

A Hospital-Based Study to Determine the Effect of Phototherapy on Serum Magnesium Level in Term Neonates with HyperbilirubinemiaPrem Kumar¹, Rakesh Kumar², Sujit Kumar³¹Senior Resident, Department of Pediatrics, Nalanda Medical College and Hospital, Patna, Bihar, India²Senior Resident, Department of Pediatrics, Nalanda Medical College and Hospital, Patna, Bihar, India³Professor, Department of Pediatrics, Nalanda Medical College and Hospital, Patna, Bihar, India

Received: 06-08-2023 Revised: 23-09-2023 / Accepted: 24-10-2023

Corresponding Author: Dr. Rakesh Kumar

Conflict of interest: Nil

Abstract**Aim:** The aim of the present study was to determine the effect of phototherapy on serum magnesium level in term neonates with hyperbilirubinemia.**Material & methods:** A prospective hospital-based comparative study was conducted on 200 eligible neonates admitted in Department of Pediatrics, Nalanda Medical College and Hospital, Patna, Bihar, India receiving phototherapy for the period of one year. Informed consent was obtained from the parents of the selected neonates. This study included 200 full-term neonates who were subjected to phototherapy for treating neonatal hyperbilirubinemia according to the guidelines of the American Academy of Pediatrics.**Results:** Our study included 200 full-term neonates with jaundice who received phototherapy for treating neonatal indirect hyperbilirubinemia, comprising 130 (65%) males, and 70 (35%) females, with the mean gestational age of 37± 0.8 weeks and mean postnatal age of 5.2 ± 1.4 days. There were 68 (34%) neonates delivered by normal vaginal delivery and 132 (66%) neonates delivered by cesarean section. Mean birth weight was 3.1 kg. The mean difference of jaundice onset age, intrauterine age, admission weight and mother's age were not significant. The amount of total serum bilirubin decreases in all groups. Serum total magnesium level in single and double phototherapy decreases after treatment, but this decrease is significant only in the double phototherapy group (P = 0.022). In the intensive group, this parameter has slightly increased, which was not statistically significant (P = 0.530). The serum total magnesium level and its changes were reported in three groups before and after phototherapy. The serum magnesium level in new borns before treatment was normal in all three treatment groups. The status of each patient showed that single, double, and intensive phototherapy groups have magnesium content of more than 2.2 mg/dl, respectively.**Conclusion:** In the present study, the serum magnesium level showed a significant reduction only in the double phototherapy method and remained in the normal range in the other two groups. On the other hand, in all three treatment groups, the level of serum magnesium before the treatment was normal and did not increase significantly.**Keywords:** Hyperbilirubinemia, Magnesium, PhototherapyThis is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Introduction**

In neonates, jaundice is a common occurrence that requires immediate medical attention. Unconjugated bilirubin deposits in the skin, nail bed, and sclera of babies with jaundice, turning the skin, nail bed, and sclera yellow. [1] Neonates appear jaundiced when it exceeds 7 mg/dl; clinical jaundice affects one-quarter to half of all term infants, and higher percentages are typical in infants born before term. Furthermore, the maximum blood bilirubin level in well-term newborns is over 12.9 mg/dl in 6.1 percent of them. [2] Hyperbilirubinemia is a serious medical condition that is the leading cause of infant hospitalisation in Southeast Asia. [3] Indirect

hyperbilirubinemia (unconjugated) and direct hyperbilirubinemia (conjugated) are the two kinds of jaundice in newborns. Direct hyperbilirubinemia has little effect on the brain, whereas indirect hyperbilirubinemia is toxic and detrimental.

