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A STUDY ON PHOTOTHERAPY INDUCED ELECTROLYTE CHANGES IN TERM NEONATES

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ABSTRACT

Background: Neonatal hyperbilirubinemia is a common condition requiring phototherapy, which, although effective, may lead to electrolyte disturbances.
Objectives: To evaluate changes in serum electrolytes in term neonates undergoing phototherapy and to assess factors influencing these changes.
Methods: This prospective observational study with a control group was conducted in a tertiary care hospital in Bikaner, Rajasthan. A total of 300 term neonates with hyperbilirubinemia were included, comprising 150 neonates receiving phototherapy (study group) and 150 neonates not requiring phototherapy (control group). Serum electrolytes (sodium, potassium, calcium, and magnesium) were measured at admission and after 48 hours. Data were analyzed using appropriate statistical tests, with p<0.05 considered significant.
Results: Both groups were comparable in baseline characteristics. Serum bilirubin levels decreased significantly after phototherapy (p<0.001). A significant reduction in serum sodium, potassium, calcium, and magnesium levels was observed in the study group compared to controls (p<0.001). Hypocalcemia was the most common electrolyte abnormality (31.33%), followed by hyponatremia (16.66%), hypomagnesemia (14%), and hypokalemia (3.33%). The incidence of electrolyte disturbances increased significantly with the duration of phototherapy (p<0.001). Most neonates remained asymptomatic; however, hypocalcemia was the most frequent symptomatic abnormality.
Conclusion: Phototherapy is associated with significant electrolyte disturbances in term neonates, particularly hypocalcemia. Routine monitoring of electrolytes, especially during prolonged phototherapy, is recommended to prevent complications.

***Keywords**: Neonatal hyperbilirubinemia; Phototherapy; Hypocalcemia; Electrolyte imbalance; Term neonates; Hyponatremia; Neonatal care.*

INTRODUCTION

Neonatal hyperbilirubinemia is one of the most common clinical conditions encountered during the early neonatal period, affecting a significant proportion of newborns worldwide. It is estimated that nearly 60% of term and up to 80% of preterm neonates develop clinical jaundice within the first week of life [1]. In most cases, this represents a physiological process due to the immaturity of hepatic conjugation mechanisms and increased red blood cell turnover. However, elevated levels of unconjugated bilirubin can pose serious risks, including bilirubin-induced neurologic dysfunction (BIND), acute bilirubin encephalopathy, and kernicterus, which may result in permanent neurodevelopmental impairment if not managed promptly [2].

Phototherapy remains the cornerstone of treatment for neonatal hyperbilirubinemia and is widely regarded as a safe, effective, and non-invasive intervention. It acts by converting bilirubin into water-soluble isomers through photo-oxidation and structural isomerization, allowing excretion without the need for hepatic conjugation [3]. The widespread availability and efficacy of phototherapy have significantly reduced the need for exchange transfusion and its associated complications. Nevertheless, like any therapeutic modality, phototherapy is not without adverse effects.

Several side effects of phototherapy have been documented, including hyperthermia, dehydration, skin rash, loose stools, retinal damage, and the rare “bronze baby syndrome.” More recently, attention has been drawn to its potential impact on serum electrolyte balance, particularly calcium, sodium, potassium, and magnesium levels [4]. These electrolyte disturbances, though often subclinical, may have important clinical implications, especially in vulnerable neonatal populations.

Among these, hypocalcemia has been most extensively studied. The proposed mechanism involves transcranial illumination suppressing melatonin secretion from the pineal gland, which in turn affects calcium homeostasis by increasing cortisol activity and enhancing calcium uptake into bone [5]. Various studies have reported a wide prevalence of phototherapy-induced hypocalcemia, ranging from 18.8% to 60.3% in neonates undergoing treatment [1]. Clinically significant hypocalcemia may manifest as jitteriness, irritability, apnea, seizures, or cardiac abnormalities such as prolonged QT interval, emphasizing the need for careful monitoring.

