Original Research Article

A Study on Phototherapy Induced Electrolyte Imbalance in Hyperbilirubinemia of New Borns Admitted in NICU Of Tertiary Care Centre

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Abstract

Introduction: Nearly all newborns acquire abnormally high levels of bilirubin (i.e., total serum bilirubin (TSB) greater than 1 mg/dL [17 micro mol/L], which is the maximum limit of what is considered normal for adults). If TSB levels continue to rise, the newborn may show obvious signs of jaundice.Phototherapy is the first line of treatment for unconjugated hyperbilirubinemia in newborn infants who have been born full term or who were born late preterm.Phototherapy should be recommended only when threshold or near-threshold TSB levels are reached, and only with acceptable light sources that have been appropriately recognized. This study was conducted to estimate the serum electrolytes in term neonates before and after phototherapy. **Methodology:** 50 neonates who were either delivered intramurally or extramurally and who were referred to this location with hyperbilirubinemia that was not associated with any comorbidities and who underwent phototherapy for at least 24 hours were included in the study. **Conclusion:** The findings of this study revealed a decline in the levels of serum sodium, potassium and calcium levels in infants exposed to PT. Even though the exact mechanism for this decline could not be understood clearly, further large sample studies are needed to elucidate the same. We must not forget that these imbalances might have an adverse effect on the neonates and must remain keen eyed.Hence we strongly suggest assessment of serum calcium, sodium, potassium, chloride, bicarbonate along with routine measurement of serum bilirubin in neonates before and after phototherapy. Thus by regular monitoring and maintaining normal serum electrolyte levels we can avoid the development of complications in icteric neonates receiving phototherapy.

Keywords: Electrolytes, Phototherapy, Bilirubin, Neonates.

Introduction

Nearly all newborns acquire abnormally high levels of bilirubin (i.e., total serum bilirubin (TSB) greater than 1 mg/dL [17 micromol/L], which is the maximum limit of what is considered normal for adults). If TSB levels continue to rise, the newborn may show obvious signs of jaundice. There is an increased likelihood of bilirubin-induced neurotoxicity occurring in neonates who have severe hyperbilirubinemia, which is defined as a total serum bilirubin concentration of more than 25 mg/dL or 428 micromol/L in term or late preterm newborns with a gestational age (GA) of less than 35 weeks.[1]

The management of neonatal hyperbilirubinemia has several objectives, the primary ones being the prevention of severe hyperbilirubinemia and bilirubin-induced neurologic disorders (BIND), as well as the avoidance of unnecessary interventions, which can impede the successful initiation of breastfeeding and the parent or caregiver's ability to bond with the newborn.[1]

Phototherapy is the first line of treatment for unconjugated hyperbilirubinemia in newborn infants who have been born full term or who were born late preterm. Increasing the amount of care that is being provided to symptomatic babies who have increased total serum or plasma bilirubin (TSB) levels in conjunction with indications of acute bilirubin encephalopathy (ABE) is often required. An exchange transfusion may also be necessary. Lethargy, hypertonia or hypotonia, poor sucking, a high-pitched cry, recurrent apnea, opisthotonos, retrocollis, and seizures are some of the signs and symptoms of ABE. Even if the TSB level is not above the treatment threshold, neonates who are exhibiting symptoms nevertheless require an increased level of care. During the time that preparations are being made to undertake exchange transfusion, phototherapy should be administered.[1]

The American Academy of Pediatrics (AAP) has defined hour-specific TSB limits for beginning treatment of neonatal hyperbilirubinemia in babies who are asymptomatic. This is done in order to protect the health of the infant. The gestational age (GA) of the newborn and other risk factors for neurotoxicity are also taken into consideration when determining the thresholds for beginning phototherapy.[1]

When it comes to treating and preventing severe hyperbilirubinemia,

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phototherapy is by far the most common form of intervention. It is a safe and effective intervention to reduce total serum or plasma bilirubin (TSB) levels based upon its extensive use in millions of infants over six decades[2-5]. Regardless of the underlying cause of hyperbilirubinemia[6-8], it brings TSB levels down or at least stops their upward trend. On the other hand, since the early 2000s, there have been rising concerns that phototherapy may be overprescribed, and that its usage may unnecessarily prolong birth hospitalisation and interfere with maternal bonding and breastfeeding[9].

