ORIGINAL ARTICLE

Electrolyte changes in neonates before and after phototherapy

Kavita Yadav, Vedika A. Bhat, Alka Bhambri

Department of Paediatrics, Rohilkhand Medical College, Bareilly, Uttar Pradesh, India

Corresponding Author:
Dr. Alka Bhambri,
Department of Paediatrics,
Rohilkhand Medical College,
Bareilly, Uttar Pradesh, India.
Mobile: +91-9412463227.
E-mail: bhambri.alka@gmail.com

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Background: Neonatal hyperbilirubinemia is one of the most common cause of hospital admission in neonatal intensive care unit and phototherapy remains the mainstay for treatment of neonatal hyperbilirubinemia. The present study aims to evaluate the electrolytes changes in term and preterm neonates undergoing phototherapy. **Materials and Methods:** In present study, a total of 45 neonates were involved. S. Sodium, S. Potassium, S. Calcium, S. Magnesium, S. Phosphorus levels were sent before starting of phototherapy. Phototherapy was given to neonates and when the serum bilirubin levels came 2–3 mg/dl below age specific levels on the normogram, above blood parameters were sent again. **Results:** Our study revealed that there was a significant ($P < 0.05$) decline in serum electrolyte levels after phototherapy. However, all the neonates remained asymptomatic and did not require any intervention. Furthermore, electrolyte changes were seen more in preterm neonates as compared to term neonates. **Summary:** There is significant change in electrolytes in neonates receiving phototherapy. Low birth weight and preterm neonates are at higher risk of developing electrolyte imbalances and they require close monitoring.

KEY WORDS: Electrolytes, neonatal hyperbilirubinmeia, neonates

INTRODUCTION

Neonatal hyperbilirubinemia is a common physical finding in 1st week of life.[1] It is a common cause of concern to parents and the most common cause of hospital readmission during neonatal period.[1] The clinical symptoms of jaundice is yellowish discoloration of skin due to deposition of unconjugated bilirubin. Clinically jaundice appears in the neonates when bilirubin level goes >7 mg/dl.[2] 60% term and 80% preterm neonates develop jaundice during the 1st week of life, among them only 6.1% of term neonates are found to have a S. Bilirubin >12.9 mg/dL and 3% have a S. Bilirubin >15 mg/dl.[3]

Neonatal hyperbilirubenemia is treated by phototherapy, exchange transfusion or pharmacological agents. Among these three, phototherapy is the mainstay of treatment of neonatal hyperbilirubinemia and it also decreases the incidence of exchange transfusion and bilirubin encephalopathy. Phototherapy has been effectively used as comparatively noninvasive and inexpensive method for treatment of neonatal hyperbilirubinemia. Today exchange transfusions are very rare and are used only as a rescue therapy to avoid kernicterus in newborns with severe hyperbilirubinemia when phototherapy is not effective. As any treatment has its adverse effects, phototherapy also has some side effects but they are not harmful or severe. The main side effects are hyperthermia, feed intolerance, loose stools, skin rashes, bronze baby syndrome, retinal changes, dehydration, hypocalcemia, redistribution of blood flow, genotoxicity and electrolyte imbalances.[2]

Very few studies are currently available that describes adverse effects of phototherapy on electrolytes. Most of the studies showed that phototherapy causes hypocalcemia, which is more in preterm (90%) than term (75%).[4]

It is known that phototherapy converts bilirubin into water soluble isomers that are easily eliminated through the gastrointestinal tract or lost in urine.[5] This is because bilirubin absorbs light most strongly in blue region of spectrum near 460 nm wavelength. Gallidium nitride light emitting diodes,

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which delivers high intensity light of narrow wavelength spectrum, have been developed and are increasingly being used to treat neonatal jaundice.[5]

The aim of phototherapy is to avoid increase in previously increased total serum bilirubin levels, to thwart progression to encephalopathy or kernicterus and to stop the total bilirubin from getting higher to a level that would require exchange transfusion. Since there are only few studies elaborating on the effect of phototherapy on serum electrolytes published till now, more studies are required to reach a conclusion about these effects on the high–risk neonates.

