Section: Paediatric

Original Research Article

EFFECT OF LED PHOTOTHERAPY ON TOTAL SERUM CALCIUM LEVELS IN TERM NEONATES WITH JAUNDICE

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Received *: 07/05/2025*
Received in revised form *: 03/07/2025*
Accepted *: 25/07/2025*

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DOI: 10.70034/ijmedph.2025.3.199

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (3); 1081-1085

ABSTRACT

Background: Jaundice or hyperbilirubinemia in newborns is a prevalent condition tends to occur in about 60% of term and 80% of preterm infants within the first week of life. Various types of phototherapies are available for treatment of neonatal hyperbilirubinemia. LEDs are a more recent kind of light source that uses less energy, lasts a long time, is portable, and produces little heat. Present study was aimed to use to measure the change in total serum calcium levels between pre and after phototherapy using LED Phototherapy system in term infants with neonatal hyperbilirubinemia.

Materials and Methods: Total 70 term newborns having weight =/> 2500 grams both (in-born and out-born) requiring phototherapy were included in the study. Phototherapy was given by using single surface LED at a distance of 40 cm from the neonates. Total serum calcium and total serum bilirubin levels was estimated before start of phototherapy and at 24 hours, 48 hours and 72 hours or at end of phototherapy.

Results: TSB was found to be reduced significantly (9.22 ± 2.35 mg/dl) after providing the 24 hours of phototherapy when compared to the baseline values (14.98 ± 3.10 mg/dl). The TSB was found to be further reduced significantly to after 48 hours of phototherapy (10.30 ± 1.03 mg/dl). Calcium was found to be reduced significantly (9.16 ± 0.73 mg/dl) after providing the 24 hours of phototherapy when compared to the baseline values (9.18 ± 0.73 mg/dl). The calcium was found to be further reduced significantly to after 48 hours of phototherapy (8.54 ± 0.77 mg/dl).

Conclusion: A significant modulation in TSB and calcium levels were observed during 24 hours and 48 hours after phototherapy. Further large-scale studies are required to validate the findings of this study.

Keywords: Bilirubin, calcium, phototherapy, neonate, jaundice, hyperbilirubinemia.

INTRODUCTION

Jaundice or hyperbilirubinemia in newborns is a prevalent condition tends to occur in about 60% of term and 80% of preterm infants within the first week of life.[1] The incidence has risen to 10–14% over time, most likely as a result of more advanced diagnostic tools.[2] Hyperbilirubinemia cause morbidity in 60% of preterm and 80% of term neonates. Additionally, it is the most typical cause of readmission after being discharged from the hospital.[3] Hyperbilirubinemia usually occurs from the accumulation of unconjugated lipid soluble and non-polar bilirubin pigment in the skin. Indirect (unconjugated) hyperbilirubinemia occurs as a result of excessive bilirubin formation and because of this neonatal liver cannot clear bilirubin rapidly enough from the blood. While the majority of babies with jaundice are healthy, all infants who are icteric require medical intervention.[4]

Hyperbilirubinemia can be treated in the following ways: (a) By phototherapy- conversion of bilirubin to

lumirubin, thus bypassing the liver's bilirubin conjugation system and excretes in the form of stercobilinogen or urobilinogen without further metabolism; (b) Mechanically bilirubin can be removed by exchange transfusion. Various types of phototherapies are available for treatment of neonatal hyperbilirubinemia, these includes- Blue and white tubes phototherapy, Halogen/ CFL light phototherapy & Light Emitting Diodes (LED) phototherapy. Because the blue (425–475 nm) region of the light spectrum is where LEDs are focused, they are long-lasting, low-power consumption, produce minimal heat, and could be put near an infant.[5]

Despite being a safer treatment option, phototherapy does have certain side effects, including as hypocalcemia, hyperthermia, feed intolerance, vomiting, decreased urine output, bronze baby syndrome, dehydration, electrolytes disturbance, diarrhea, gonadal damage, retinal damage, etc. Hypocalcemia is defined as in term newborn total serum calcium level less than 8mg/dl.[6] Calcium is one of the most important electrolytes that is necessary for the growth and development of young children as well as the metabolism of newborns. Recent studies have indicated that phototherapy may be a contributing factor to hypocalcemia, though research in this area remains limited.[7] Hypocalcemia in neonates born at term or preterm with a birth weight exceeding 1500 g is characterized by total blood calcium below 8 mg/dL or ionized calcium under 4.4 mg/dL. For extremely low birth weight newborns, the condition is defined as total serum calcium less than 7 mg/dL or ionized calcium below 4 mg/dL.[8]

