



A STUDY OF WBC INDICES DURING FIRST WEEK OF LIFE IN NORMAL TERM NEONATES

Dr. Mohammad Asif	Associate Professor Paediatrics, RNT Medical College, Udaipur.
Dr. Anuradha Sanadhyा	Associate Professor Paediatrics, RNT Medical College, Udaipur.
Dr. Suresh Goyal	Senior Professor Paediatrics, RNT Medical College, Udaipur.
Dr. Manoj Kumar Garg*	Senior Resident Paediatrics, RNT Medical College, Udaipur. *Corresponding Author

ABSTRACT **Introduction-** Transition from foetal to neonatal life is associated with major changes in WBC counts due to homeostatic control. The neutrophilia at birth is transient, with the result that soon after birth; the lymphocytes become the major population in the peripheral blood, which persists during early childhood.

Aims & objective- This study was planned to study normal levels and changes of total and differential leukocyte counts in cord blood and during first week of life.

Material & method: 100 Normal term neonates with gestational age >37 weeks & birth weight >2100 gm were included in the study. Total and differential leukocyte count was studied in cord blood, 24 hrs, 48 hrs, 7th day of life and mean, range & standard deviation were calculated.

Results: In this study Mean±SD TLC (Total Leukocyte Count) in cord blood, at 24 hrs, 48 hrs & 7 days was $16.8 \pm 4.35 \times 10^3/\mu\text{L}$, $15.2 \pm 3.70 \times 10^3/\mu\text{L}$, $14.0 \pm 3.49 \times 10^3/\mu\text{L}$ & $11.9 \pm 2.91 \times 10^3/\mu\text{L}$ respectively. Mean TLC values showed a decreasing trend with the postnatal age, it decreased by $4.9 \times 10^3/\mu\text{L}$ in first 7 days of life. Range of TLC in cord blood, at 24 hrs, 48 hrs & 7 days was $8.4 - 29.3 \times 10^3/\mu\text{L}$, $8.1 - 23.4 \times 10^3/\mu\text{L}$, $7.2 - 22.8 \times 10^3/\mu\text{L}$ & $5.5 - 18.3 \times 10^3/\mu\text{L}$ respectively. Mean±SD neutrophils in cord blood, at 24 hrs, 48 hrs & 7 days were $62.9 \pm 7.36\%$, $68.9 \pm 7.63\%$, $63.4 \pm 7.15\%$ and $53.4 \pm 7.43\%$ respectively. The trend of mean neutrophils showed that there was initial rise to fall again till 7 days of life. Mean±SD lymphocytes in cord blood, at 24 hrs, 48 hrs & 7 days were $31.0 \pm 7.27\%$, $24.7 \pm 7.06\%$, $30.9 \pm 6.90\%$ and $38.2 \pm 6.50\%$ respectively. The trend of mean lymphocyte levels showed initial fall at 24 hrs to rise again till 7 days of life. Mean±SD monocytes in cord blood, at 24 hrs, 48 hrs & 7 days were $3.2 \pm 1.00\%$, $2.5 \pm 0.76\%$, $2.5 \pm 0.83\%$ and $4.2 \pm 1.17\%$ respectively. The trend of mean monocytes level showed a fall at 24 hrs then remains steady for next 24 hrs and rise again till 7 days of life. Mean±SD eosinophils in cord blood, at 24 hrs, 48 hrs & 7 days were $2.4 \pm 0.77\%$, $3.5 \pm 1.65\%$, $2.8 \pm 1.15\%$ and $3.5 \pm 1.41\%$ respectively. Mean eosinophils levels showed a initial rise at 24 hrs then fall at 48 hrs to again rise at 7 days. Mean±SD basophils in cord blood, at 24 hrs, 48 hrs & 7 days were $0.5 \pm 0.24\%$, $0.4 \pm 0.35\%$, $0.4 \pm 0.14\%$ and $0.6 \pm 0.19\%$ respectively.