MATERIALS AND METHODS

A prospective hospital-based observational comparative study was conducted on 45 eligible neonates, who were admitted in neonatal intensive care unit (NICU), Rohilkhand Medical College from November 1, 2019 to October 31, 2020. Informed signed consent was taken from parents and the study was approved by Ethical Committee. Our study included both preterm and term neonates who had unconjugated hyperbilirubinemia and required phototherapy.

The eligible neonates were put under double surface phototherapy with a wavelength of 425–475 nm with a distance of 25–30 cm from skin. Before starting of phototherapy venous samples were sent for serum electrolytes ($Na+$, $K+$, $Ca2+$, $Mg2+$, $PO4-$). Repeat blood samples were sent for serum electrolytes at 12 h of phototherapy. Based on response to phototherapy, samples were taken 12 hourly till serum bilirubin level come 2–3 mg/dl below the age-specific levels on the normogram. $Na+$ and $K+$ were determined by Easylite Analyzer. $Mg2+$ was determined by Calmagite method using ERBA CHEM V semi autoanalyzer. Phosphorus was determined using ultraviolet Molybydate method, using ERBA 360 auto analyzer. Calcium was determined using Arsenzo method, using ERBA 360 auto analyzer. Comparative study was done between the before phototherapy and after phototherapy samples. The data were analyzed with Statistical Package for Social Sciences Version23.0. Co-relation between various parameters was done using Pearson coefficient, $P < 0.05$ was considered significant.

Table 1: Gender distribution of neonates

Gender	Number	Percentage
Male	25	55.60
Female	20	44.40
Total	45	100

Table 2: Birth weight (in kg) distribution of neonates

Birth weight (in kg)	Number	Percentage
LBW (<2.5 kg)	17	37.8
Normal (2.5–4.0 kg)	28	62.2
Total	45	100

LBW: Low birth weight

Table 3: Gestational age (in weeks) distribution of neonates

Gestation age (in weeks)	Number	Percentage
<37 weeks	16	35.6
37–42 weeks	29	64.4
Total	45	100

RESULTS

In our study, out of 45 neonates, 25 (55.60%) were male and 20 (44.40%) were female [Table 1].

Out of 45 neonates, 17 (37.8%) were low-birth-weight and 28 (62.2%) had normal birth weight [Table 2]. Mean birth weight of neonates was 2.66 ± 0.53 kg.

Out of 45 neonates, 16 (35.6%) were preterm neonates (<37 weeks) and 29 (64.4%) were term neonates (37–42 weeks). Mean Gestation Age (in weeks) of neonates was 36.73 ± 2.50 weeks [Table 3].

It shows that electrolyte changes were seen more in low birth weight as copared to normal birth weight.

It shows that electrolyte changes were seen more in preterm neonates as compared to term neonates [Table 4].

In this study, we found that 6 (13.3%) neonates, out of total 45 neonates developed hyponatremia after phototherapy. This difference was statistically significant with $P < 0.001$ [Table 4].

In our study, we found that 7 (15.4%) newborns, out of 45 newborns developed hypocalcaemia after phototherapy which was found to be statistically significant difference with $P < 0.001$ [Table 4].

In our study, only 3 (6.7%) neonates, out of 45 neonates developed hypokalemia after phototherapy which was statistically significant with $P < 0.001$ [Table 4].

DISCUSSION

This study was a hospital based prospective study of neonates admitted in NICU with neonatal hyperbilirubinemia. The study was aimed at evaluating the electrolyte changes in preterm and term neonates undergoing phototherapy. In our study, we estimated serum electrolytes of 45 neonates, who had neonatal hyperbilirubinemia and were receiving phototherapy. We compared the electrolyte changes before and after phototherapy and co- related the electrolyte changes with gestational age and birth weight. The study was conducted for a period of 1 year.