Hyponatremia is another electrolyte imbalance observed in neonates receiving phototherapy, with a reported prevalence of approximately 17.4% [1]. This may be attributed to increased insensible water loss, altered fluid balance, and changes in renal handling of sodium. Although less frequently discussed, alterations in potassium and magnesium levels have also been reported, which can influence neuromuscular and cardiovascular function [6].

Despite the growing body of literature, there remains variability in the reported incidence and severity of electrolyte disturbances associated with phototherapy. Differences in study populations, duration and intensity of phototherapy, and baseline neonatal characteristics contribute to these inconsistencies. Furthermore, many studies have included both term and preterm neonates, making it difficult to draw conclusions specific to term infants, who may have different physiological responses.

In addition, there is a relative paucity of data from developing countries, including India, where the burden of neonatal jaundice is high and healthcare resources may be limited. Understanding the extent and pattern of electrolyte changes in this setting is crucial for optimizing neonatal care and preventing potential complications. Early identification and timely correction of these imbalances can improve clinical outcomes and reduce morbidity.

Therefore, the present study was undertaken to evaluate the changes in serum electrolytes—namely sodium, potassium, calcium, and magnesium—in term neonates undergoing phototherapy for unconjugated hyperbilirubinemia. The study also aims to identify factors influencing these changes, thereby contributing to better clinical monitoring and management strategies in neonatal practice.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study with a control group was conducted in the Department of Pediatrics, Sardar Patel Medical College and Associated Group of P.B.M. Hospitals, Bikaner, Rajasthan.

Study Duration: The study was carried out after obtaining ethical clearance and continued until the required sample size was achieved.

Sample Size and Sampling Technique: The sample size was calculated using the standard formula for estimating proportions, where Z represents the standard normal deviate at a 95% confidence interval (taken as 1.96), P represents the expected prevalence of electrolyte changes (taken as 25%), and d represents the allowable error or precision (taken as 5%). Based on this calculation, the required sample size was 288, which was rounded off to 300 neonates for convenience. The study included 150 term neonates undergoing phototherapy (study group) and 150 term neonates not requiring phototherapy (control group). A consecutive sampling technique was used, and all neonates fulfilling the inclusion criteria were enrolled until the desired sample size was achieved.

Study Population: The study was conducted on 300 term neonates (intramural and extramural) admitted with hyperbilirubinemia at P.B.M. Hospital, Bikaner.

Inclusion Criteria: The study group comprised 150 term neonates with hyperbilirubinemia requiring phototherapy, while the control group included 150 term neonates with hyperbilirubinemia not requiring phototherapy. Controls were matched with the study group for age, sex, gestational age, and birth weight.

Exclusion Criteria: Neonates with asphyxia, prematurity, low birth weight, infants of diabetic mothers, onset of jaundice <24 hours, those requiring exchange transfusion, conjugated hyperbilirubinemia, hemolytic anemia (Rh/ABO incompatibility), congenital malformations, respiratory distress, septicemia, acute renal failure, and other systemic illnesses were excluded.

Methodology and Data Collection: After obtaining Institutional Ethics Committee approval and written informed consent from parents/guardians, detailed history and clinical examination were performed. Data collected included demographic details, perinatal history, maternal history, and relevant family history. Neonatal parameters such as gestational age, birth weight, age (in days), sex, type and place of delivery, and presenting complaints were recorded. A comprehensive clinical examination, including general physical and systemic examination (respiratory, cardiovascular, gastrointestinal, and central nervous systems), was carried out for all neonates.

Laboratory Investigations: Venous blood samples were collected at admission for estimation of total and direct serum bilirubin, serum electrolytes (sodium, potassium, calcium, and magnesium), and blood grouping.

Phototherapy Protocol: Phototherapy was administered using four 40-W blue light lamps (460–490 nm) positioned at a distance of 30–45 cm from the neonate, following standard institutional protocols.

Measurement of Electrolytes: Serum electrolytes were measured at admission and after 48 hours.