Range of neutrophils in cord blood, at 24 hrs, 48 hrs & 7 days was $38.7 - 86.6\%$, $49.3 - 89.5\%$, $49.6 - 88.4\%$ & $25.3 - 73.7\%$ respectively. Range of lymphocytes in cord blood, at 24 hrs, 48 hrs & 7 days was $9.1 - 55.5\%$, $8.1 - 43.2\%$, $8.0 - 45.1\%$ & $19.3 - 62.0\%$ respectively. Range of monocytes in cord blood, at 24 hrs, 48 hrs & 7 days was $1.8 - 8.2\%$, $1.0 - 7.1\%$, $0.2 - 6.2\%$ & $0.4 - 6.3\%$ respectively. Range of eosinophils in cord blood, at 24 hrs, 48 hrs & 7 days was $0.1 - 5.7\%$, $0.2 - 8.8\%$, $0.4 - 6.0\%$ & $0.5 - 9.8\%$ respectively. Range of basophils in cord blood, at 24 hrs, 48 hrs & 7 days was $0.0 - 1.2\%$, $0.0 - 3.0\%$, $0.1 - 0.9\%$ & $0.1 - 1.6\%$ respectively.

Summary- This study showed very wide range of leukocytes levels that seems to be abnormally high or low in healthy term neonate in cord blood and during first week of life but these were actually normal for that neonatal period depending upon gestational and post natal age.

Conclusion: The normal values of total and differential leukocytes in neonates are different from other age groups and it varies with postnatal age and gestational age so same reference range of total and differential leukocytes should not be used in all neonates. Instead 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 : leukocytes, neutrophils, lymphocytes, monocytes, eosinophils and basophils.**INTRODUCTION:**

The WBC and differential is readily available and commonly used to evaluate both symptomatic and asymptomatic infants at risk for sepsis. Interpretation of neonatal WBC has been compromised by the impact of differences mediated by gestational age, postnatal age, mode of delivery, and maternal conditions. Maternal fever, neonatal asphyxia, meconium aspiration syndrome, pneumothorax, and hemolytic disease have all been associated with neutrophilia while maternal pregnancy-induced hypertension and preeclampsia are associated with neonatal neutropenia.[1] One finding common to all published neonatal WBC data is the "roller coaster" shape of the WBC and ANC (absolute neutrophil count) curves in the first 72 hours of life. This suggests that optimal interpretation of WBC data to predict EOS should account for the natural rise and fall in WBC during this period.[2] The WBC and ANC are most predictive of infection when these values were low. An elevated WBC ($>20,000$) is neither worrisome nor reassuring in neonates.[3]

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 WBC and differentials.[2] The reference ranges of these WBC and differentials are usually established on the basis of the statistical distribution of results within a sample of population.[4]

The studies done to find normal distribution levels of above are very limited till date.

The normal reference range of WBC and differentials quoted in various textbooks have a very wide range & seems to be abnormal.[1][2][3][5] The normal reference range of these parameters in a term neonate quoted in Rennie textbook of Neonatology[3] & Nelson textbook of pediatrics[2] is as follows TLC: at birth mean- $18.1(9-30) \times 10^9/\text{litre}$, at 24 hr $(9.4-34) \times 10^9/\text{litre}$. Neutrophils: 54-62%, lymphocytes: 25-33%, monocytes: 3-7%, eosinophils: 1-3% and basophils 0.0-0.75%.

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. These abnormal looking WBC and differentials do not have any pathophysiological or clinical effects in neonate and are considered to be normal for that period.[5] This study was planned to study these normal physiological changes of WBC and differentials during first week of life which will help in better diagnosis and management of disorders & abnormalities during first week of life. This study will help to establish that these extreme and abnormal values of WBC and differentials which do not have any clinicopathological effects on neonate and are normal for that neonatal period and will also establish a normal reference range of these

parameters during first week of life.

Material And Methods:

This study was conducted at in Department of Pediatrics of RNT Medical College Udaipur. The study was carried out during the year 2009. A total of 100 term neonates delivered at Mahila Chiktsalaya were included in the study. The cases that fulfilled the inclusion and exclusion criteria during work up were randomly selected to be included in the study.