The study was initiated after clearance from the Institutional Ethical Committee and a written consent was taken from

Table 4: Comparison of mean value of different study variables before and after phototherapy with birth weight

LBW (<2.5 kg)	Before phototherapy Mean±SD	After phototherapy Mean±SD	Mean difference	*P*-value
S. Sodium	138.52±1.46	135.13±1.68	2.390	<0.001*
S. Potassium	4.64±0.28	4.32±0.38	0.320	<0.001*
S. Calcium	8.14±0.22	7.18±0.32	0.960	<0.001*
S. Magnesium	2.08±0.10	1.96±0.11	0.180	<0.001*
S. Phosphorus	3.68±0.12	3.30±0.10	0.380	<0.001*
Normal Birth weight (>2.5 kg)				
S. Sodium	140.94±1.52	140.19±1.84	0.750	<0.001*
S. Potassium	4.97±0.32	4.49±0.48	0.480	<0.001*
S. Calcium	9.01±0.39	8.46±0.62	0.680	<0.001*
S. Magnesium	2.23±0.13	2.01±0.14	0.220	<0.001*
S. Phosphorus	3.92±0.15	3.68±0.16	0.240	<0.001*

LBW: Low birth weight

Table 5: Frequency table showing comparison of S. Sodium before and after phototherapy

S. Sodium before phototherapy	S. Sodium after phototherapy			Total (%)
	<135 mmol/d (%)	135–145 mmol/dl (%)	>145 mmol/dl (%)	
135–145 mmol/dl	6 (100)	30 (88.2)	3 (60)	39 (86.7)
>145 mmol/dl	0 (0)	4 (11.8)	2 (40)	6 (13.3)
Total	6 (13.3)	34 (75.6)	5 (11.1)	45 (100)

Table 6: Co-relation of post phototherapy serum electrolytes with birth weight

S. Sodium	LBW (<2.5 kg) *n*=17 *n* (%)	Normal Birth weight (≥2.5 kg) *n*=28 *n* (%)	Total	*P*-value
<135	3 (17.6)	3 (10.7)	6 (13.3)	0.048*
135–145	13 (76.5)	21 (75)	34 (75.6)	
>145	1 (5.9)	4 (14.3)	5 (11.1)	
S. Potassium				
<3.5	2 (11.8)	1 (3.6)	3 (6.7)	0.006*
3.5–5.5	14 (82.4)	22 (78.6)	36 (80)	
>5.5	1 (5.9)	5 (17.9)	6 (13.3)	
S. Calcium				
<6	1 (5.9)	0 (0)	1 (2.2)	0.001*
6–6.9	4 (23.5)	2 (7.1)	6 (13.3)	
7–7.9	5 (29.4)	8 (28.6)	13 (28.9)	
8–8.9	5 (29.4)	11 (39.3)	16 (35.6)	
>9	2 (11.8)	7 (25.0)	9 (20.0)	
S. Magnesium				
<1.6	1 (5.9)	1 (3.6)	2 (4.4)	0.516[#]
>1.6	16 (94.1)	27 (96.4)	43 (95.6)	
S. Phosphorus				
<2.5	0 (0)	0 (0)	0 (0)	1.000[#]
2.5–4.5	17 (100)	28 (100)	45 (100)	

LBW: Low birth weight

Table 7: Co-relation of post phototherapy serum electrolytes with gestational age (in weeks)

Electrolytes	Gestational age (in weeks)			*P*-value
	<37 weeks *n*=16 *n* (%)	37-42 weeks *n*=29 *n* (%)	Total	
S. Sodium				
<135	3 (18.8)	3 (10.3)	6 (13.3)	0.049*
135–145	12 (75.0)	22 (75.9)	34 (75.6)	
>145	1 (6.2)	4 (13.8)	5 (11.1)	
S. Potassium				
<3.5	2 (12.5)	1 (3.4)	3 (6.7)	0.003*
3.5–5.5	13 (81.3)	23 (79.3)	36 (80.0)	
>5.5	1 (6.3)	5 (17.2)	6 (13.3)	
S. Calcium				
<6	1 (6.3)	0 (0)	1 (2.2)	0.011*
6–6.9	3 (18.8)	3 (10.3)	6 (13.3)	
7–7.9	5 (31.3)	8 (27.6)	13 (28.9)	
8–8.9	4 (25.0)	12 (41.4)	16 (35.6)	
>9	3 (18.8)	6 (20.7)	9 (20.0)	
S. Magnesium				
<1.6	1 (6.3)	1 (3.4)	2 (4.4)	0.306[#]
>1.6	15 (93.8)	28 (96.6)	43 (95.6)	
S. Phosphorus				
<2.5	0 (0)	0 (0)	0 (0)	1.000[#]
2.5–4.5	16 (100)	29 (100)	45 (100)	

