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Original Research Article

A study of serum sodium and potassium levels in normal term neonates

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Abstract

Introduction: Transition from foetal to neonatal life is associated with major changes in fluid and electrolyte levels due to homeostatic control.

Aims & objective: This study was planned to study changes of serum sodium and serum potassium in cord blood and during first week of life.

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

Results: The range of serum sodium in cord blood, at 24 hrs, 48 hrs & 7 days in our study was 128.0–156.0 meq/L, 128.0–150.0 meq/L, 134.0–154.0 meq/L & 128.0 – 150.0 meq/L respectively. The range of serum potassium in cord blood, at 24 hrs, 48 hrs & 7 days in our study was 4.2 – 7.2 meq/L, 4.0 – 6.6 meq/L, 4.0 – 6.5 meq/L & 3.8 – 6.2 meq/L respectively.

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

Conclusion: The normal values of Serum sodium and serum potassium in neonates are different from other age groups and it varies with postnatal age and gestational age so same reference range of electrolytes 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: Serum sodium, serum potassium, term neonates, cord blood, foetal transition, homeostatis.

1. Introduction

The importance and difficulty of assessment and management of fluid and electrolyte status during the first week of life in the neonate can be as great as is ever encountered in medicine. One reason is that the transition from foetal to neonatal life is associated with major changes in water and electrolyte homeostatic control. Before birth, the foetus has a constant supply of water and electrolytes from the mother across the placenta; foetal water and electrolyte homeostasis is largely a function of placental and maternal homeostatic mechanisms that is reflected in cord blood.[3]

After birth neonate must rapidly assume responsibility for its own fluid and electrolyte homeostasis in an environment in which fluid and electrolyte availability and losses fluctuate much more widely than 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 fluid and electrolyte balance. These small changes in fluid and electrolyte quantity represent large proportionate changes in neonate because of neonate's small size.[1,3]

The reference ranges of these serum sodium and potassium are usually established on the basis of the statistical distribution of results within a sample of population.[1] The studies done to find normal distribution levels of these electrolytes till date are very limited.

The normal reference range of serum electrolytes & hemogram quoted in various textbooks have a very wide range & seems to be abnormal [8,12-14]. The normal reference range of these parameters in a term neonate quoted in Rennie textbook of Neonatology & Nelson textbook of pediatrics is as follows[19,20]: Serum Na⁺: 133-146 meq/L, Serum K⁺: 3.2-5.5 meq/L.

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 neonate period first week of life is associated with fluid and electrolyte changes in an attempt to maintain homeostasis after transition from foetal to neonatal period. These abnormal electrolyte levels are common during this period & are a part of that physiological process of transition from foetal to neonatal period. These abnormal serum sodium and potassium levels do not have any pathophysiological or clinical effects in neonate and are considered to be normal for that period [3].

This study was planned to study these normal physiological changes of serum sodium and potassium in during first week of life which will help in better diagnosis and management of fluid and electrolyte disorders during first week of life. This study will help to establish that these extreme and abnormal values of serum sodium and serum potassium 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.

2. Material and methods

This study was conducted at Pannadhay Mahila Chikitsalaya, Department of Pediatrics, R. N. T. Medical College, Udaipur. The study was carried out during the period of June 2009 to November 2009. A total of 100 term neonates delivered at Pannadhay Mahila Chikitsalaya 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 [15].

- Investigations: serum sodium and serum potassium 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.

2.1 Inclusion Criteria

Normal healthy term neonates delivered at Pannadhay Mahila Chikitsalaya vaginally or by caesarean section with gestational age ≥ 37 weeks and birth weight $> 2100\text{gm}$ ($\geq 10^{\text{th}}$ percentile for term neonates)[16] were included in the study.

2.2 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.
- 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.
- Any evidence of any gross congenital or chromosomal malformation.
- Evidence of antenatal steroids given to mother.

2.3 Methods

As per proforma, 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.[15]

2.4 Investigations

The estimation of serum sodium and serum potassium 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 analysed 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.

The quantitative estimation of serum sodium and serum potassium was done on automated analyzer –Roche Diagnostics.