Work up done for the cases to be included in the study was:

- An informed written consent to participate in the study from parents was taken
- Detailed antenatal, natal, postnatal history.
- Clinical examination of neonate at birth, 24 hrs, 48 hrs & 7 days of life.
- Assessment of gestational age using New Ballard Scoring System.[6]
- Investigations: complete hemogram in cord blood, at 24 hrs, 48 hrs and 7days of life. (subject to fulfillment of inclusion and exclusion criteria)

The cases that were included in the study were having following inclusion and exclusion criteria.

Inclusion Criteria

Normal healthy term neonates delivered at Mahila Chiktsalaya vaginally or by caesarean section with gestational age ≥ 37 weeks and birth weight $> 2100\text{gm}$ ($\geq 10^{\text{th}}$ 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; any evidence of IUGR; 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, Evidence of antenatal steroids given to mother.

Methods

As per Performa, detailed antenatal, natal & post natal history was taken, gestational age estimation was done according to New Ballard Scoring System as below & clinical examination was performed.[6]

Investigations

The estimation of WBC and differentials was done by collecting cord blood and venous blood at 24 hrs, 48 hrs and 7 days of life using standard methods used in the Institute and was analyzed at Aravali Path Labs Pvt Ltd (under Rajasthan Medicare Relief Society) in the hospital. The samples were collected during the hospital stay at birth, 24 hrs & 48 hrs & 7 days of life. Cases that were discharged before 7 days of life were called up in outpatient department for sample collection and attended personally.

Complete blood count was performed on automated analyzer-Sysmex XT-2000i (5 Part Analyzer) which is based on the following testing principles:[7]

1. Hydrodynamic focussing method.
2. Flow cytometry method using semiconductor lazer..

Specimen collection

Collection of cord blood: using the Bag method[8]

Once the cord is clamped and cut, the maternal end of cord was elevated and by using the force of gravity to drain the blood from the cord and placenta into plain & EDTA vials.

Collection of venous blood:

The venous blood was drawn under strict aseptic precaution from fresh venipuncture site using 24 gauge and 22 gauge needle.

Statistical calculations

- **Mean:** $\frac{\text{sum of all observations}}{\text{Total no.of observations}}$

$$\bullet \quad \text{Standard deviation: } \sqrt{\frac{\sum(\text{any observation} - \text{Mean})^2}{\text{total number of observations}}}$$

- Range: It is the difference between maximum value and minimum value of the observations, and is expressed using both max and min values.
- Median: It is the middle value of all data set after arranging from min to maximum.

RESULTS:

The present study was conducted at Department of Pediatrics, RNT Medical College, Udaipur during the year 2009.

Out of the 100 cases 55(55%) cases were male 45(45%) cases were females in the study.

Out of total 100 cases, 48(48%) cases were of 38 weeks of gestation, 36(36%) cases were of 40 weeks gestation and 16(16%) were of 42 weeks of gestational age. Mean, median and standard deviation of gestational age of neonates in the study were 39.4 weeks, 40 weeks and 1.3 weeks, respectively.

Highest number of neonates (52%) had birth weight in Range of 2500-2999 grams and the least number of neonates (6%) had a birth weight ≥ 3500 grams. Mean, median and standard deviation of birth weight was 2808 grams, 2780 grams and 306 grams, respectively. Range of birth weight was 2210 to 3900 grams.

Out of the 100 neonates 31(31%) were delivered by cesarean section and 69(69%) were spontaneously normal delivered.

