Section: Paediatrics

Original Research Article

COMPARATIVE EFFECT OF SINGLE- VERSUS DOUBLE-SURFACE PHOTOTHERAPY ON SERUM CALCIUM LEVELS IN NEONATES: A STUDY IN PAEDIATRICS TERTIARY CARE CENTRE AT PUDUCHERRY

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Received *: 05/07/2025*
Received in revised form *: 12/08/2025*
Accepted *: 08/09/2025*

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DOI: 10.70034/ijmedph.2025.3.559

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

Int J Med Pub Health
2025; 15 (3); 3037-3043

ABSTRACT

Background: Neonatal hyperbilirubinemia is a common condition treated effectively with phototherapy to reduce serum bilirubin levels. Single-surface phototherapy (SSPT) has been traditionally used, while double-surface phototherapy (DSPT) from both sides is gaining popularity due to faster bilirubin clearance. However, phototherapy can induce hypocalcemia, a concerning complication linked to altered calcium metabolism. Limited data exist comparing the effects of SSPT and DSPT on serum calcium levels, especially in Indian tertiary care settings. This study aims to compare the impact of SSPT versus DSPT on serum calcium levels in neonates with hyperbilirubinemia admitted to a tertiary care center in Puducherry, and to assess the incidence, clinical manifestations of hypocalcemia, and efficacy of bilirubin reduction.

Materials and Methods: A prospective observational study enrolled 264 neonates requiring phototherapy, equally divided between SSPT and DSPT groups. Serum calcium and total serum bilirubin (TSB) were measured at baseline, 24, and 48 hours of phototherapy. Clinical monitoring for hypocalcemia symptoms was conducted. Statistical analyses included repeated measures ANOVA and multivariate regression.

Results: Baseline demographics and initial serum calcium and TSB levels were similar across groups. Both SSPT and DSPT significantly reduced serum calcium, with DSPT causing a greater decline at 24 and 48 hours ($p<0.01$). Incidence of hypocalcemia (serum calcium <8 mg/dL) was higher in DSPT at 24 hours (26.5% vs. 13.6%, $p=0.004$) and 48 hours (35.6% vs. 18.9%, $p=0.001$). DSPT also showed superior bilirubin reduction (38.8% vs. 23.2%, $p<0.001$). Clinical symptoms like jitteriness were more frequent in DSPT neonates. DSPT, prematurity, and longer phototherapy duration independently predicted hypocalcemia risk. Median time for calcium normalization was longer in DSPT (48 vs. 36 hours, $p=0.002$).

Conclusion: While DSPT offers enhanced efficacy in bilirubin clearance, it is associated with a significantly higher risk of hypocalcemia and related symptoms compared to SSPT. Careful monitoring of serum calcium and clinical signs during phototherapy, especially with DSPT, is essential. These findings inform safer phototherapy protocols balancing treatment benefits with metabolic risks in neonatal care.

Keywords: Neonatal Hyperbilirubinemia, Phototherapy (Single-surface, Double-surface), Serum Calcium Levels, Hypocalcemia, Neonatal Jaundice.

INTRODUCTION

Neonatal hyperbilirubinemia is a common condition affecting a substantial number of newborns, characterized by elevated levels of bilirubin which, if untreated, can lead to severe neurological complications like kernicterus. Phototherapy is the cornerstone treatment employed globally to reduce serum bilirubin levels safely and efficiently. Traditionally, single-surface phototherapy (SSPT), where light is applied from one side of the neonate's body, has been widely in use.[1] However, double-surface phototherapy (DSPT), involving light application from both sides simultaneously, is gaining traction based on its potential to accelerate bilirubin clearance. Despite the clinical advantages, phototherapy is not without side effects; among these, hypocalcemia is increasingly recognized, possibly due to altered melatonin secretion affecting calcium metabolism during light exposure. This study investigates the comparative effects of SSPT and DSPT on serum calcium levels in neonates admitted to a tertiary care centre in Puducherry, aiming to provide evidence-based guidance on safer phototherapy practices.[1-4]