- **Study group:** before initiation and after 48 hours of phototherapy
- **Control group:** at admission and after 48 hours of observation

Laboratory Methods: Serum bilirubin was measured using an automated analyzer based on the Diazo method (Van den Bergh, 1918). Serum electrolytes were analyzed using an Ion Selective Electrode (ISE) analyzer (Beckman Coulter AU680).

Quality Control: Standard laboratory protocols were followed, including regular calibration of equipment, use of control samples, and proper documentation of all procedures.

Statistical Analysis: Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) software. Continuous variables were expressed as mean ±standard deviation, while categorical variables were presented as frequencies and percentages. Comparison of means between groups was performed using the independent t-test, and paired comparisons were done using the paired t-test. Categorical variables were analyzed using the Chi-square test or Fisher's exact test, as appropriate. A *p-value <0.05* was considered statistically significant.

Ethical Considerations: Ethical approval was obtained from the Institutional Ethics Committee of S.P. Medical College and Associated Group of P.B.M. Hospitals, Bikaner. Written informed consent was obtained from parents or guardians prior to enrollment.

RESULTS

A total of **300 term neonates** were included in the study, comprising **150 in the phototherapy (study) group** and **150 in the control group**. Both groups were comparable in terms of baseline demographic and clinical characteristics. Table 1 shows that both study and control groups were comparable in terms of age, gender, demographic area, birth weight, gestational age, and type of delivery, with no statistically significant differences (p>0.05).

Table 1: Baseline Characteristics of Study and Control Groups

Variable	Study Group (n=150)	Control Group (n=150)	p-value
Age ≤3 days	123 (82%)	121 (80.66%)	0.51
Male (%)	84 (56%)	80 (53.33%)	0.72
Rural (%)	80 (53.33%)	77 (51.34%)	0.81
Birth weight (kg)	2.91 ± 0.21	2.89 ± 0.24	0.445
Gestational age (weeks)	38.04 ± 0.87	38.14 ± 0.93	0.168
NVD (%)	88 (58.66%)	87 (58%)	0.99

Table 2 demonstrates that mean serum bilirubin was significantly higher in the study group at admission and showed a significant reduction after phototherapy (p<0.001), confirming its effectiveness.

Table 2: Comparison of Serum Bilirubin Levels

Parameter	Study Group (n=150)	Control Group (n=150)	p-value
Admission bilirubin (mg/dL)	16.49 ± 1.99	10.05 ± 1.65	<0.001
Discharge bilirubin (mg/dL)	12.95 ± 2.39	12.80 ± 2.30	0.252
Before vs After (Study group)	16.49 → 12.95	—	<0.001

Table 3 shows a significant decline in serum sodium, potassium, calcium, and magnesium levels in the study group after phototherapy compared to baseline and control group (p<0.001).

Table 3: Changes in Serum Electrolytes (Study vs Control)

Electrolyte	Admission (Study)	Discharge (Study)	Control (Discharge)	p-value
Sodium (mEq/L)	142.35 ± 2.99	139.43 ± 3.75	142.63 ± 2.83	<0.001
Potassium (mEq/L)	4.98 ± 0.40	4.83 ± 0.51	4.97 ± 0.42	0.004
Calcium (mg/dL)	10.11 ± 0.56	9.11 ± 0.90	10.04 ± 0.52	<0.001
Magnesium (mg/dL)	2.30 ± 0.19	2.05 ± 0.76	2.29 ± 0.19	<0.001

Table 4 indicates that hypocalcemia (31.33%) was the most common electrolyte abnormality, followed by hyponatremia, hypomagnesemia, and hypokalemia.

Table 4: Prevalence of Electrolyte Abnormalities in Study Group (n=150)

Electrolyte Abnormality	Number of Cases	Percentage
Hypocalcemia	47	31.33%
Hyponatremia	25	16.66%
Hypomagnesemia	21	14%
Hypokalemia	5	3.33%

Table 5 shows that electrolyte abnormalities increased significantly with the duration of phototherapy, with maximum incidence at 72 hours (p<0.001).