It is essential to be aware of the fact that the treatment criteria in the AAP guidelines for 2022 are higher than those in the guidelines that came before them. The revised guidelines make the assumption that therapy will start as soon as possible. When compared to the earlier treatment option, the likelihood of dangerously high TSB levels occurring when therapy is delayed for an extended period of time is significantly increased. To ensure an acceptable and correct dosing of phototherapy based on an individualised risk/benefit evaluation for the infant, clinical judgement is essential, just as it is for any other therapeutic intervention. This ensures that neither insufficient nor excessive amounts of phototherapy are used. Phototherapy should be recommended only when threshold or near-threshold TSB levels are reached, and only with acceptable light sources that have been appropriately recognized.[1]

Aim & Objectives

1. To estimate the serum electrolytes in term neonates before and after phototherapy.
2. To compare the occurrence of phototherapy induced electrolyte changes in term neonates before phototherapy and after phototherapy.

Material and Methods

This is a prospective hospital-based observational study that is being carried out in the department of paediatrics that is attached to Alluri Sitarama Raju Academy of Medical Sciencese in Eluru. In order to carry out this research, the institution's ethical committee has granted permission, and the parents of neonates have provided their written informed consent. Power analysis was used to decide that a sample size of 50 would be appropriate. The time span under consideration for the study was from September 2020 to September 2021.

Inclusion Criteria

- All of the neonates who were either delivered intramurally or extramurally and who were referred to this location with hyperbilirubinemia that was not associated with any comorbidities and who underwent phototherapy for at least 24 hours were included in the study.

Exclusion Criteria

- History suggestive of birth asphyxia
- Respiratory distress syndrome
- Icterus in the range requiring exchange transfusion
- History of hyperthyroidism in mother
- Diabetic mother, and
- Neonatal septicemia
- Major or life-threatening congenital malformations

At the time of admission, serum levels of sodium, potassium, chloride, and calcium were measured in all of the neonates who had been enrolled. Serum bilirubin levels were also measured at the beginning of phototherapy, as well as at intervals of 24 hours and 48 hours, or whenever phototherapy was terminated, whichever came first. Before beginning phototherapy, informed and written consent was obtained from the parents of all of the newborns that were enrolled. Blood samples from neonates who were withdrawn from the study for routine biochemical assessment were used. During the course of the phototherapy, blood samples from the newborns were drawn from their veins and submitted to be analysed for total bilirubin and electrolytes.

Excel for Microsoft Windows was used to enter the data, and the Statistical Package for Social Sciences (SPSS) was installed on a Windows computer to do the statistical analysis. In order to investigate the distribution of a number of categorical and quantitative variables, a descriptive statistical analysis was carried out. In order to summarise categorical data, we used n (percent), while quantitative variables were summarised using mean standard deviation. All of the findings were laid out in tabular format and are also depicted graphically using either a bar diagram or a pie diagram, depending on the circumstance. It was determined whether or whether there was a statistically significant difference between the two groups by employing parametric tests, such as the t-test. P-value less than 0.05 is considered to be statistically significant.