When indirect bilirubin levels in neuronal cells reach dangerously high levels, it accumulates in the nerve membrane, permanently harming the central nervous system. [3] Bilirubin build-up in the neurons of the brain basal ganglia causes encephalopathy, Kernicterus, and athetoid cerebral palsy. High bilirubin levels in newborns, in contrast to adult jaundice, impair the neurological system,

which is linked to the neonate's blood-brain barrier not fully maturing. [4-7] Magnesium is the body's fourth most abundant element, with the vast bulk of it stored in intracellular compartments. The relationship between extracellular magnesium concentrations and manifestation, on the other hand, is important to doctors. The gastrointestinal, skeletal, and renal systems are the main organ systems involved with magnesium homeostasis, despite the fact that the regulators regulating these organs at the cellular level are still unknown. Hypermagnesemia is uncommon, occurring largely in the elderly and those with renal failure, and there is evidence that plasma ionised Mg levels are linked to the severity of hyperbilirubinemia in infants. [2]

Magnesium plays a role in protecting the neural system against hypoxia and neurotoxic effects of bilirubin, through blocking N-methyl -D- aspartate (NMDA) receptor. Bilirubin leads to hyperactivity of the NMDA receptor and exerts neurotoxic effects through binding to NMDA, which has a key role in synaptic physiologic functions and memory. [8] There was a positive relation between serum magnesium and bilirubin levels, and it was propounded that rising of magnesium in hyperbilirubinemia might be a compensatory mechanism against toxic effects of bilirubin. Magnesium protects the nervous system against hypoxia and neurotoxic effects of bilirubin. It seems to apply these protective effects by blocking the NMDA receptor. [9] Deposition of bilirubin in neurons causes permanent neuronal injury. Magnesium is an NMDA antagonist, and it acts against the neurotoxic effects of bilirubin. Several adverse effects have been reported for phototherapy in the treatment of neonatal hyperbilirubinemia but less has been reported regarding the effect of phototherapy on serum magnesium levels. [9]

Therefore, this study was carried out to determine the effect of phototherapy on serum magnesium level in term neonates with hyperbilirubinemia.

Materials & Methods

A prospective hospital-based comparative study was conducted on 200 eligible neonates admitted in Department of Pediatrics, NMCH, Patna, Bihar, India, receiving phototherapy for the period of one year. Informed consent was obtained from the parents of the selected neonates. This study included 200 full-term neonates who were subjected to phototherapy for treating neonatal

hyperbilirubinemia according to the guidelines of the American Academy of Pediatrics. ¹⁰

Exclusion Criteria

- Neonates who had direct bilirubin more than 20%, exchange transfusion cases.
- Neonates with cephalohematoma, congenital malformation.
- Inborn errors of metabolism and sepsis.
- Neonates whose mothers received magnesium sulfate or oxytocin at any time during gestation,
- Intrauterine growth retardation,
- Infants of diabetic mothers,
- Neonates on intravenous fluid,
- Hypocalcemia
- Hypomagnesemia before starting phototherapy, and
- Hemolytic hyperbilirubinemia.

Each neonate was subjected to detailed history taking (gestational age, mode of delivery, detailed prenatal, natal history, age on admission, and day of onset of jaundice, family history of neonatal jaundice) and clinical examination.

Before starting phototherapy, venous blood sample was sent for serum magnesium (total and ionized), and it was considered as control. Serial measurements of (total-ionized) serum magnesium levels were done at 48 h after phototherapy and after termination of phototherapy. Laboratory investigations included serial measurements of total serum bilirubin levels (at admission, 48 h after phototherapy and at discharge), blood groups and rhesus factor to infant and mother, reticulocyte count, serum calcium, complete blood count, C-reactive protein, liver function test, and Coombs test. Thereafter, all data were tabulated and analyzed statistically to detect the effect of phototherapy on the serum magnesium level.

Statistical Analysis

The collected data were revised, coded, tabulated, and introduced to a computer software using (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, New York: IBM Corp.). Shapiro test was done to test the normality of data distribution. Paired sample t test was used to assess changes over time. The correlation coefficient defines the strength and direction of the linear relationship between two variables. P value is significant if less than 0.05 at confidence interval 95%.

Results

Table 1: Demographic details

Gender	N%
Male	130 (65)
Female	70 (35)
Mode of delivery	
NVD	68 (34)
LSCS	132 (66)
Neonatal age (days) Mean±SD	5.2±1.4
Gestational days (weeks) Mean±SD	37±0.8
Birth weight (kg) Mean±SD	3.1±0.3

Our study included 200 full-term neonates with jaundice who received phototherapy for treating neonatal indirect hyperbilirubinemia, comprising 130 (65%) males, and 70 (35%) females, with the mean gestational age of 37±0.8 weeks and mean postnatal age of 5.2 ± 1.4 days. There were 68 (34%) neonates delivered by normal vaginal delivery and 132 (66%) neonates delivered by cesarean section. Mean birth weight was 3.1 kg.