By reducing production of melatonin from the pineal gland, transcranial illumination during phototherapy likely prevents the cortisol action on bone calcium and causes hypocalcemia. Cortisol directly affects calcium by increasing calcium uptake and resulting in hypocalcemia.[9] In full-term babies, the overall frequency of hypocalcaemia in those using phototherapy was 8.7%.[10] In an additional study, phototherapy resulted in hypocalcaemia in 90% of preterm and 75% of term newborns.[11] Research has been conducted to examine the alterations in calcium concentrations following the administration of traditional blue and white light therapy for newborn hyperbilirubinemia.[12] LEDs are a more recent kind of light source that uses less energy, lasts a long time, is portable, and produces little heat.[13] Our goal was to use an LED phototherapy system to measure the change in total calcium levels between pre and after phototherapy in term infants with neonatal hyperbilirubinemia.

MATERIALS AND METHODS

Study design: Present study was a prospective cross-sectional study that was conducted at the Department of Paediatrics at Adesh Medical College and Hospital, Shahabad, Kurukshetra, Haryana. Total 70 term newborns having weight =/> 2500 grams both (in-born and out-born) requiring phototherapy were included in the study. Term neonates with hypocalcemia before initiation of phototherapy, small for gestation age/large for gestation age, IUGR baby, babies having requirement of exchange transfusion, birth asphyxia with APGAR at 5minutes <7 and/or respiratory distress cases, cases with neonatal sepsis, congenital malformations, babies whose mother having diabetes/hypothyroidism, mother on anticonvulsant and babies given cow's milk/ formula feeds were excluded from the study.

Phototherapy: Phototherapy was given by using single surface LED (Zeal Medical Pvt. Ltd at 4/19-A, Piramal Industrial Estate, S. V. Road, Goregaon West, Mumbai - 400104) at a distance of 40 cm from the neonates. The baby position was changed 2 hourlies to give maximum exposure of phototherapy and neonatal eyes and genitals was properly covered. No head caps were used during phototherapy.

Data collection: All variables like age (day of life), birth weight (grams), mode of delivery, birth gestation in weeks, duration of phototherapy (hours), total serum bilirubin (mg/dl), total serum calcium (mg/dl) were recorded for each neonate in a designed proforma during the study.

Serum calcium and total serum bilirubin: Total serum calcium and total serum bilirubin levels was estimated before start of phototherapy and at 24 hours, 48 hours and 72 hours or at end of phototherapy. 1 ml blood sample was taken in a plain vial (red top) for estimation of serum bilirubin and total serum calcium level and sent to biochemistry laboratory. Total serum bilirubin and serum calcium level was estimated by using fully automated Erba Mannheim (EM-360) machine manufactured by Transasia Bio-medicals Limited (Erba diagnostics Mannheim GmbH- mallaustr, 69-73, D-68219, Mannheim/Germany). Total serum bilirubin estimation by Diazo method by using reagents (R1- Sulphanilic acid, HCl, Cetrimide, R2- Sodium Nitrite) of XL system packs kit and for total serum calcium estimation reagent used Arsenazo III and buffer (pH 6.5 ±0.1) of XL system packs kit of Erba Mannheim company.

Study outcome: Pre and Post phototherapy calcium levels were analyzed to measure any statistical difference in values. Correlation between duration of phototherapy and serum calcium levels was also studied.

Statistical analysis: Data collected was entered into the MS Excel spreadsheet. Categorical variables were presented in number and percentage. Continuous variables were presented as mean +/- Standard deviation. Paired t -test was used to compare serum calcium levels before and after exposure to phototherapy. A p value <0.05 was considered as statistically significant. Correlation of serum calcium levels with duration of phototherapy was done. Data was analyzed statistically by using SPSS 27.0 software.

RESULTS

Most of the cases belong to the 4th day of age of life (27.1%) followed by 3rd day (24.3%), 2nd day (17.1%), 5th day (17.1%). The least number of cases belong to the 7th day (1.4%) and 8th day of life (1.4%). Majority of neonates were males (51.4%) indicating a male predominance. There were 48.6% females among all neonates. Normal vaginal delivery (NVD) was observed in the 30% cases while delivery was done by lower segment caesarean section (LSCS) in 70% cases. The gestation age of most of the cases was 37-37+6 weeks (44.3%) followed by 38-38+6 weeks (31.4%), 39-39+6 weeks (17.1%) and 40-40+6 weeks (7.1%). APGAR Score at 1 minute was 8 in majority of cases (92.9%) whereas 7.1% cases have the APGAR score of 7, and after 5 minutes the APGAR score in all cases was 9. Neonatal complications were not observed in any case. Type of feeding was breastfed in all cases. Duration of phototherapy in majority of cases was 24 hours (92.9%) whereas in 7.1% cases 48 hours of phototherapy was provided. [Table 1].