Table 8: Frequency table showing comparison of S. Calcium before and after phototherapy

S. Calcium before phototherapy	S. Calcium after phototherapy					Total (%)
	<6 mg/dl (%)	6–6.9 mg/dl (%)	7–7.9 mg/dl (%)	8–8.9 mg/dl (%)	>9 mg/dl (%)	
7–7.9 mg/dl	1 (100)	5 (83.3)	1 (7.7)	0 (0)	0 (0)	7 (15.6)
8–8.9 mg/dl	0 (0)	1 (16.7)	9 (69.2)	6 (37.5)	1 (11.1)	17 (37.8)
>9 mg/dl	0 (0)	0 (0)	3 (23.1)	10 (62.5)	8 (88.9)	21 (46.7)
Total	1 (2.2)	6 (13.2)	13 (28.9)	16 (35.6)	9 (20.0)	45 (100)

Table 9: Frequency table showing comparison of S. Potassium before and after phototherapy

S. Potassium before phototherapy	S. Potassium after phototherapy			Total
	<3.5 mmol/dl	3.5–5.5 mmol/dl	>5.5 mmol/dl	
3.5–5.5 mmol/dl	2 (66.7)	32 (88.9)	5 (83.3)	39 (86.7)
>5.5 mmol/dl	1 (33.3)	4 (11.1)	1 (16.7)	6 (13.3)
Total	3 (6.7)	36 (80.0)	6 (13.3)	45 (100)

parents/guardian after explaining the procedure of the study in detail.

There are very less studies which aim at understanding the electrolyte changes in neonates undergoing phototherapy, especially on serum sodium, calcium, magnesium, potassium and phosphorus levels and comparing the effect of phototherapy on electrolytes in preterm and term. Through this study, we endeavored to look into electrolyte imbalances in neonates receiving phototherapy.

In our study, we studied 45 neonates, out of which 25 (55.60%) were males and 20 (40.40%) were females. In this study, out of 45 neonates, 17 (37.8%) neonates had low-birth-weight and 28 (62.2%) neonates had normal birth weight. The mean birth weight of neonates was 2.66 ± 0.53 kg.

In our study we included 16 (35.6%) preterm neonates and 29 (64.4%) term neonates. Karamifar *et al.*[6] and Sethi *et al.*[7] selected preterms whereas Taheri *et al.*[5] and Eghbalian *et al.*[8] included only term neonates in their study. In our study, there was decline in serum sodium levels after phototherapy which was statistically significant i.e., $P < 0.001$. The mean serum sodium before and after phototherapy was 139.94 ± 1.55 and 138.69 ± 1.96, which was similar to Reddy *et al.*[4] (139.02 ± 3.12 and 138.16 ± 3.36), Kumar *et al.*[9] (139.01 ± 3.119 and 138.15 ± 3.35) and Gayatri *et al.*[1] (141.97 ± 2.795 and 140.66 ± 4.751).

In our study, we found out that out of 45 neonates, 6 (13.3%) neonates developed hyponatremia after phototherapy [Table 5]. Although the neonates remained asymptomatic and no intervention was required for hyponatremia. In our study, we found that mean sodium levels before and after phototherapy in low-birth-weight neonate were 138.52 ± 1.46 and 135.13 ± 1.68 respectively and this difference was significant with a $P < 0.001$.

Our study found that incidence of hyponatremia in neonates undergoing phototherapy was high in low-birth-weight neonate (17.6%) as compared to normal weight neonates (10.7%) [Table 6]. These results are similar to those of Reddy *et al.* (17.2% low-birth-weight and 2.6% normal birth weight), Kumar *et al.* (17.2% low-birth-weight and 2.6% normal birth weight neonates) and Gayatri *et al.* (18.75% low-birth-weight and 10.32% normal birth weight).

This implies that low-birth-weight neonates are at a higher risk of developing hyponatremia as compared to normal birth weight neonates and continuous monitoring of sodium levels is required. Furthermore, we found that 18.8% preterm neonates developed hyponatremia after phototherapy as compared to term neonates (10.3%) [Table 7]. This is similar to other studies i.e., Reddy *et al.* (17.6% preterm and 3.1% term neonates developed hyponatremia), Kumar *et al.* (17.5% preterm and 3.1% term neonates developed hyponatremia post phototherapy), Gayatri *et al.* (18.3% preterm and 11.02% term neonates).