Table 5: Electrolyte Changes with Duration of Phototherapy

Duration	Hyponatremia (%)	Hypokalemia (%)	Hypocalcemia (%)	Hypomagnesemia (%)
24 hrs	0.66%	0%	0%	0%
48 hrs	4.28%	1.42%	8.57%	4.28%
72 hrs	20%	3.33%	38.89%	16.66%
p-value	<0.001	<0.001	<0.001	<0.001

Serum sodium, potassium, calcium, and magnesium levels declined significantly following phototherapy (all p<0.001). The reduction in electrolyte levels was progressive and directly related to the duration of phototherapy, with greater disturbances observed at longer exposure durations. Despite these biochemical changes, the majority of neonates remained asymptomatic. Among those who were symptomatic, hypocalcemia was the most clinically significant, with 27.66% of affected neonates showing symptoms, most commonly jitteriness. Hypomagnesemia was symptomatic in 23.8% of cases, while hyponatremia was symptomatic in 12% of neonates, primarily presenting as lethargy. Hypokalemia, although present, was clinically asymptomatic in all cases.

DISCUSSION

The present study was a prospective observational study with a control population conducted at a tertiary care center. A total of 300 term neonates were included, with 150 neonates in the phototherapy (study) group and 150 in the control group. Both groups were well matched in terms of baseline characteristics, ensuring comparability and minimizing confounding factors.

In our study, the majority of neonates presented within the first three days of life, with 82% in the study group and 80.66% in the control group. This early presentation is consistent with the natural course of neonatal hyperbilirubinemia. Similar findings were reported by Akpınar Gözetici et al. (2021) [7] and Alshaymaa E. Mohamed (2023) [18], where most neonates presented within the early neonatal period, indicating no age-related bias.

Gender distribution in our study showed a slight male predominance, with 56% males in the study group and 53.33% in the control group. This finding is comparable to studies by Akpınar Gözetici et al. (2021) [7], Phani Krishna and Santosh T. Soans (2018) [1], and Arvind Shukla et al. (2022) [9], all of which demonstrated a similar male predominance without statistical significance.

The demographic distribution, birth weight, gestational age, and type of delivery were comparable between the two groups, confirming that both groups were appropriately matched. Similar observations were reported by Narinder Singh et al. (2019) [10], Rangaswamy KB et al. (2019) [11], and P. Indira et al. (2015) [12], supporting the validity of our study design.

A significant finding of our study was the reduction in serum bilirubin levels following phototherapy. The mean serum bilirubin decreased from 16.49±1.99 mg/dL to 12.95±2.39 mg/dL ($p < 0.001$), confirming the effectiveness of phototherapy. Similar statistically significant reductions have been reported by Usharani et al. (2018) [5], Javaid S. et al. (2021) [13], and Gayatri Bezboruah (2019) [14], reinforcing phototherapy as an effective modality for managing neonatal hyperbilirubinemia.

The present study demonstrated that phototherapy is associated with significant electrolyte disturbances. Hypocalcemia was the most common abnormality (31.33%), followed by hyponatremia (16.66%), hypomagnesemia (14%), and hypokalemia (3.33%). These findings are consistent with Subhashini B et al. (2019) [15], who also reported hypocalcemia as the most frequent electrolyte disturbance.

Serum sodium levels showed a significant decline after phototherapy, decreasing from 142.35±2.99 mEq/L to 139.43±3.75 mEq/L ($p < 0.001$). This is in agreement with studies by P. Indira et al. (2015) [12], Arvind Shukla (2022) [9], and Reddy et al. (2015) [2], all of which demonstrated a significant reduction in serum sodium levels following phototherapy. The decline may be attributed to increased insensible water loss and altered renal handling of sodium.