Table 1: Maternal and neonatal parameters.

Variable	Domain	Number	Percentage
Age (Day of life)	2nd	12	17.1
	3rd	17	24.3
	4th	19	27.1
	5th	12	17.1
	6th	6	8.6
	7th	1	1.4
	8th	1	1.4
	9th	2	2.9
Gender	Male	36	51.4
	Female	34	48.6
Mode of Delivery	NVD	21	30.0
	LSCS	49	70.0
Gestational Age	37-37+6 Weeks	31	44.3
	38-38+6 weeks	22	31.4
	39-39+6 Weeks	12	17.1
	40-40+6 Weeks	5	7.1
APGAR Score	7	5	7.1
	8	65	92.9
Duration of phototherapy	24 Hours	65	92.9
	48 Hours	5	7.1

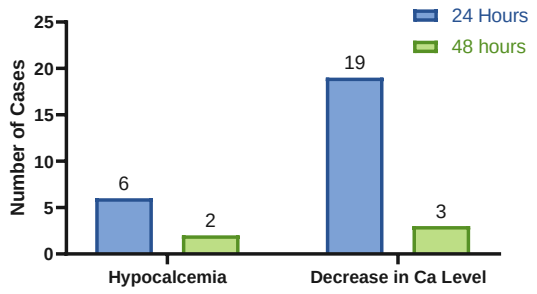

Figure 1: Effect on Serum Calcium Level.

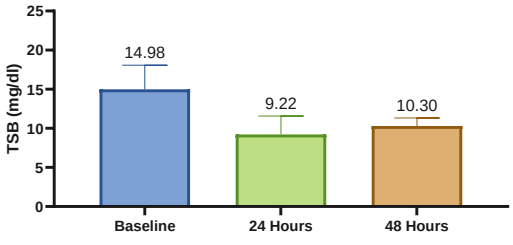

Figure 2: TSB before and after phototherapy.

At 24 hours, hypocalcemia was observed in 8.6% cases and decrease in calcium level was observed in 27.1% cases. At 48 hours, hypocalcemia was observed in another 2.9% cases and decrease in calcium level was observed another in 4.3% cases. Overall, hypocalcemia was observed in 11.4% cases and decrease in calcium level was observed in 31.4% cases. Decreased in calcium level was observed in total 42.9% cases [Figure 1].

TSB was found to be reduced significantly (9.22 ± 2.35 mg/dl) after providing the 24 hours of phototherapy when compared to the baseline values (14.98 ± 3.10 mg/dl). The TSB was found to be further reduced significantly to after 48 hours of phototherapy (10.30 ± 1.03 mg/dl) [Figure 2]. Calcium was found to be reduced significantly (9.16 ± 0.73 mg/dl) after providing the 24 hours of phototherapy when compared to the baseline values (9.18 ± 0.73 mg/dl). The calcium was found to be further reduced significantly to after 48 hours of phototherapy (8.54 ± 0.77 mg/dl) [Figure 3].

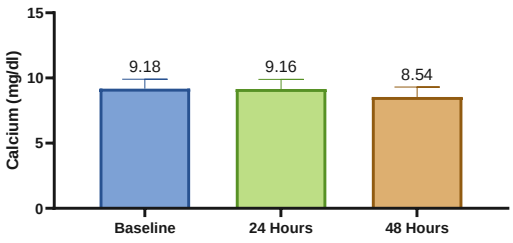

Figure 3: Calcium before and after phototherapy.

DISCUSSION

There is a paucity of prior research indicating a shift in calcium levels after LED phototherapy. The purpose of this study was to ascertain how the serum electrolyte levels of babies receiving LED phototherapy for neonatal jaundice changed over duration. In this study, serum electrolyte levels were evaluated in 70 term babies both before and after phototherapy. We compared the TSB and calcium before and after the phototherapy. The study began with the approval of the Institutional Ethical Committee and was completed after the neonate parent was informed of the procedures in detail and signed a written informed consent form.

In present study, most of the cases belong to the 4th day of age of life (27.1%) followed by 3rd day (24.3%), 2nd day (17.1%), 5th day (17.1%). The least number of cases belong to the 7th day (1.4%) and 8th day of life (1.4%). The results of present study were comparable to Taheri et al.[14] Majority of neonates were males (51.4%) in present study indicating a male predominance. There were 48.6% females among all neonates. The results of present study were similar to that seen in Purohit et al. study (50). In the study by Balamkar et al., out of total 100 neonates, there were 61.0% males and 39.0% were females.[15] In the study by Nazim et al. 52.0% of the neonates were male, and 48.0% were female.[16]

