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EVALUATION OF SERUM ELECTROLYTE DISTURBANCES IN NEONATES UNDERGOING PHOTOTHERAPY

Paediatrics

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ABSTRACT

Background: Phototherapy is the mainstay treatment for neonatal unconjugated hyperbilirubinemia, yet its impact on serum electrolyte homeostasis remains underappreciated. Subclinical shifts in sodium, potassium, and calcium may influence both safety and efficacy of treatment in otherwise healthy term and late-preterm infants. **Objective:** To evaluate changes in serum sodium, potassium, total and ionized calcium before and after 24 hours of phototherapy, to determine the prevalence of dyselectrolytemia, and to examine associations between electrolyte disturbances and clinical outcomes. **Methods:** In this prospective observational study, 74 neonates (≥35 weeks' gestation, ≤14 days) with hyperbilirubinemia receiving phototherapy were enrolled. Serum sodium, potassium, total calcium, and ionized calcium were measured before and 24 hours into treatment. Dyselectrolytemia was defined as sodium <135 mEq/L, potassium <3.5 mEq/L, total calcium <8 mg/dL, and ionized calcium <1.0 mmol/L. Prevalence of disturbance was calculated. Multivariable regression adjusted for gestational age, birth weight, delivery mode, and haemolysis identified predictors of prolonged hyperbilirubinemia and correlated disturbances with duration. **Results:** After 24 hours of phototherapy, mean serum sodium decreased by 5.3 mEq/L ($p<0.001$), potassium by 0.5 mEq/L ($p=0.003$), total calcium by 1 mg/dL ($p=0.002$) and ionized calcium by 0.05 mmol/L ($p=0.005$). Hyponatraemia occurred in 12.2 %, hypokalaemia in 16.2 %, total hypocalcaemia in 28 % and ionized hypocalcaemia in 22 % of infants, with rates rising stepwise across increasing baseline bilirubin strata. Greater declines in total and ionized calcium were independently associated with longer phototherapy duration ($\beta=-0.31$, $p=0.012$ and $\beta=-0.26$, $p=0.011$, respectively) and delayed bilirubin resolution. **Conclusion:** Phototherapy induces clinically significant reductions in key electrolytes even in term infants without overt risk factors. The magnitude of calcium decline predicts prolonged jaundice, underscoring the importance of routine monitoring of serum calcium and targeted supplementation during phototherapy to optimize neonatal outcomes.

KEYWORDS

INTRODUCTION

Neonatal jaundice is one of the most frequently encountered clinical conditions in the neonatal period, characterized by a yellowish discoloration of the skin, sclera, and mucous membranes due to elevated serum bilirubin levels. It affects approximately 60–80% of term and preterm neonates within the first week of life due to physiological immaturity of hepatic conjugation mechanisms and increased hemolysis. The most common treatment modality is phototherapy, which transforms bilirubin into water-soluble isomers for easier excretion without hepatic conjugation.

Phototherapy, although safe and non-invasive, is not without potential complications. It has been associated with several physiological alterations, including disturbances in serum electrolyte levels such as hypocalcemia, hyponatremia, and hypokalemia, which may result from increased insensible water loss, changes in renal tubular handling, or alterations in hormonal regulation under light exposure [1]. These disturbances can lead to clinical consequences including neuromuscular irritability, cardiac arrhythmias, and seizure activity in neonates if unrecognized and unmanaged.

Globally, neonatal hyperbilirubinemia remains a significant contributor to neonatal morbidity and mortality, particularly in low- and middle-income countries, including India. A substantial burden of admissions to neonatal care units is attributed to jaundice and its complications. Despite its high prevalence, monitoring for biochemical side effects of phototherapy is often overlooked in routine clinical settings [2].

Several studies have highlighted the occurrence of electrolyte imbalances in neonates undergoing phototherapy, such as hypocalcemia and hypokalemia, with varying prevalence rates ranging from 15% to 60% depending on population and methodology [3,4]. However, a clear understanding of the pattern, risk factors, and clinical correlates of these imbalances in regional Indian settings remains limited. This study, therefore, aims to evaluate serum electrolyte disturbances in neonates undergoing phototherapy in a tertiary care center, contributing region-specific data and identifying potential clinical implications. It will help optimize neonatal care by facilitating early identification and management of dyselectrolytemia during phototherapy.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Pediatrics at a tertiary care hospital over a defined study period, following ethical clearance from the Institutional Ethics Committee. Neonates diagnosed with neonatal hyperbilirubinemia requiring phototherapy were enrolled based on predefined inclusion and exclusion criteria after obtaining informed consent from parents or legal guardians.