2.5 Specimen collection

2.5.1 Collection of cord blood: using the Bag method [16]

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. No squeezing was done while collecting blood from the cord. After collection of blood it was sent to laboratory and was analysed as soon as possible.

2.5.2 Collection of venous blood

The venous blood was drawn under strict aseptic precaution from fresh venipuncture site using 24 gauge and 22 gauge needle. The blood sample was collected in both plain vials and EDTA vials. Care was taken to avoid any squeezing while collecting blood samples.

After collection of blood it was sent to laboratory and was analysed as soon as possible.

2.6 Statistical calculations

- Mean: Sum of all observations / Total no. of observations.
- Standard deviation: Square root of (any observation – mean value ÷ total no. of observation).
- 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.

3. Results

The present study was conducted at Department of Pediatrics Pannadhay Mahila Chikitsalaya, R.N.T Medical College, Udaipur during the period of October 2009 to November 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. 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.

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 grams, 2780 grams and 306 grams, respectively. The range of birth weight in this study was 2210 to 3900 grams.

In this study out of the 100 neonates 31(31%) were delivered by cesarean section and 69(69%) were spontaneously normal delivered.

The mean, median and standard deviation of serum sodium in cord blood at birth in this study were 141.7 meq/L, 142.6 meq/L and 4.92 meq/L resp. The range of serum sodium in cord blood was 128.0-156.0 meq/L.

The mean, median and standard deviation of serum sodium at 24 hrs of life in this study were 139.6 meq/L, 141.0 meq/L and 4.47 meq/L respectively. The range of serum sodium at 24 hrs was 128.0–150.0 meq/L.

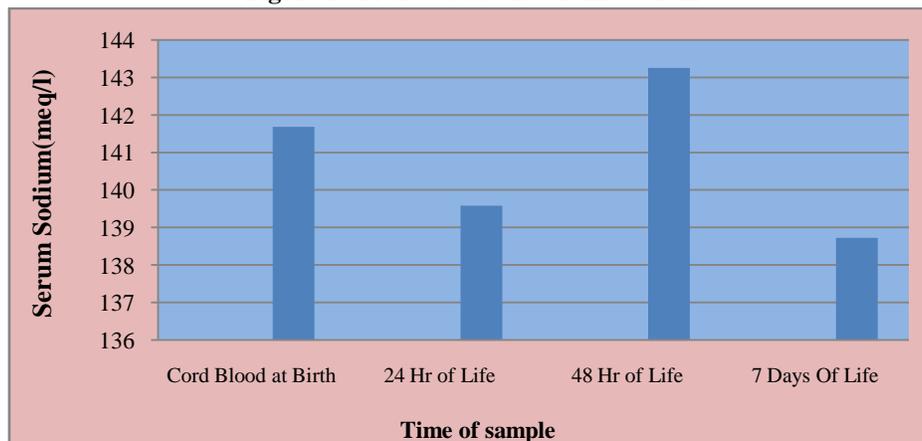
The mean, median and standard deviation of serum sodium at 48 hrs of life in this study were 143.3 meq/L, 144.0 meq/L and 3.94 meq/L resp. The range of serum sodium at 48 hr s was 134.0 – 154.0 meq/L

The mean, median and standard deviation of serum sodium at 7 days of life in this study were 138.7 meq/L, 139.0 meq/L and 3.48 meq/L respectively. The range of serum sodium at 7 days of life was 128.0–150.0 meq/L.

Table 1: Trend of Mean Serum Sodium

Time of sample	Mean Serum Sodium (meq/l)	Standard deviation (meq/l)	Range (meq/L)
Cord Blood at Birth	141.7	4.92	128.0 – 156.0
24 Hr of Life	139.6	4.48	128.0 – 150.0
48 Hr of Life	143.3	3.95	134.0 – 154.0
7 Days Of Life	138.7	3.49	128.0 – 150.0

Figure 1: Trend of Mean Serum Sodium



The mean, median and standard deviation of serum potassium in cord blood at birth in this study were 6.0 meq/L, 6.1 meq/L and 0.56 meq/L resp. The range of serum potassium in cord blood was 4.2-7.2 meq/L

The mean, median and standard deviation of serum potassium at 24 hrs of life in this study were 6.0 meq/L, 6.1 meq/L and 0.48 meq/L respectively. The range of serum potassium at 24 hrs was 4.0-6.6 meq/L.