Table 2: Characteristics of neonates for the treatment groups

Variable	Single		Double		Intensive		P value
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	
Jaundice onset age (day)	3.55 ± 1.72	2-12	3.16 ± 1.40	2-9	3.14 ± 1.52	2-10	0.412
Intrauterine age (week)	38.43 ± 0.50	38-40	38.42 ± 0.85	38-41	38.74 ± 0.74	38-41	0.032
Admission weight (gr)	2640 ± 324	2500-3900	3246 ± 340	2500-4150	3132 ± 360	2500-4000	0.168
Mother's age (year)	28.42 ± 4.36	17-39	28.48 ± 5.30	16-40	29.41 ± 5.25	16-42	0.128

The mean difference of jaundice onset age, intrauterine age, admission weight and mother's age were not significant.

Table 3: Total serum bilirubin levels before and after single, double, and intensive phototherapy

Phototherapy types	Before	After	p-value
Single	15.30 ± 0.5	8.42 ± 1.48	<0.001
Double	18.32 ± 0.72	8.75 ± 1.42	<0.001
Intensive	20.64 ± 2.44	9.20 ± 1.22	<0.001

The amount of total serum bilirubin decreases in all groups.

Table 4: Serum magnesium levels before and after single, double, and intensive phototherapy

Phototherapy types	Before	After	P
Single	2.07 ± 0.32	2.00 ± 0.34	0.525
Double	2.20 ± 0.38	2.08 ± 0.32	0.022
Intensive	2.04 ± 0.3	2.05 ± 0.28	0.530

Serum total magnesium level in single and double phototherapy decreases after treatment, but this decrease is significant only in the double phototherapy group (P = 0.022). In the intensive group, this parameter has slightly increased, which was not statistically significant (P = 0.530). The serum total magnesium level and its changes were reported in three groups before and after phototherapy.

Table 5: Serum magnesium status before and after phototherapy in three treatment groups

Phototherapy types	<1.5	1.5-2.2	<2.2	<1.5	1.5-2.2	<2.2	P
	N	N	N	N	N	N	
Single	0		14	0	50	15	0.540
Double	6	50	40	6	52	15	0.004
Intensive	4	60	26	4	40	15	0.944

The serum magnesium level in new borns before treatment was normal in all three treatment groups. The status of each patient showed that single, double, and intensive phototherapy groups have magnesium content of more than 2.2 mg/dl, respectively.

Discussion

Neonatal hyperbilirubinemia (NH) is the commonest clinical problem occurring during the first week of life, as more than two thirds of newborns develop clinical jaundice [11,12] that can be treated by phototherapy, exchange transfusion, or by pharmacologic agents. Phototherapy is the most common intervention in therapy used as it is relatively safe and non-invasive. [13,14] The conventionally used light sources in phototherapy are fluorescent tubes and halogen spotlights. However, they cannot be placed close to the infant as they produce considerable amount of heat. Due to this limitation, light-emitting diodes (LEDs) have been used as alternatives as they produce low heat rendering them safe to be placed very close to the infant. [15,16] Jaundice is the most common condition that requires medical attention and hospital readmission in newborns. The yellowish coloration of the skin and sclera in newborns with jaundice is the result of the accumulation of unconjugated bilirubin. [17]

Our study included 200 full-term neonates with jaundice who received phototherapy for treating neonatal indirect hyperbilirubinemia, comprising 130 (65%) males, and 70 (35%) females, with the mean gestational age of 37 ± 0.8 weeks and mean postnatal age of 5.2 ± 1.4 days. There were 68 (34%) neonates delivered by normal vaginal delivery and 132 (66%) neonates delivered by cesarean section. Mean birth weight was 3.1 kg. The mean difference of jaundice onset age, intrauterine age, admission weight and mother's age were not significant. The amount of total serum bilirubin decreases in all groups. Our study showed that there was a statistically significant positive correlation between total bilirubin and magnesium (total and ionized) in all studied neonates. This agreed with the study done by Sapkota. [9]