In this study Mean, median and standard deviation of TLC in Cord Blood At birth were $16.8 \times 10^3/\mu\text{L}$, $16.3 \times 10^3/\mu\text{L}$ and $4.35 \times 10^3/\mu\text{L}$ respectively. Range of TLC in cord blood was $8.4 - 29.3 \times 10^3/\mu\text{L}$. Mean, median and standard deviation of TLC at 24 hrs of life in this study were $15.2 \times 10^3/\mu\text{L}$, $14.9 \times 10^3/\mu\text{L}$ and $3.49 \times 10^3/\mu\text{L}$ respectively. Range of TLC at 24 hrs was $8.1 - 23.4 \times 10^3/\mu\text{L}$. Mean, median and standard deviation of TLC at 48 hrs of life in this study were $14.0 \times 10^3/\mu\text{L}$, $13.2 \times 10^3/\mu\text{L}$ and $3.49 \times 10^3/\mu\text{L}$ respectively. Range of TLC at 48 hrs was $7.2 - 22.8 \times 10^3/\mu\text{L}$. Mean, median and standard deviation of TLC at 7 days of life in this study were $11.9 \times 10^3/\mu\text{L}$, $11.9 \times 10^3/\mu\text{L}$ and $2.91 \times 10^3/\mu\text{L}$ respectively. Range of TLC at 7 days of life was $5.5 - 18.3 \times 10^3/\mu\text{L}$. [Table/Fig-1]

Time of sample	Mean TLC ($\times 10^3/\mu\text{L}$)	Standard deviation ($\times 10^3/\mu\text{L}$)	Range ($\times 10^3/\mu\text{L}$)
Cord Blood at Birth	16.8	4.35	8.4 - 29.3
24 Hr of Life	15.2	3.70	8.1 - 23.4
48 Hr of Life	14.0	3.49	7.2 - 22.8
7 Days Of Life	12.7	2.91	5.5 - 18.3

[Table/Fig-1]: Levels of mean, standard deviation and range of TLC (total leukocyte count)

In this study mean, median and standard deviation of Neutrophils in Cord Blood at birth were 62.9%, 63.2% and 7.4% respectively. Range of Neutrophils in cord blood was 38.7 - 86.6%. Mean, median and standard deviation of Neutrophils at 24 hrs of life in this study were 68.9%, 70.5% and 7.63% respectively. Range of Neutrophils at 24 hrs was 49.3 - 89.5%. Mean, median and standard deviation of Neutrophils at 48 hrs of life in this study were 63.4%, 62.7% and 7.15% respectively. Range of Neutrophils at 48 hrs was 49.6 - 88.4%. The mean, median and standard deviation of Neutrophils at 7 days of life in this study were 53.4%, 52.9% and 7.43% respectively. The range of Neutrophils at 7 days of life was 25.3 - 73.7%. [Table/Fig-2]

Time of sample	Mean(%)	Standard deviation (%)	Range (%)
Cord Blood at Birth	62.9	7.36	38.7 - 86.6
24 Hr of Life	68.9	7.63	49.3 - 89.5
48 Hr of Life	63.4	7.15	49.6 - 88.4
7 Days Of Life	53.4	7.43	25.3 - 73.7

[Table/Fig-2]: Levels of mean, standard deviation and range of Neutrophils

In this study mean, median and standard deviation of Lymphocytes in Cord Blood At birth were 31.0%, 31.2% and 7.26% respectively. Range of Lymphocytes in cord blood was 9.1 - 55.5%. Mean, median and standard deviation of Lymphocytes at 24 hrs of life in this study were 24.7%, 23.3% and 7.01% respectively. Range of Lymphocytes at 24 hrs was 9.1 - 55.5%. Mean, median and standard deviation of

Lymphocytes at 48 hrs of life in this study were 30.9%, 31.5% and 7.01% respectively. Range of Lymphocytes at 48 hrs was 8.0% - 45.1%. Mean, median and standard deviation of Lymphocytes at 7 days of life in this study were 38.2%, 38.7% and 6.50% respectively. Range of Lymphocytes at 7 days of life was 19.3% - 62.0%. [Table/Fig-3]

Time of Sample	Mean (%)	Standard deviation (%)	Range(%)
Cord Blood at Birth	31.0	7.27	9.1 – 55.5
24 Hr Of Life	24.7	7.02	8.1 – 43.2
48 Hr Of Life	30.9	6.79	8.0 – 45.1
7 Days Of Life	38.2	6.50	19.3 – 62.0