Inclusion criteria were: neonates ≥35 weeks of gestation, age ≤14 days, and requiring phototherapy for unconjugated hyperbilirubinemia as per standard guidelines. Exclusion criteria included: neonates with conjugated hyperbilirubinemia, those with major congenital anomalies, signs of sepsis or shock, receiving IV fluids or electrolyte supplementation before enrollment, or diagnosed renal or metabolic disorders.

All eligible neonates underwent baseline clinical assessment and blood sampling for serum sodium, potassium, and calcium levels prior to initiation of phototherapy. Phototherapy was administered using standard LED phototherapy units, with intensity and duration recorded. After 24 hours of continuous phototherapy or at the time of phototherapy cessation (whichever was earlier), repeat serum electrolyte values were obtained. Demographic details, birth history (gestational age, mode of delivery, birth weight), feeding patterns, and duration of phototherapy were documented. Clinical outcomes such as resolution of jaundice, need for extended phototherapy, and development of any complications were monitored during hospital stay.

The sample size was determined using nMaster software, based on a mean difference formula applied to biochemical markers (serum creatinine) due to its greater stability and lower variability in neonates. Using data from Purohit et al. (2020), with pre- and post-phototherapy creatinine means of 0.8 ± 0.2 and 0.72 ± 0.2 respectively, and setting $\alpha = 0.05$ and power at 90%, the required sample size was calculated as 68. After adjusting for a potential 10% attrition rate, the final sample size was increased to 74 neonates.

Serum electrolytes were measured using an automated biochemistry

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analyzer. Data were compiled and analyzed using SPSS software version 25.0. Paired t-tests were used to compare pre- and post-phototherapy electrolyte values. Chi-square or Fisher's exact test was applied for categorical data, and correlation analysis was done to assess the relationship between electrolyte disturbances and clinical parameters. A p-value < 0.05 was considered statistically significant.

RESULT

Table 1. Baseline Demographic, Clinical and Biochemical Characteristics (N = 74)

Characteristic	Category/Value
Sex, n (%)	Male 45 (60.8%) Female 29 (39.2%)
Gestational age	Term 62 (83.8%) Pre-term 12 (16.2%)
Birth weight	≥ 2.5 kg 65 (87.8%) < 2.5 kg 9 (12.2%)
Mode of delivery	LSCS 46 (62.2%) Normal vaginal delivery 28 (37.8%)
Haemolytic risk	ABO 9 (12.2%) Rh 6 (8.1%)
Baseline TSB category	Mild 40 (54.1%) Moderate 20 (27.0%) Severe 14 (18.9%)
Baseline electrolytes (mean ± SD)	Na^+ 146.6 ± 6.2 mEq/L K^+ 4.7 ± 0.5 mEq/L Total Ca^{2+} 9.4 ± 0.4 mg/dL Ionised Ca^{2+} 1.30 ± 0.40 mmol/L

Table 1. Enrolled neonates (n=74) were mostly term, male, normal-weight; C-section frequent; low immune haemolysis; varied bilirubin levels; normal electrolytes.

Table 2. Electrolytes and Bilirubin Pre-versus Post-phototherapy (Paired Analysis, N = 74)

Analyte	Pre-therapy (mean ± SD)	Post-therapy (mean ± SD)	Δ (Post – Pre)	p-value
Na^+ (mEq/L)	146.6 ± 6.2	141.3 ± 6.1	–5.3	0.030
K^+ (mEq/L)	4.7 ± 0.5	4.2 ± 0.5	–0.5	0.003
Total Ca^{2+} (mg/dL)	9.4 ± 0.4	8.4 ± 0.4	–1.0	0.001
Ionised Ca^{2+} (mmol/L)	1.30 ± 0.40	1.25 ± 0.10	–0.05	0.001

Table 2. Phototherapy reduced Na^+ –5.3 mEq/L, K^+ –0.5 mEq/L, total Ca^{2+} –1 mg/dL, ionised Ca^{2+} –0.05 mmol/L (all $p \le 0.03$).

