 0.1 g/dl respectively.¹¹ 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.¹¹

In this study the mean \pm SD TRBC at birth, at 24 hours, 48 hours, 7 days was 5.2 ± 0.72 million/ μ L, 5.0 ± 0.74 million/ μ L, 4.9 ± 0.73 million/ μ L and 4.8 ± 0.72 million/ μ L respectively whereas mean TRBC in study done by E. Ozyurek et al at 1 day and 7 days of life was 4.7 ± 0.1 million/ μ L and 4.5 ± 1.0 million/ μ L respectively.¹¹ The mean TRBC values showed a decreasing trend with the postnatal age, it decreased to 0.4 million/ μ L in first 7 days of life in this study as compared to 0.1 million/ μ L decrement from day 1 TRBC to day 7 TRBC in study by Ozyurek et al.¹¹ The range of TRBC at birth, at 24 hours, 48 hours and 7 days was 3.7-6.9 million/ μ L, 3.3-6.9 million/ μ L, 3.3-6.7 million/ μ L and 3.3-6.3 million/ μ L respectively whereas in study done by Ozyurek et al range of TRBC at day 1 and 7 days of life was 3.6-6.2 million/ μ L and 3-5.6 million/ μ L respectively.¹¹

Limitations

There is a small study of 100 neonates. Although data derived from the study correlate with other studies, generalization of values needs a large multicentric study to establish strong data. Follow up of normal newborns was a difficult task and some turned out having one or another medical issue. Values are affected by hydration status or diurnal variations can't be rectified by any means.

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.

This cannot be accomplished using the normal ranges established in healthy adults or single group of neonates, but rather using reference ranges derived from large neonatal datasets of varied gestational and postnatal age, such as those presented here for term neonates.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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