[Table/Fig-3]: Levels of mean, standard deviation and range of Lymphocytes

In this study mean, median and standard deviation of Monocytes in cord blood at birth were 3.2%, 3.2% and 1.0% respectively. Range of Monocytes in cord blood was 1.8 - 8.2%. Mean, median and standard deviation of Monocytes at 24 hrs of life in this study were 2.5%, 2.4% and 0.78% respectively. Range of Monocytes at 24 hrs was 1.0 - 7.1%. Mean, median and standard deviation of Monocytes at 48 hrs of life in this study were 2.5%, 2.4% and 0.83% respectively. Range of Monocytes at 48 hrs was 0.2 - 6.2%. Mean, median and standard deviation of Monocytes at 7 days of life in this study were 4.2%, 4.3% and 1.17% respectively. Range of Monocytes at 7 days of life was 0.4 - 6.3%. [Table/Fig-4]

Time of sample	Mean (%)	Standard deviation (%)	Range (%)
Cord Blood at Birth	3.2	1.00	1.8 – 8.2
24 Hr Of Life	2.5	0.77	1.0 – 7.1
48 Hr Of Life	2.5	0.83	0.2 – 6.2
7 Days Of Life	4.2	1.16	0.4 – 6.3

[Table/Fig-4]: Levels of mean, standard deviation and range of Monocytes

In this study mean, median and standard deviation of eosinophils in cord blood at birth were 2.4%, 2.3% and 0.77% respectively. Range of eosinophils in cord blood was 1.0 - 5.7%. Mean, median and standard deviation of eosinophils at 24 hrs of life in this study were 3.5%, 3.5% and 1.65% respectively. Range of eosinophils at 24 hrs was 0.2% - 8.8%. Mean, median and standard deviation of eosinophils at 48 hrs of life in this study were 2.8%, 2.5% and 1.15% respectively. Range of eosinophils at 48 hrs was 0.4 - 6.0%. Mean, median and standard deviation of eosinophils at 7 days of life in this study were 3.5%, 3.5% and 1.41% respectively. Range of eosinophils at 7 days of life was 0.5% - 9.8%. [Table/Fig-5]

Time of sample (%)	Mean (%)	Standard deviation (%)	Range (%)
Cord Blood at Birth	2.4	0.78	1.0 – 5.7
24 Hr Of Life	3.5	1.65	0.2 – 8.8
48 Hr Of Life	2.8	1.50	0.4 – 6.0
7 Days Of Life	3.5	1.40	0.5 – 9.8

[Table/Fig-5]: Levels of mean, standard deviation and range of Eosinophils

In this study mean, median and standard deviation of basophils in cord blood at birth were 0.5%, 0.5% and 0.23% respectively. Range of basophils in cord blood was 0.0 - 1.2%. Mean, median and standard deviation of basophils at 24 hrs of life in this study were 0.4%, 0.4% and 0.34% respectively. Range of basophils at 24 hrs was 0.0 - 3.0%. Mean, median and standard deviation of basophils at 48 hrs of life in this study were 0.4%, 0.4% and 0.13% respectively. Range of basophils at 48 hrs was 0.1% - 0.9%. Mean, median and standard deviation of basophils at 7 days of life in this study were 0.4%, 0.4% and 0.13% respectively. Range of basophils at 7 days of life was 0.1% - 1.6%. [Table/Fig-6]

Time of sample	Mean (%)	Standard deviation (%)	Range (%)
Cord Blood at Birth	0.5	0.23	0.0 – 1.2
24 Hr Of Life	0.4	0.34	0.0 – 3.0
48 Hr Of Life	0.4	0.13	0.1 – 0.9
7 Days Of Life	0.6	0.19	0.1 – 1.6

[Table/Fig-6]: Levels of mean, standard deviation and range of basophils.