Furthermore, our study demonstrated a clear duration-dependent relationship, with increasing incidence of hyponatremia as the duration of phototherapy increased. Similar findings were reported by P. Indira et al. (2015) [12] and Pradeep Kumar Jena et al. (2019) [1], supporting the role of prolonged phototherapy in electrolyte imbalance.

Serum potassium levels also showed a significant reduction following phototherapy ($p=0.001$). Although hypokalemia was less common, the decline in potassium levels is consistent with findings by Rangaswamy KB et al. (2019) [11] and Arvind Shukla (2022) [9]. However, some studies have reported minimal or no significant changes, indicating variability in potassium response.

A key finding of our study was the significant decline in serum calcium levels after phototherapy, from 10.11±0.56 mg/dL to 9.11±0.90 mg/dL ($p < 0.001$). Hypocalcemia was the most frequent electrolyte abnormality observed. Similar findings have been reported by Gayatri Bezboruah (2019) [14], Javaid S. et al. (2021) [13], Mohamed Abdullah Mohamed El Gendi et al. (2020) [16], and P. Indira et al. (2015) [12]. The proposed mechanism involves suppression of melatonin leading to increased calcium uptake by bones. The incidence of hypocalcemia also increased significantly with longer duration of phototherapy, consistent with studies by Narinder Singh et al. (2019) [10] and Pradeep KJ et al. (2019) [17].

Serum magnesium levels also declined significantly following phototherapy ($p < 0.001$). This finding is consistent with studies by Alshaymaa E. Mohamed (2023) [18], Ehsanipour F. et al. (2020) [19], and Khatab A. et al. (2021) [20], all of which demonstrated a significant reduction in serum magnesium levels after phototherapy. The decline in magnesium levels also showed a duration-dependent pattern.

Another important observation in our study was that electrolyte disturbances increased significantly with the duration of phototherapy. The incidence of hypocalcemia, hyponatremia, and hypomagnesemia was highest in neonates receiving phototherapy for 72 hours. Similar duration-dependent trends have been reported in multiple studies [1,10,12].
Despite these biochemical changes, most neonates remained asymptomatic. Among symptomatic cases, hypocalcemia was the most clinically significant, presenting commonly as jitteriness, lethargy, and irritability. Similar findings were reported by Narinder Singh et al. (2019) [10], Dushyant Rastogi et al. (2016) [4], and RK Yadav et al. (2012) [21], where jitteriness was the most common manifestation.

Overall, our study highlights that while phototherapy is highly effective in reducing serum bilirubin levels, it is associated with significant electrolyte disturbances, particularly hypocalcemia and hyponatremia. These changes are more pronounced with increasing duration of phototherapy and may have clinical implications if not monitored appropriately.

CONCLUSION
Phototherapy is an effective and essential modality for the management of neonatal hyperbilirubinemia; however, it is associated with significant electrolyte disturbances. The present study demonstrates that serum sodium, potassium,

calcium, and magnesium levels decline significantly following phototherapy, with hypocalcemia being the most common abnormality. The changes were found to be progressive and directly related to the duration of phototherapy, with higher incidence observed in neonates receiving prolonged exposure. Although most electrolyte disturbances were asymptomatic, a proportion of neonates, particularly those with hypocalcemia, exhibited clinical manifestations such as jitteriness and lethargy. These findings highlight the importance of monitoring serum electrolytes, especially during prolonged phototherapy. Early identification and appropriate management of electrolyte imbalances can help prevent potential complications. Routine electrolyte assessment should be considered as part of standard care in neonates undergoing phototherapy.

DECLARATIONS

Ethical Approval and Consent to Participate: The study was conducted after obtaining approval from the Institutional Ethics Committee of S.P. Medical College and Associated Group of P.B.M. Hospitals, Bikaner. Written informed consent was obtained from the parents/guardians of all participants.

Availability of Data and Materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests: The authors declare that they have no competing interests.

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Authors 'Contributions: All authors contributed to the study conception, design, data collection, analysis, and manuscript preparation. All authors read and approved the final manuscript.

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