Hence, with above results and with concordance with other studies, it is implied that preterm neonates are at a higher risk of developing hyponatremia, who are undergoing phototherapy as compared to term neonates undergoing phototherapy. Although neonates developed hyponatremia following phototherapy, but none of the neonates developed any clinical symptoms and remained asymptomatic.

In our study, we found that following phototherapy, there was significant decline in the mean serum calcium levels which was statistically significant ($P < 0.001$). The mean S. calcium levels before phototherapy was 8.98 ± 0.37 and after phototherapy was 8.25 ± 0.64. In our study, we co-related hypocalcemia following phototherapy with gestational age and found that preterm neonates are at higher risk of developing hypocalcemia as compared to term neonates. 18.8% of preterm neonates developed hypocalcemia as compared to 10.3% of term neonates [Table 7]. These results were similar to studies conducted by Karamifar *et al.* (22.6% preterm and 8.7% term neonates), Reddy *et al.* (41.2% preterm and 6.2% term neonates), Gayatri *et al.* (25.34% preterm and 10.24% term neonates) but differed from Arora *et al.*,[3] where hypocalcemia was seen more in term neonates in comparison to preterm neonates.

In our study, co-relation of hypocalcemia following phototherapy was done with birth weight and it was found that low-birth-weight neonates (31.3%) are at a higher risk of developing hypocalcemia as compared to normal birth weight neonates

(27.6%). This was similar to studies conducted by Reddy *et al.* (36.2% in low-birth-weight and 6.2% in normal birth weight) and Gayatri *et al.* (26.25% in low-birth-weight and 7.94% in normal birth weight).

The neonates who developed hypocalcemia following phototherapy did not show any features clinically and remained asymptomatic [Table 8]. In our study, we found that following phototherapy there was significant decline in serum potassium levels which was statistically significant with $P < 0.001$. The mean serum potassium levels before phototherapy were 4.81 ± 0.34 and after phototherapy were 4.20 ± 0.43.

This was similar to study by Suneja *et al.*,[10] where mean potassium levels before phototherapy were 6.095 ± 1.4 and after phototherapy were 5.28 ± 1.08 and Gayatri *et al.* where mean potassium levels before phototherapy were 5.01 ± 0.683 and after phototherapy were 4.63 ± 0.666. In Reddy *et al.*, there was no decline in serum potassium levels, before and after phototherapy and our results were not in consonance with their study. Hence, actual relationship between serum potassium with phototherapy needs to be evaluated further with large sample size.

In our study, total of 3 (6.7%) neonates developed hypokalemia, out of which 2 (12.5%) were preterm and 1 (3.4%) was term neonate [Table 9]. Study by Reddy *et al.* is in consonance with our study where only 0.4% neonates developed hypokalemia following phototherapy. In our study, we found that there was a significant decline in mean serum magnesium and phosphorus levels, but there was no co-relation of decline of these electrolytes with gestational age and birth weight.

CONCLUSION

In our study, there was statistically significant decline in mean serum electrolyte after phototherapy. The incidence of hypocalcemia following phototherapy was 15.4% and it was higher in preterm (25.1%) and low-birth-weight neonates (29.4%) as compared to term (10.3%) and normal birth weight neonates (7.1%).

The incidence of hyponatremia after phototherapy was 13.3% and it was higher in preterm (18.8%) and low-birth-weight neonates (17.6%) as compared to term neonates (10.3%) and normal birth neonates (10.7%). The incidence of hypokalemia following phototherapy was 6.7% and it was higher in preterm neonates (12.5%) and low birth neonates (11.8%) as compared to term neonates (3.4%) and normal birth weight neonates (3.6%).

It was also observed that, in most of the neonates, following phototherapy there was significant decrease in serum sodium, potassium and calcium levels, but all the neonates remained asymptomatic and no intervention was required. Hence, all neonates require continuous monitoring while undergoing phototherapy and further studies are required to know about the effect of phototherapy.

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