Serum total magnesium level in single and double phototherapy decreases after treatment, but this decrease is significant only in the double phototherapy group ($P = 0.020$). In the intensive group, this parameter has slightly increased, which is not statistically significant ($P = 0.565$). The serum total magnesium level and its changes were reported in three groups before and after phototherapy. The serum magnesium level in new borns before treatment was normal in all three treatment groups. The study by Khatab AA [18] concluded that average magnesium value noted before phototherapy was 2.8 mg/dl and after phototherapy

was 1.7 mg/dl, showing a significant difference. Subhashini et al [19] observed that serum magnesium levels before phototherapy in newborns were increased. There was a significant decrease in the level of magnesium after phototherapy, but none reached hypomagnesemia. Bezboruah and Majumder [20] discovered only a significant reduction of mean serum magnesium value following phototherapy.

The status of each patient showed that single, double, and intensive phototherapy groups have magnesium content of more than 2.2 mg/dl, respectively. In our study, serum magnesium level showed a significant reduction after phototherapy in double phototherapy, but this difference did not show significant changes in both single and intensive phototherapy methods. The reason for insignificant findings in single and intensive phototherapy methods may be a delay in blood sampling due to ethical issues because in our study, no additional blood sampling was performed. Reduced serum magnesium levels after double phototherapy are probably due to increased levels of plasma magnesium in association with hyperbilirubinemia, in which after phototherapy, the magnesium level decreases in association with bilirubin reduction. Since only 1% of the body's magnesium is extracellular, most of these changes are due to the displacement of magnesium between the inside and outside of the cell. Therefore, with increasing bilirubin, plasma levels of magnesium also increase as a result of cellular degradation or as a defense mechanism. In Khosravi et al.'s study, the total serum magnesium levels decreased significantly after phototherapy; it is similar to our results in double phototherapy methods. [21]

The serum magnesium level in new borns before treatment was normal in all three treatment groups. The status of each patient showed that single, double, and intensive phototherapy groups have magnesium content of more than 2.2 mg/dl, respectively. In a study, Sarici et al.'s reported that in the severe hyperbilirubinemia group, serum ionized magnesium levels were significantly higher in comparison to the moderate hyperbilirubinemia group.²² But our results revealed that the serum magnesium level was normal in all three groups before the treatment, and there was no increase in serum magnesium level. In Sarici et al [22] study, the increase in magnesium levels in severe hyperbilirubinemia was caused by magnesium leakage from damaged neurons and red blood cells to exert its protective effect on the nervous system. Shahriarpanah et al²³ found that the serum level of magnesium decreased through relieving hyperbilirubinemia, and the increase in the plasma level of magnesium might be owing to synchronization with hyperbilirubinemia too.

Conclusion

Bilirubin exerts its neurotoxicity effect by binding to the NMDA receptor in the neural synapse. Magnesium is one of the most important inhibitors of the NMDA receptor. The body increases the level of extracellular magnesium to reduce the neurotoxicity effects of bilirubin as a defense mechanism. In the present study, the serum magnesium level showed a significant reduction only in the double phototherapy method and remained in the normal range in the other two groups. On the other hand, in all three treatment groups, the level of serum magnesium before the treatment was normal and did not increase significantly.