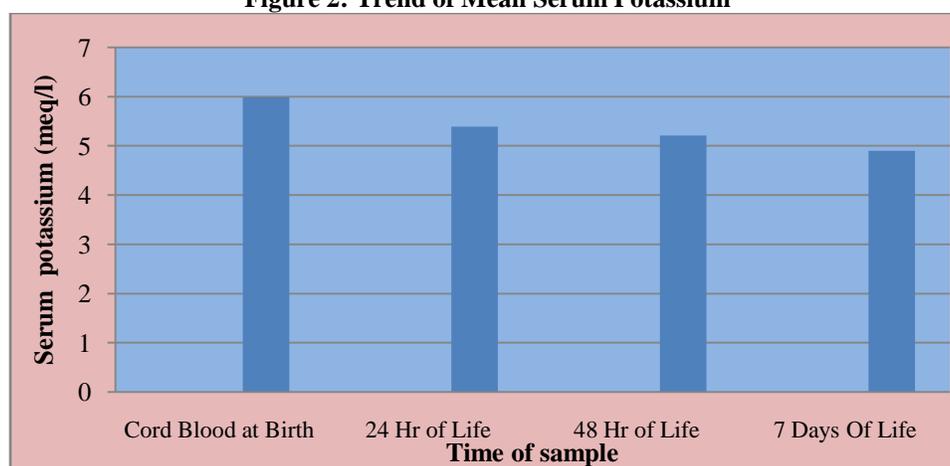
The mean, median and standard deviation of serum potassium at 48 hrs of life in this study were 5.2 meq/L, 5.2 meq/L and 0.49 meq/L respectively. The range of serum potassium at 48 hrs was 4.0-6.5 meq/L.

The mean, median and standard deviation of serum potassium at 7 days of life in this study were 4.9 meq/L, 4.9 meq/L and 0.45 meq/L respectively. The range of serum potassium at 7 days of life was 3.8-6.2 meq/L.

Table 2: Trend of Mean Serum Potassium

Time of sample	Mean Serum Potassium(meq/l)	Standard deviation(meq/l)	Range (meq/l)
Cord Blood at Birth	6.0	0.57	4.2 – 7.2
24 Hr of Life	5.4	0.49	4.0 – 6.6
48 Hr of Life	5.2	0.49	4.0 – 6.5
7 Days Of Life	4.9	0.45	3.8 – 6.2

Figure 2: Trend of Mean Serum Potassium



4. Discussion

In this study the mean \pm SD serum sodium in cord blood, at 24 hrs, 48 hrs & 7 days was 141.7 ± 4.92 meq/L, 139.6 ± 4.48 meq/L, 143.3 ± 3.95 meq/L & 138.7 ± 3.49 meq/l respectively, the corresponding figures in other studies were as follows: in study done by P. T Acharya and W. W Payne [1] the mean \pm SD serum sodium in cord blood, at 24hrs & 48hrs was 146.78 ± 8.1 meq/L, 146.42 ± 6.5 meq/L & 148.7 ± 4.3 meq/L respectively. In study of preterm infants by Jack L. Thomas & Thomas E. Reichelderfer[6] mean \pm SD serum sodium was 139.6 ± 3.2 meq/L at 7 days of life. The trend of serum sodium showed a decreasing trend with transient rise at 48 hrs to fall till 7 days to a level below cord sodium values. This trend of serum sodium observed in our study was similar to that in study by P. T Acharya and W. W Payne[1].

The range of serum sodium in cord blood, at 24 hrs, 48 hrs & 7 days in our study was 128.0-156.0 meq/L, 128.0-150.0 meq/L, 134.0-154.0 meq/L & 128.0 - 150.0 meq/L respectively whereas in study done by P. T Acharya and W. W Payne[1] the range of serum sodium in cord

blood, at 24hrs & 48 hrs was 126.0 - 166.0 meq/L, 131.0-156.0 meq/L & 139.0 - 162.0 meq/L respectively. In study done by Jack L Thomas & Thomas E. Reichelderfer[6] the range of serum sodium at 7 days of life was 133-146 meq/L. The levels of serum sodium found in our study showed a very wide range as found in study by Acharya and Payne [1] and Jack L Thomas & Thomas E. Reichelderfer[6].