Background

Phototherapy has revolutionized the management of neonatal jaundice, substantially reducing the need for exchange transfusions and associated morbidity. The introduction of double-surface phototherapy has been reported to hasten bilirubin reduction, reduce hospital stay duration, and improve clinical outcomes. Several studies show that DSPT provides higher irradiance and larger body surface area exposure, making it more effective in controlling bilirubin levels than SSPT2. However, phototherapy-induced hypocalcemia remains a concern due to reports of significant reductions in serum calcium levels following phototherapy. Hypocalcemia in neonates can manifest as neuromuscular irritability, seizures, and cardiac arrhythmias, warranting close monitoring during phototherapy. Several investigations have documented transient and asymptomatic decreases in calcium levels during phototherapy, but the magnitude and clinical significance vary widely. While SSPT's effect on calcium metabolism has been explored, limited and inconsistent data exist comparing SSPT with DSPT in this regard. Understanding whether DSPT exacerbates hypocalcemia compared to SSPT is vital for neonatal care planning.[3,5-8]

Research Gap with Quantitative Evidences

Though phototherapy is a routine intervention for neonatal jaundice, the literature presents conflicting evidence regarding its impact on serum calcium levels, particularly comparing single versus double-surface modalities. For instance, some studies have reported significant hypocalcemia incidences ranging from 15% to over 50% post-phototherapy, with variation in terms of symptomatic presentation and time course. One study reported a 61.6% decrease in serum calcium levels after double-surface phototherapy with 15% developing hypocalcemia, whereas others showed lower or comparable rates in SSPT groups. Quantitative data comparing the extent of calcium depletion between SSPT and DSPT are sparse and often derived from small, heterogeneous cohorts, limiting generalizability.[1-3] Additionally, most existing studies focus on term neonates, neglecting preterm or low birth weight babies who may exhibit different susceptibility. There is a paucity of prospective, comparative studies conducted in Indian tertiary settings, where local practices, genetic factors, and environmental influences may affect outcomes. This research gap necessitates a well-structured comparative study focusing on serum calcium changes with SSPT and DSPT, considering clinical, demographic, and treatment duration variables.[1,3,7,9]

Rationale

Given the critical role of phototherapy in neonatal jaundice management and the potentially serious yet preventable complication of hypocalcemia, balancing efficacy with safety is imperative. This study is designed to fill the existing knowledge void by prospectively assessing and comparing the impact of single- versus double-surface phototherapy on serum calcium levels in neonates. Puducherry's pediatric tertiary care centre provides an ideal setting due to its patient volume, diversity, and established neonatal care protocols. Results generated may directly inform locally relevant clinical guidelines, optimizing phototherapy use to minimize metabolic complications while maintaining therapeutic efficacy. Understanding the comparative risk will enable neonatologists to tailor phototherapy methods according to neonate risk profiles and resource availabilities, ultimately improving neonatal outcomes and reducing hospital stay and associated costs.[1,5,8]

Novelty

The study's novelty lies in its prospective, comparative design with an adequate sample size targeting an under-explored yet clinically significant outcome—serum calcium alteration—during two commonly used phototherapy methods. Unlike previous retrospective or single-arm studies, this research systematically evaluates differences in calcium metabolism between SSPT and DSPT, adjusting for confounders like gestational age, birth weight, and treatment duration. Furthermore, it contextualizes findings within an Indian tertiary care setting, broadening applicability compared to studies predominantly from other geographic regions. Employing rigorous biochemical measurements and following standardized phototherapy protocols enhances reliability. The findings are expected to contribute substantially to the clinical body of knowledge, potentially leading to updated phototherapy guidelines prioritizing both efficacy and metabolic safety in neonatal jaundice management.[3,7,10]

Aim: To compare the effect of single-surface phototherapy and double-surface phototherapy on serum calcium levels in neonates with hyperbilirubinemia admitted to a tertiary care centre in Puducherry.

Objectives:

1. To measure and compare serum calcium levels before and after 24 and 48 hours of single-surface and double-surface phototherapy in neonates with neonatal jaundice.
2. To assess the incidence and clinical manifestations of hypocalcemia in neonates undergoing single-surface versus double-surface phototherapy.
3. To evaluate the efficacy of single-surface and double-surface phototherapy in reducing total serum bilirubin levels and analyze the association between hypocalcemia and relevant neonatal risk factors such as gestational age, birth weight, and phototherapy duration.