DISCUSSION:

The total WBC and differential counts for a term newborn are significantly different from those in older children and adults. In this study finding shows that newborns have a high WBC count with relative neutrophilia at birth. Then Total leukocyte count continues declining in early neonatal period. Mean TLC counts decrease

gradually from $16.8 \pm 4.36 \times 10^3/\mu\text{L}$ at birth to $11.9 \pm 2.91 \times 10^3/\mu\text{L}$ at 7 days of life. In study done by Sasankul W, et al[9] mean TLC at 12 - 24 hrs of life was $18.48 \pm 6.6 \times 10^3/\mu\text{L}$ and study done by E. Ozuyrek et al[10] mean TLC at day 1 and 7 days was $14.96 \pm 0.04 \times 10^3/\mu\text{L}$ & $10.56 \pm 0.33 \times 10^3/\mu\text{L}$ respectively both of them showed high TLC at birth than decline almost similar to this study. Range of TLC in cord blood, at 24 hrs, 48 hrs & 7 days was $8.4 - 29.3 \times 10^3/\mu\text{L}$, $8.1 - 23.4 \times 10^3/\mu\text{L}$, $7.2 - 22.8 \times 10^3/\mu\text{L}$ & $5.5 - 18.3 \times 10^3/\mu\text{L}$ respectively whereas in study done by E. Ozuyrek et al[10] range of TLC at day 1 and 7 days of life was $7.19 - 22.55 \times 10^3/\mu\text{L}$ & $6.68 - 15.40 \times 10^3/\mu\text{L}$ respectively. The high leukocyte count at birth mostly arises from bone marrow mobilization of the preexisting pool owing to stress during labor and not as much from an increase in WBC production.[11]

In this study we observed mean \pm SD neutrophil high $62.9 \pm 7.36\%$ at birth to rise to peak at 24 hrs $68.9 \pm 7.63\%$ then gradually decline to $63.4 \pm 7.15\%$ at 48 hrs and $53.4 \pm 7.43\%$ at 7 days of life. Similar observations were published by Manroe and col-leagues.[12] According to this study, for neutrophils, peak minimum value of $7,800/\mu\text{L}$ and a maximum of $14,500/\mu\text{L}$ occurred between 12 and 14 hours of age, and a minimum value of $1,750/\mu\text{L}$ was established by 72 hours of age, whereas a stable maximum value of $5,400/\mu\text{L}$ was not reached until 120 hours (5 days) of age. Values thereafter remained unchanged through the 28th day of the study. Range of neutrophils in cord blood, at 24 hrs, 48 hrs & 7 days was $38.7 - 86.6\%$, $49.3 - 89.5\%$, $49.6 - 88.4\%$ & $25.3 - 73.7\%$ respectively. A much more extensive study of blood neutrophil con-centrations of neonates based on more than 30,000 CBCs was published recently.[13] Although the new study showed similar dynamics of neutrophil counts from birth to 72 hours of age, a significantly higher upper limit ($18,000/\mu\text{L}$), lower limit at delivery ($3,500/\mu\text{L}$), and shorter interval for peak values after delivery (8 hours) were present. The upper limits at the peaks were also higher ($28,500/\mu\text{L}$), whereas the lower limits were slightly lower ($7,500/\mu\text{L}$). The trend of higher limits was observed at 72 hours as well ($13,000/\mu\text{L}$). Same observations were showed by Ozuyrek et al[10] which showed mean \pm SD neutrophils $64.90 \pm 5.00\%$ at birth to $30.41 \pm 1.60\%$ at 7 days of life.

In this study the trend of mean lymphocyte levels showed initial fall at 24 hrs to rise again till 7 days of life. Observed mean \pm SD lymphocyte $31.0 \pm 7.27\%$ at birth to fall in 24 hrs $24.7 \pm 7.06\%$, and then gradually rise to $30.9 - 6.90\%$ at 48 hrs and $38.2 \pm 6.50\%$ at 7 days of life. Study done by Ozuyrek et al[10] showed mean \pm SD lymphocytes $26.57 \pm 1.45\%$ at birth to $58.59 \pm 2.25\%$ at 7 days of life. The neutrophilia at birth is transient, with the result that soon after birth; the lymphocytes become the major population in the peripheral blood, which persists during early childhood.[11]

In this study other differentials such as monocytes, basophils and eosinophils does not show any significant variation or values different than which is seen in childhood or adult populations.