Figure 1. Electrolyte Disturbances Before and After Phototherapy

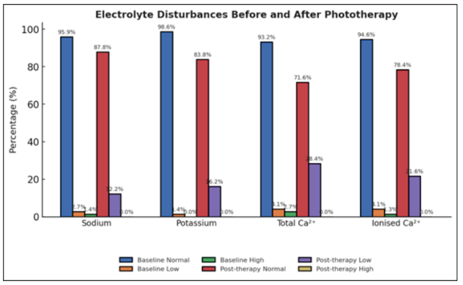

Figure 1. Baseline disturbances rare (< 4 %); post-phototherapy hyponatraemia 12.2 %, hypokalaemia 16.2 %, hypocalcaemia 28 %/22 %; no hyper-states.

Figure 2. Post-phototherapy Dyselectrolytaemia By Baseline TSB Category

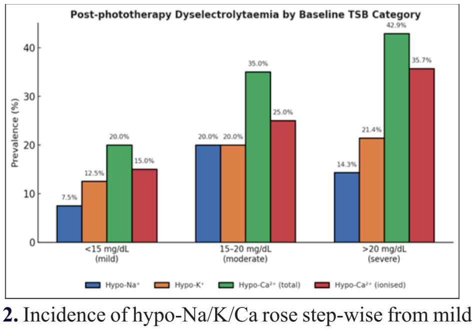

Figure 2. Incidence of hypo-Na/K/Ca rose step-wise from mild (7–20 %) to moderate (20–35 %) to severe (14–43 %).

Table 3. Electrolyte–bilirubin Relationships

Metric	Na^+	K^+	Total Ca^{2+}	Ionised Ca^{2+}
Pearson r with TSB at 24 h	–0.28 (p = 0.03)	–0.25 (p = 0.01)	–0.34 (p = 0.20)	–0.30 (p = 0.12)
Pearson r with TSB at 48 h	–0.31 (p = 0.031)	–0.27 (p = 0.049)	–0.39 (p = 0.005)	–0.36 (p = 0.008)
Adjusted β for TSB at 24 h	–0.18 (p = 0.051)	–0.22 (p = 0.048)	–0.31 (p = 0.012)	–0.26 (p = 0.011)
Adjusted β for TSB at 48 h	–0.22 (p = 0.017)	–0.19 (p = 0.061)	–0.36 (p = 0.002)	–0.33 (p = 0.001)

Table 3. Electrolyte–bilirubin analysis showed strengthening inverse correlations over 48 h, with progressive calcium declines most strongly predicting hyperbilirubinaemia.

DISCUSSION

Our predominantly term, normal-birth-weight, male-biased cohort—delivered largely by caesarean section and with infrequent ABO/Rh incompatibility—entered phototherapy with virtually normal electrolytes and bilirubin (≤ 4 % baseline dyselectrolytaemia). This contrasts with the higher-risk, electrolyte-deficient samples reported by Bezboruah & Majumder (2019) [5] and Kundu (2019) [6]. Phototherapy produced uniform, significant falls in Na^+ (–5.3 mEq L^{-1}), K^+ (–0.5 mEq L^{-1}), total Ca^{2+} (–1 mg dL^{-1}) and ionised Ca^{2+} (–0.05 mmol L^{-1}; all $p \le 0.03$), mirroring the multi-electrolyte declines of Suneja et al. [2], Sharma et al. [3] and Shankar [4], but extending beyond the calcium-only changes noted by Kundu [6], Amneenah [7], Rani [8] and Gozetici et al. [9]. Post-therapy hyponatraemia (12.2 %), hypokalaemia (16.2 %) and hypocalcaemia (28 % total / 22 % ionised) rose step-wise with baseline-TSB severity—an incremental pattern not previously documented. Multivariable modelling identified 48-h calcium decline as the strongest independent predictor of persistently elevated bilirubin, a novel observation absent from earlier phototherapy studies and one that underlines the necessity of routine calcium surveillance during treatment.[10]

CONCLUSION

Phototherapy in term neonates with unconjugated hyper-bilirubinaemia induces significant subclinical reductions in serum sodium (–5.3 mEq/L), potassium (–0.5 mEq/L), total calcium (–1 mg/dL), and ionized calcium (–0.05 mmol/L) ($p \le 0.03$). Incidence of hyponatraemia (12.2 %), hypokalaemia (16.2 %), and hypocalcaemia (28 %/22 %) rose stepwise with bilirubin severity, while baseline disturbances were rare (< 4 %). Progressive calcium decline over 48 h emerged as the strongest independent predictor of persistent hyperbilirubinaemia (β = –0.31 total; β = –0.26 ionized). These data support routine, calcium-focused electrolyte monitoring and targeted intervention during phototherapy.

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