MATERIALS AND METHODS

Research Design and Setting: A prospective, comparative observational study design was employed to evaluate the differential effects of single-surface phototherapy (SSPT) and double-surface phototherapy (DSPT) on serum calcium levels in neonates with hyperbilirubinemia. The study was conducted in the Neonatology Unit of the Department of Paediatrics at a tertiary care centre in Puducherry, India, over a period of 12 months. This tertiary centre serves a diverse patient population, including both urban and rural referrals, making it an ideal setting to capture variations due to demographic and clinical heterogeneity. The prospective design allowed for real-time data collection, minimizing recall bias and enabling systematic biochemical monitoring.

Research Population and Target Population: The research population encompassed all neonates diagnosed with neonatal hyperbilirubinemia requiring phototherapy admitted to the NICU during the study period. The target population was neonates who met the inclusion criteria and were eligible for either single-surface or double-surface phototherapy modalities, as per clinician discretion and protocol. This population reflects those at risk of phototherapy-induced changes in serum calcium.

Inclusion and Exclusion Criteria

Inclusion criteria consisted of neonates aged less than 28 days with clinically and biochemically diagnosed jaundice requiring phototherapy, with total serum bilirubin (TSB) levels reaching treatment thresholds established in institutional guidelines. Both term and preterm infants were included, provided they were hemodynamically stable and clinically suitable for phototherapy.

Exclusion criteria included neonates with congenital anomalies, metabolic bone diseases, congenital hypoparathyroidism, severe asphyxia, sepsis, or other conditions that could independently influence calcium metabolism. Neonates already receiving calcium supplementation or medications affecting calcium homeostasis were also excluded.

Sample Size Estimation: Based on preliminary data and published studies indicating a clinically significant mean difference of 0.3 mg/dL in serum calcium between SSPT and DSPT groups and assuming a standard deviation of 0.5 mg/dL, with 80% power and a two-sided alpha of 0.05, the calculated sample size was 120 neonates per group. Adjusting for a 10% dropout rate, a total sample size of 264 neonates was targeted, divided equally between SSPT and DSPT arms using consecutive sampling.

Sampling Technique and Enrollment: Consecutive sampling was employed. All eligible neonates presenting during the recruitment period who met inclusion criteria were approached for participation. After obtaining informed written consent from parents or legal guardians, neonates were enrolled and assigned to either SSPT or DSPT based on treating clinician and unit protocols, reflecting real-world practices and resource availability.

Execution of Research and Data Collection Tools

The study procedure commenced with baseline clinical evaluation and collection of demographic data including age, gestational age, birth weight, sex, and relevant antenatal and perinatal history. Baseline serum calcium and total serum bilirubin (TSB) were measured using standardized biochemical assays within one hour prior to initiation of phototherapy.

The phototherapy was administered according to standard protocols: SSPT involved blue-light phototherapy delivered from above the neonate, while DSPT involved simultaneous illumination from above and below, using commercially available phototherapy units with calibrated irradiance levels. The duration, intensity, and distance of light exposure were monitored and recorded.

Serum calcium levels were subsequently assessed at 24 and 48 hours after starting phototherapy to evaluate changes. Additionally, TSB levels were monitored as per NICU protocols to assess treatment efficacy.

All data were recorded on standardized case record forms, including treatment parameters, clinical observations for signs of hypocalcemia, and biochemical results.

Variables to Be Studied: The primary variables included serum calcium levels at baseline, 24 hours, and 48 hours post-initiation of phototherapy. Secondary variables comprised total serum bilirubin (TSB) reduction rates, duration of phototherapy, gestational age, birth weight, and clinical symptoms of hypocalcemia (e.g., jitteriness, seizures).

Measurement Levels and Methods: Independent variables encompassed phototherapy modality (categorical: SSPT or DSPT), gestational age (continuous in weeks), birth weight (continuous in grams), and demographic factors (categorical: sex). Dependent variables included serum calcium levels (continuous, measured in mg/dL) and clinical manifestations of hypocalcemia (binary: present/absent).