SUMMARY:

The major findings of the study were following:

- Out of the 100 healthy full term neonates, Male to female ratio in the study was 1.22:1(11:9). Mean birth weight in this study was 2808 ± 306 grams and maximum number of neonates (52%) had birth weight in Range of 2500-2999 grams.
- Mean, standard deviation & range of WBC and differentials obtained in our study were as under: [Table/Fig-7]

CBC Parameter	Cord Blood at Birth	24 Hrs Of Life	48 Hrs Of Life	7 Days Of Life
	Mean \pm SD (Range)			
TLC ($\times 10^3/\mu\text{L}$)	16.8 ± 4.36 ($8.4 - 29.3$)	15.2 ± 3.70 ($8.1 - 23.4$)	14.0 ± 3.49 ($7.2 - 22.8$)	11.9 ± 2.91 ($5.5 - 18.3$)
Neutrophils (%)	62.9 ± 7.36 ($38.7 - 86.6$)	68.9 ± 7.63 ($49.3 - 89.5$)	63.4 ± 7.15 ($49.6 - 88.4$)	53.4 ± 7.43 ($25.3 - 73.7$)
Lymphocyte (%)	31.0 ± 7.27 ($9.1 - 55.5$)	24.7 ± 7.02 ($8.1 - 43.2$)	30.9 ± 6.80 ($8.0 - 45.1$)	38.2 ± 6.50 ($19.3 - 62.0$)
Monocytes (%)	3.2 ± 1.00 ($1.8 - 8.2$)	2.5 ± 0.76 ($1.0 - 7.1$)	2.5 ± 0.83 ($0.2 - 6.2$)	4.2 ± 1.17 ($0.4 - 6.3$)
Eosinophils (%)	2.4 ± 0.78 ($1.0 - 5.7$)	3.5 ± 1.65 ($0.2 - 8.8$)	2.8 ± 1.15 ($0.4 - 6.0$)	3.5 ± 1.41 ($0.5 - 9.8$)
Basophils (%)	0.5 ± 0.24 ($0.0 - 1.2$)	0.4 ± 0.35 ($0.0 - 3.0$)	0.4 ± 0.14 ($0.1 - 0.9$)	0.6 ± 0.19 ($0.1 - 1.6$)

[Table/Fig-7]: Reference table for TLC and Differentials in newborn

3. The WBC and differentials obtained in our study varied a lot from cord blood to 7 days of life as given in table and & showed a very wide range that seems to be abnormally high /low but these values are normal for this neonatal period depending upon the postnatal age in term neonates.
4. The study shows that normal values of WBC and differentials in neonates vary with postnatal age and gestational age. So, the same reference range of CBC parameters cannot be used in all neonates. Instead, a reference range should be used depending upon postnatal age in both term and preterm neonates.

CONCLUSIONS

The normal WBC and differentials values in healthy term neonates observed in this study showed a very wide range & seem to be abnormal, but are actually normal for that neonatal period depending upon the postnatal age. Recognizing that a WBC and differentials element is abnormally high or low can influence many clinical decisions in our day to day practice but unfortunately the reference ranges for the various WBC and differentials during the neonatal period are not simple, but change considerably with advancing gestational and postnatal age.

WBC and differentials levels 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, polycythaemia & others may be missed and 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.

Recommendations

1. WBC and differentials results for newborn must be interpreted according to data for baby's gestational and postnatal age.
2. The dataset result observed in our study should be used as a reference value for WBC and differentials in full term neonates.
3. Similar studies to find out reference values of these parameters should be done in preterm and small for gestational age neonates.

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