In this study the mean \pm SD serum potassium in cord blood, at 24 hrs, 48 hrs & 7 days was 6.0 ± 0.57 meq/L, 5.4 ± 0.49 meq/L, 5.2 ± 0.49 meq/L & 4.9 ± 0.45 meq/l respectively, the corresponding figures in other studies were as follows: in study done by P. T Acharya and W. W Payne[1] the mean \pm SD serum potassium in cord blood, at 24hrs & 48hrs was 7.79 ± 2.0 meq/L, 6.19 ± 0.73 meq/L & 5.92 ± 0.8 meq/L respectively. In study of preterm infants by Jack L. Thomas & Thomas E. Reichelderfer[6] mean \pm SD serum potassium was 5.6 ± 0.5 meq/L at 7 days of life. The trend of serum potassium in our study showed a decreasing trend with postnatal age and it falls steadily to a level below cord potassium values. This trend of serum

potassium obtained in our study was similar to that in study

The range of serum potassium in cord blood, at 24 hrs, 48 hrs & 7 days in our study was 4.2 – 7.2 meq/L, 4.0 – 6.6 meq/L, 4.0 – 6.5 meq/L & 3.8 – 6.2 meq/L respectively whereas in study done by P. T Acharya and W.W Payne[1] the range of serum potassium in cord blood, at 24hrs & 48hrs was 5.6 – 12.0 meq/L, 5.3 – 7.7 meq/L & 5.0 – 7.7 meq/L respectively. In study done by Jack L Thomas & Thomas E. Reichelderfer[6] the range of serum potassium at 7 days of life was 4.6–6.7 meq/L. The levels of serum potassium found in our study showed a very wide range as found in study by Acharya and W.W Payne [1] and Jack L Thomas & Thomas E. Reichelderfer[6].

by P. T Acharya and W. W Payne [1].

5. Summary

The major findings of the study were following:

1. Out of the 100 healthy full term neonates, Male to female ratio in the study was 1.22:1(11:9). The mean birth weight in this study was 2808 ± 306 grams and maximum number of neonates (52%) had birth weight in the range of 2500-2999 grams.
2. The mean, standard deviation & range of serum sodium and potassium levels obtained in our study were as under:

Table 3:

Serum Electrolytes	Cord Blood at Birth	24 Hrs of Life	48 Hrs of Life	7 Days of Life
	Mean ± SD (Range)	Mean ±SD (Range)	Mean ± SD (Range)	Mean ± SD (Range)
Serum Sodium (Meq/L)	141.7 ± 4.92 (128.0 - 156.0)	139.6 ± 4.48 (128.0 – 150.0)	143.3 ± 3.95 (134.0 – 154.0)	138.7 ± 3.49 (128.0-150.0)
Serum Potassium (Meq/L)	6.0 ± 0.57 (4.2 – 7.2)	5.4 ± 0.49 (4.0 – 6.6)	5.2 ± 0.49 (4.0 – 6.5)	4.9 ± 0.45 (3.8 – 6.2)

3. The various serum sodium and potassium levels 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 that neonatal period depending upon the gestational and postnatal age.

4. The study shows that normal values serum electrolyte in neonates are different from other age groups and it varies with postnatal age and gestational age so same reference range electrolytes should not be used in all neonates instead a reference range should be used depending upon postnatal age in both term and preterm neonates.

6. Conclusions

The normal serum sodium and potassium values in healthy term neonates observed in this study showed a very wide range & seems to be abnormal, but are actually normal for that neonatal period depending upon the postnatal age. Recognizing that a serum sodium or serum potassium 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 electrolytes during the neonatal period are not simple, but change considerably with advancing gestational and postnatal age. Results of serum sodium and potassium 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, dyselectrolytemias & 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.

7. Recommendations

1. Electrolyte 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 serum sodium and potassium 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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