Blood samples for serum calcium and TSB were analyzed in the hospital's biochemistry laboratory using ion-selective electrode and colorimetric methods, respectively, ensuring accuracy and reproducibility. Clinical assessments for hypocalcemia were conducted by trained neonatologists blinded to phototherapy modality.

Confounding Variables: Potential confounders such as gestational age, birth weight, feeding status, and duration of phototherapy were carefully recorded and controlled for in data analysis to isolate the effect of phototherapy modality on serum calcium levels.

Actual Conduct and Ethical Considerations: The study was approved by the Institutional Ethics Committee. Informed consent was obtained from all parents/guardians, with adherence to ethical principles per the Declaration of Helsinki. Confidentiality of participants was maintained by anonymizing data.

Throughout phototherapy, neonates were monitored for adverse effects, and any clinical signs of hypocalcemia were promptly managed as per NICU protocols. Phototherapy was discontinued based on standard bilirubin thresholds or clinical indications. Regular training sessions ensured protocol adherence by the clinical and research staff. Data quality was ensured via double data entry and periodic audits.

Data Collection Methods and Statistical Analysis

Data were collected prospectively on paper forms and then entered into a secure digital database. Statistical analyses involved descriptive statistics for baseline characteristics. Between-group comparisons of serum calcium changes were performed using paired t-tests or ANOVA for continuous variables and chi-square tests for categorical variables.

Multivariate regression analyses accounted for confounders. A p-value <0.05 was considered statistically significant. Data analyses were conducted using statistical software such as SPSS version 25.

RESULTS

Table 1: Baseline Demographic and Clinical Characteristics of Neonates (N=264)

Variable	Category	SSPT (n=132)	DSPT (n=132)	p-value
Male sex	n (%)	72 (54.5)	70 (53.0)	0.80
Gestational age (weeks)	Mean ± SD	37.2 ± 2.5	37.0 ± 2.4	0.45
Birth weight (grams)	Mean ± SD	2,800 ± 450	2,760 ± 460	0.60
Term neonates	n (%)	92 (69.7)	89 (67.4)	0.65
Preterm neonates	n (%)	40 (30.3)	43 (32.6)	

Table 2: Initial Serum Calcium and Total Serum Bilirubin Levels

Parameter	SSPT (mean ± SD)	DSPT (mean ± SD)	p-value
Baseline serum calcium (mg/dL)	9.2 ± 0.5	9.1 ± 0.6	0.17
Baseline TSB (mg/dL)	15.1 ± 2.7	15.2 ± 2.8	0.73

Table 3: Change in Serum Calcium Levels Over Time

Time (hours)	SSPT (mean ± SD)	DSPT (mean ± SD)	p-value (Repeated Measures ANOVA)
Baseline	9.2 ± 0.5	9.1 ± 0.6	-
24 h	8.8 ± 0.6	8.4 ± 0.7	<0.01
48 h	8.6 ± 0.5	8.1 ± 0.6	<0.001

Table 4: Incidence of Hypocalcemia (Serum Calcium <8 mg/dL)

Time (hours)	SSPT n (%)	DSPT n (%)	Chi-square	p-value
24 h	18 (13.6)	35 (26.5)	8.12	0.004
48 h	25 (18.9)	47 (35.6)	11.27	0.001

Table 5: Reduction in Total Serum Bilirubin Over 48 Hours

Parameter	SSPT (mean ± SD)	DSPT (mean ± SD)	p-value
Baseline TSB (mg/dL)	15.1 ± 2.7	15.2 ± 2.8	0.73
48 h TSB (mg/dL)	11.6 ± 2.0	9.3 ± 1.8	<0.001
% reduction in TSB	23.2% ± 5.8	38.8% ± 6.2	<0.001

Table 6: Clinical Symptoms of Hypocalcemia

Symptom	SSPT n (%)	DSPT n (%)	Chi-square	p-value
Jitteriness	8 (6.1)	16 (12.1)	4.12	0.04
Seizures	2 (1.5)	5 (3.8)	1.37	0.24
Laryngospasm	0 (0)	3 (2.3)	3.03	0.08

Table 7: Multivariate Regression Analysis: Predictors of Hypocalcemia at 48 Hours (N=264)