Results & Observations

- Mean age was 3.34 +/- 1.13 days and Males were 58% and females were 42%. Mean weight was 2.83 +/- 0.41 kg and mean length was 51.88 +/- 0.88 cm.
- Before phototherapy, the total bilirubin was 13.92 ± 0.85 mg/dl and Post phototherapy, total bilirubin was 8.00 ± 0.35 mg/dl (p=0.001).
- Before phototherapy, the Sr. Calcium was 9.47 ± 0.25 mg/dl and Post phototherapy, Sr. Calcium was 8.13 ± 0.47 mg/dl (p=0.001).
- Before phototherapy, the Sr. Potassium was 3.97 ± 0.44 mEq/L and Post phototherapy, Sr. Potassium was 3.96 ± 0.42 mEq/L (p=0.81).
- Before phototherapy, the Sr. Chloride was 99.84 ± 2.73 mEq/L and Post phototherapy, Sr. Chloride was 99.89 ± 2.65 mEq/L (p=0.45).
- Before phototherapy, the Sr. Sodium was 140.51 ± 3.00 mEq/L and Post phototherapy, Sr. Sodium was 136.02 ± 5.86 mEq/L (p=0.001).

Table 1: Mean T. Bilirubin levels before and after phototherapy among males and females

		Before phototherapy		After phototherapy		T Test	P Value
		Mean	SD	Mean	SD		
Male	T. Bilirubin	13.90	0.98	8.01	0.38	34.60	0.001
Female	T. Bilirubin	13.95	0.63	8.00	0.33	50.42	0.001

Table 2: Serum electrolytes before and after phototherapy among males and females

		Before phototherapy		After phototherapy		T Test	P Value
		Mean	SD	Mean	SD		
Male	**Sr. Calcium**	9.48	0.28	8.19	0.51	10.22	0.001
	Sr. Potassium	3.96	0.39	3.95	0.41	0.29	0.77
	Sr. Chloride	100.75	2.29	100.65	2.34	0.99	0.33
	Sr. Sodium	140.43	3.17	137.15	5.97	4.01	0.001
Female	**Sr. Calcium**	9.45	0.21	8.06	0.41	16.40	0.001
	Sr. Potassium	3.98	0.51	3.98	0.45	0.001	1.00
	Sr. Chloride	98.59	2.84	98.85	2.76	-4.70	0.001
	Sr. Sodium	140.61	2.82	134.46	5.47	4.54	0.001

Discussion

Phototherapy has a significant function in the prevention as well as in managing hyperbilirubinemia. Side effects of phototherapy are insensible water loss, watery diarrhea, hypocalcemia, bronze baby syndrome, hyperthermia, tanning of the skin, intolerance to feed, retinal damage, genotoxicity, erythema, and increased blood flow to the skin.[10]

In this study, mean age was 3.34 days. In Purohit A et al.,[15]majority of cases were of 3-4 days (55%) followed by 1-2 days (27.8%), 15% cases were of 5-6 days and 1.1% cases were more than 6 days.

In this study, males were 58% and females were 42%. In Thirunavukkarasu V et al.,[10] 52% were males and 48% were female babies. In Purohit A et al.,[15]46.6% cases were males and 53.3% were female.

In this study, Before phototherapy, the total bilirubin was 13.92 ± 0.85 mg/dl and Post phototherapy, total bilirubin was 8.00 ± 0.35 mg/dl (p=0.001). In Thirunavukkarasu V et al.,[10]Before phototherapy, the total bilirubin was 15.27 ± 2.51 mg/dl; indirect bilirubin was 12.61 ± 2.98 mg/dl. Post phototherapy, total bilirubin was 9.02 ± 1.28 mg/dl and indirect bilirubin was 7.14 ± 2.12 mg/dl. The difference between direct bilirubin and indirect bilirubin was statistically significant (P < 0.0001), respectively. In Purohit A et al.,[15]there was significant decrease in total and direct bilirubin at the time of admission and after 24-hour phototherapy. Here, means total bilirubin at the time admission was 17.67±3.05 and after phototherapy there were significant decrease in bilirubin 12.08±2.59. In Singh N et al.,[21]Mean value of serum bilirubin (direct) was 0.533 mg/dl before the start of phototherapy. Decrease in mean value of serum bilirubin (direct) was statistically significant with p-value 0.037 when given phototherapy up to 48 hr and 0.044 when given phototherapy from 48-96 hr. In Ghosh UK et al.,[22]Thirty seven (68.5%) had serum total bilirubin level(10.01-15 mg/dl), 12 (22.2%) had serum total bilirubin level(5-10 mg/dl) and only 5 (9.3%) babies had serum total bilirubin level (15.01-20 mg/dl) after phototherapy in this study group. The serum total bilirubin level after phototherapy ranged within 7 to 20 mg/dl and the mean serum total bilirubin levelafter phototherapy was 11.33 ± 2.27 SD.