References

1. Gregory ML, Martin CR, Cloherty JP. Neonatal hyperbilirubinemia. In: Cloherty JP, Eichenwald EC, Stark AR. editors. Philadelphia, PA: Lippincott-Raven; 2012. p. 304-39.
2. Sapkota NK. Effect of phototherapy on serum bilirubin and ionized magnesium level in hyperbilirubinemic neonates. *Innovare J Med Sci.* 2017;5(1):10-1.
3. Eghbalian F, Shabani S, Faradmali J, Jenabi E. Effects of phototherapy on the serum magnesium level in neonates with indirect hyperbilirubinemia: A prospective cohort study. *International Journal of Pediatrics.* 2022 Mar 22;2022.
4. Xiong T, Qu Y, Cambier S, Mu D. The side effects of phototherapy for neonatal jaundice: what do we know? What should we do?. *European journal of pediatrics.* 2011 Oct;170:1247-55.
5. Eghbalian F, Monsef A. Phototherapy-induced hypocalcemia in icteric newborns. *Iranian Journal of Medical Sciences.* 2015 Nov 30;27(4):169-71.
6. Monsef A, Eghbalian F. Does conventional phototherapy have any effect on platelet count in full term neonates with indirect hyperbilirubinemia. *Health.* 2011 Dec 8;3(12):709-11.
7. Eghbalian F, Pourhossein A, Zandevakili H. Effect of clofibrate in non-hemolytic indirect hyperbilirubinemia in full term neonates. *The Indian Journal of Pediatrics.* 2007 Nov;74:1003-6.
8. Imani M, Rezaee-pour M, Mohamdi M, Shiri M, Noroozifar M, Mahmudi N. Study of relationship between total Magnesium and total bilirubin levels in neonates' sera before and after phototherapy. *Razi Journal of Medical Sciences.* 2012 Oct 10;19(100):54-61.
9. Sapkota NK. Effect of phototherapy on serum bilirubin and ionized magnesium level in hyperbilirubinemic neonates. *Innovare J Med Sci.* 2017;5(1):10-1.
10. American Academy of Pediatrics Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. *Pediatrics.* 2004 Jul;114(1):297-316.
11. Ullah S, Rahman K, Hedayati M. Hyperbilirubinemia in neonates: types, causes, clinical examinations, preventive measures and treatments: a narrative review article. *Iranian journal of public health.* 2016 May;45(5):558.
12. Venaktamurthy M, Balaji MD, Reddy KT. A study on effect of phototherapy on platelet count in neonates with neonatal hyperbilirubinemia in a tertiary care rural hospital. *Int J Contemp Pediatr.* 2016 Feb;3:253-5.
13. Xiong T, Qu Y, Cambier S, Mu D. The side effects of phototherapy for neonatal jaundice: what do we know? What should we do?. *European journal of pediatrics.* 2011 Oct;170:1247-55.
14. Mreihil K, Benth JS, Stensvold HJ, Nakstad B, Hansen TW. Norwegian Neonatal Network. Phototherapy is commonly used for neonatal jaundice but greater control is needed to avoid toxicity in the most vulnerable infants. *Acta Paediatr.* 2018;107(4):611-9.
15. Mohammadzadeh M, Eliadarani FK, Badiei Z. Is the light-emitting diode a better light source than fluorescent tube for phototherapy of neonatal jaundice in preterm infants?. *Advanced Biomedical Research.* 2012 Jan 1;1(1):51.
16. Gutta S, Shenoy J, Kamath SP, Mithra P, Baliga BS, Sarpangala M, Srinivasan M. Light emitting diode (LED) phototherapy versus conventional phototherapy in neonatal hyperbilirubinemia: a single blinded randomized control trial from coastal India. *BioMed Research International.* 2019 Apr 11;2019.
17. Mitra S, Rennie J. Neonatal jaundice: aetiology, diagnosis and treatment. *British Journal of Hospital Medicine.* 2017 Dec 2;78(12):699-704.
18. Khatab AA, Ashour NM, Shehata ML. Effect of phototherapy on serum magnesium level in newborn with hyperbilirubinemia. *Menoufia Medical Journal.* 2021 Jul 1;34(3):1004.
19. Subhashini B, Vani SA, Das P, Niranjana R. Adverse effects of phototherapy on calcium, magnesium and electrolytes levels in neonatal jaundice. *Int J Clin Biochem Res.* 2019; 6(3):275-8.
20. Bezboruah G, Majumder AK. Electrolyte imbalances resulting from phototherapy in neonatal hyperbilirubinemia. *IOSRJDMSM.* 2019;18:51-8.
21. Khosravi N, Aminian A, Taghipour R. Total serum magnesium level in icteric neonates

- before and after phototherapy. Tehran University Medical Journal. 2011 Oct 1;69(7).
22. Sarici SU, Serdar MA, Erdem G, Alpay F. Evaluation of plasma ionized magnesium levels in neonatal hyperbilirubinemia. Pediatric research. 2004 Feb;55(2):243-7.
23. Shahriarpanah S, Tehrani FH, Davati A, Ansari I. Effect of phototherapy on serum level of calcium, magnesium and vitamin D in infants with hyperbilirubinemia. Iranian journal of pathology. 2018;13(3):357.