The present study included all neonates with unconjugated hyperbilirubinemia who were ≥ 37 weeks of gestation as were enrolled by Rozario et al,[17] and Usha Rani et al.[18] The gestation age of most of the cases in our study was 37-37+6 weeks (44.3%) followed by 38- 38+6 weeks (31.4%), 39-39+6 weeks (17.1%) and 40-40+6 weeks (7.1%). In the study by Nazim et al. there were 23.0% of late preterm (35–36 weeks) and 77.0% of term babies.[16] The study excluded neonates who had a gestation age of less than 37 complete weeks, had a major congenital malformation, had conjugated hyperbilirubinemia, were undergoing exchange transfusion, needed resuscitation for more than three minutes at birth, met sepsis criteria, were receiving intravenous (i/v) fluids, or had abnormal electrolytes when phototherapy started.

Normal vaginal delivery (NVD) was observed in the 30% cases in this study while delivery was done by lower segment caesarean section (LSCS) in 70% cases. Similar results have been reported in the study conducted by Vigneshwar et al. 43.0% of the neonates in the Balamkar et al. study was delivered via LSCS, whereas 57.0% were delivered vaginally.[15] According to the study by Nazim et al., 35% of newborns had a NVD and 65% had a LSCS (58).

Duration of phototherapy in majority of cases in this study was 24 hours (92.9%) whereas in 7.1% cases 48 hours of phototherapy was provided. In the study by Balamkar et al., 77.1% received phototherapy for 48 hours whereas 22.9% neonates received phototherapy for 24 hours which is corroborated with the findings of our study.[15] In the Nazim et al. study, phototherapy was administered to 23% and 77% of neonates for less than 24 hours and more than 24 hours, respectively.[16]

TSB in our study was found to be reduced significantly (9.22 ± 2.35 mg/dl) after providing the 24 hours of phototherapy when compared to the baseline values (14.98 ± 3.10 mg/dl). The TSB was found to be further reduced significantly to after 48 hours of phototherapy (10.30 ± 1.03 mg/dl). In the study by Balamkar et al., the mean TSB levels before and at the end of phototherapy was 19.48±2.78mg/dl and 11.18±3.11mg/dl respectively.[15] The mean TSB level in the Nazim et al. trial was 20.83 ± 9.29 prior to phototherapy and decreased to 12.91 ± 5.11 following phototherapy, with a statistically significant difference.[16]

In present study, the serum calcium was found to be reduced significantly (9.16 ± 0.73 mg/dl) after providing the 24 hours of phototherapy when compared to the baseline values (9.18 ± 0.73 mg/dl). The calcium was found to be further reduced significantly to after 48 hours of phototherapy (8.54 ± 0.77 mg/dl). In the study by Panneerselvam et al., the serum calcium level following LED phototherapy was 8.82 ± 0.93 mg/dL which is similar to present study (8.54 ± 0.77).[19] Similar results have been reported in the study by published by Aziz et al. (8.58 ± 0.76) and similarly by Singh et al. (8.42 ±1.19).[20,21]

Phototherapy prevents the pineal gland from producing melatonin.[22] Consequently, the effect of corticosterone on calcium in bones is decreased. Corticosterone levels in the blood decrease during phototherapy because melatonin levels do as well. Hypocalcemia is the outcome of decreased corticosterone since it decreases bone resorption. When phototherapy was administered to jaundiced babies, a decrease in parathormone synthesis resulted in hypocalcemia.[23] In Hooman et al. study, hypocalcemia in phototherapy-treated jaundiced newborns was attributed to a considerably greater amount of urine calcium excretion.[24] Curtis et al. investigated diarrhea in newborns treated with phototherapy for jaundice.[25] Their study found a significant decrease in potassium, chloride, and salt absorption in newborns who were exposed to phototherapy.

It should be mentioned that while we used LED phototherapy, the majority of the research that were discussed used blue and white phototherapy. Given that preterm infants are more likely to develop hypocalcemia; it should be noted that our study included a number of limitations. We didn't check the level of ionized calcium during phototherapy. We suggest conducting larger multicentric trials to assess the percentage of hypocalcemia in jaundiced term newborns receiving LED phototherapy.

CONCLUSION

According to the current study findings, newborns subjected to phototherapy showed a considerable modulation in their serum TSB and calcium levels. Although TSB and calcium levels in this study showed statistically significant declines, only a slight reduction was seen, meaning that none of the babies showed any clinical symptoms of hypocalcemia. We must remember that these imbalances may have a negative effect on the neonates and that we must continue to keep a close eye on them even though the precise mechanism underlying this decline has not been fully hypothesized and more large sample research are required to clarify it. In our study, phototherapy-induced depletion of total serum calcium was clearly visible, and while the symptoms were not clinically significant, the reduction might lead to the establishment of a threshold for creating hypocalcemia.

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