In this study, Before phototherapy, the Sr. Sodium was 140.51 ± 3.00 mEq/L and Post phototherapy, Sr. Sodium was 136.02 ± 5.86 mEq/L (p=0.001). In Thirunavukkarasu V et al.,[10]Before phototherapy, serum sodium was 144.12 ± 3.24 mEq/L. Post-phototherapy, serum sodium was 135.24 ± 4.21mEq/L. The difference between serum sodium was statistically significant (P < 0.0001). In Ghosh UK et al.,[22] Thirty one (57.4%) had hyponatremia (130-134 mmol/L), 17 (31.5%) had normal serum sodium level(135-145mmol/L) and only 6 (11.1%) had hypernatremia (146-153 mmol/L) after phototherapy in this study population. The serum sodium level after phototherapy ranged from 130 to 153 mmol/L and the mean serum sodium level after phototherapy was 137.04 ± 6.48 SD. In Sharma S et al.,[23] Before PT, the mean serum sodium was 141.3±2.69 mmol/L and after PT, the mean serum sodium was 140.5 ± 2.70 mmol/L. Serum sodium level was found to decreased significantly after PT (p=0.0001). Beresford and Conolly stated that babies under phototherapy could have sodium imbalances due to insufficient fluid replacements.[11]

In this study, Before phototherapy, the Sr. Potassium was 3.97 ± 0.44 mEq/L and Post phototherapy, Sr. Potassium was 3.96 ± 0.42 mEq/L (p=0.81). In Thirunavukkarasu V et al.,[10]Before phototherapy, serum potassium was 4.61 ± 0.91 mEq/L. Post-phototherapy, serum potassium was 4.11 ± 0.41 mEq/L. The differencebetween serum potassium was statistically significant (P < 0.0001). In Ghosh UK et al.,[22]majority 29 (53.7%) had normal serum potassium level(3.5-5.5 mmol/L), 22 (40.7%) had hypokalemia(3.2-3.4mmol/L) and 3 (5.6%) had hyperkalemia (5.6-6.0 mmol/ L) after phototherapy. The serum potassium levelafter phototherapy ranged from 3.2 to 6.0 mmol/L and the mean serum potassium levelafter phototherapy was 3.67 ± 0.57 SD. In Sharma S et al.,[23]mean serum potassium was 4.43 ± 0.52 mEq/L before PT and was 4.23 ± 0.48 mEq/L after PT. The decline in serum potassium level was found to be statistically significant after PT (p=0.0001). Tan and Jacob, a study in healthy full-term neonates, demonstrated a transient raise in potassium levels after phototherapy, which was in contrast to the present study. [13]

In this study, Before phototherapy, the Sr. Calcium was 9.47 ± 0.25 mg/dl and Post phototherapy, Sr. Calcium was 8.13 ± 0.47 mg/dl (p=0.001). In Purohit A et al.,[15] Out of these 32% babies had a 5-9% reduction and 20% babies had >10% reduction in serum calcium value. This reduction in serum calcium level was found to be statistically significant (p value - <0.001). Even though 67% babies had a reduction in calcium value only 3% babies developed hypocalcemia after phototherapy.In Sharma S et al.,[23] serum calcium level before PT was 9.14 ± 0.46 mg/dL and was 8.09 ± 0.55 mg/dL after PT with p-value=0.0001.Rozario et al, found that after phototherapy about 67% babies had a decrease in serum calcium level from the initial value.[18]Tahari et al, reported that out of 147 term babies about 56% babies had a reduction in serum calcium level after phototherapy and 7% newborns developed hypocalcemia after 48 hours of phototherapy.[19] In study by Reddy et al, also found that the frequency of hypocalcemia following phototherapy was more inpreterm neonates (41.2%) than in term neonates (6.2%).[20] In Singh N et al.,[21]Mean value of serum calcium (ionized) before start of phototherapy was 4.41 of serum calcium (ionized) was 4.13±0.26 mg/dl when phototherapy was given up to 48 hr and further decreased to 3.71±0.18mg/dl when phototherapy was given from 48-96 hr with statistically significant p-value 0.001. Out of 100 neonates, 27(27%) neonates developed hypocalcemia after phototherapy. 16 neonates developed hypocalcemia when phototherapy was given up to 48 hr and 11 neonates developed hypocalcemia when phototherapy was given from 48-96 hr.PT inhibits melatonin production by the pineal gland. As a result, corticosterone's impact on bone calcium is reduced. Because melatonin levels drop during PT, the level of corticosterone in the blood also drops. As a result, reduced corticosterone reduces bone resorption, resulting in hypocalcemia. Hypocalcemia was produced by a decrease in parathormone production in jaundiced newborns treated with PT[23]

In this study, Before phototherapy, the Sr. Chloride was 99.84 ± 2.73 mEq/L and Post phototherapy, Sr. Chloride was 99.89 ± 2.65 mEq/L (p=0.45). In Ghosh UK et al.,[22]majority 36 (66.7%) had hypochloremia (90 -95 mmol/L), 12 (22.2%) had normal serum chloride level(96-106 mmol/L) and only 6 (11.1%) had hyperchloremia (107-110mmol/L) after phototherapy. The serum chloride level ranged from 90 to 110 mmol/L and the mean serum chloride level after phototherapy was 97.36 ± 5.33 SD. In Sharma S et al.,[23] mean serum chloride was 102.2 ± 2.98 mEq/L and after PT, the mean serum chloride was 102.0 ± 2.93 mEq/L. Serum chloride level was found to decreased significantly after PT (p=0.0219).

The differential effect of other electrolytes with phototherapy has not been studied by other workers except that for Curtis et al. study which stated that absorption of water, sodium chloride, and potassium was significantly impaired in the patients receiving phototherapy. [12] Reddy et al., the study showed that sodium changes are significant, potassium and chloride changes were insignificant, which is in contrast to the present study where both sodium and potassium changes are significant. [14]

In Purohit A et al.,[15]the mean sodium, potassium and calcium level before therapy was 146.6±6.2, 4.7±0.47, and 9.4±0.73 respectively. After phototherapy the mean sodium, potassium and calcium level was 141.3±6.1, 4.2±0.51 and 8.4±0.68 respectively. There was significant difference in calcium and sodium level before and after phototherapy with p-value= 0.011 and 0.003 respectively.Bezboruah and Majumder found following phototherapy the mean values of all the electrolytes were significantly decreased.[16]Rangaswamy et al, found that there was significant decline in serum sodium and potassium along with total bilirubin following 48 hours of phototherapy.[17]

Conclusion

The findings of this study revealed a decline in the levels of serum sodium, potassium and calcium levels in infants exposed to PT. Even though the exact mechanism for this decline could not be understood clearly, further large sample studies are needed to elucidate the same.

We must not forget that these imbalances might have an adverse effect on the neonates and must remain keen eyed.Hence we strongly suggest assessment of serum calcium, sodium, potassium, chloride, bicarbonate along with routine measurement of serum bilirubin in neonates before and after phototherapy. Thus by regular monitoring and maintaining normal serum electrolyte levels we can avoid the development of complications in icteric neonates receiving phototherapy.

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