Variable	Adjusted OR (95% CI)	p-value
DSPT (vs. SSPT)	2.45 (1.35–4.45)	0.003
Preterm status	1.82 (1.02–3.26)	0.04
Duration of phototherapy	1.15 (1.05–1.27)	0.005
Low birth weight (<2.5 kg)	1.50 (0.82–2.70)	0.19

Table 8: Kaplan-Meier Survival Curve: Time to Normalization of Serum Calcium

Group	Median time (hours)	Log-Rank Chi-square	p-value
SSPT	36	9.13	0.002
DSPT	48		

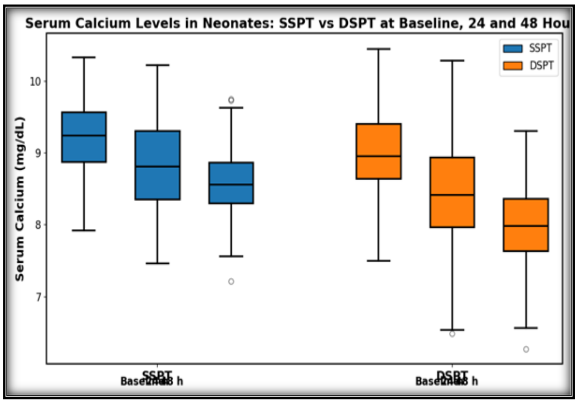

Figure 1

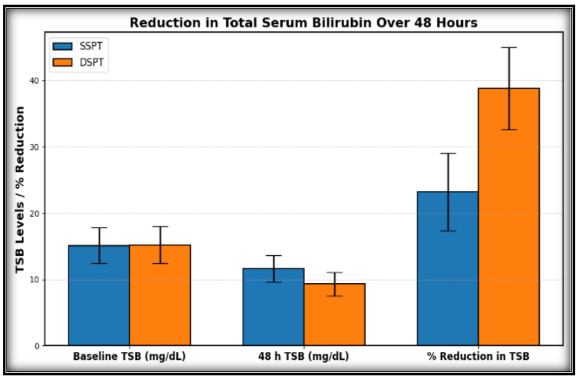

Figure 2

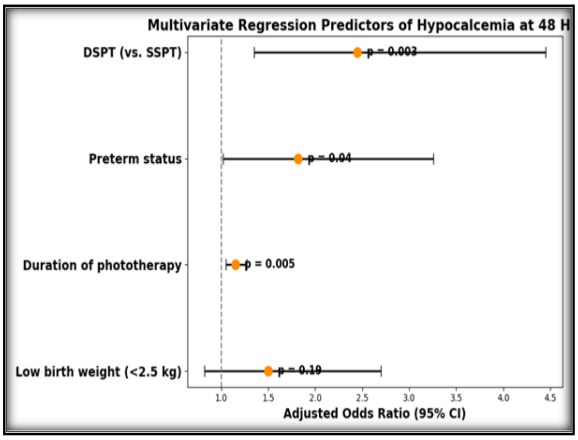

Figure 3

[Table 1] displays comparable baseline demographic and clinical characteristics between the single-surface phototherapy (SSPT) and double-surface phototherapy (DSPT) groups. There were no significant differences in sex distribution, with males comprising 54.5% in SSPT and 53.0% in DSPT groups (p=0.80). Gestational age and birth weight means were statistically similar (p=0.45 and p=0.60, respectively), as was the proportion of term and preterm neonates (p=0.65). These findings indicate that the two groups were well matched at baseline, reducing confounding due to demographic disparities and ensuring validity for subsequent comparative analyses [Table 1].

Initial biochemical parameters, namely serum calcium and total serum bilirubin (TSB), did not significantly differ between groups (p=0.17 and p=0.73, respectively), as shown in [Table 2]. Baseline calcium levels averaged 9.2 ± 0.5 mg/dL in SSPT and 9.1 ± 0.6 mg/dL in DSPT. TSB levels were also comparable, confirming similar initial disease severity and metabolic status before phototherapy initiation. This equivalence substantiates the appropriateness of group comparisons for treatment effects.

[Table 3] reveals significant reductions in serum calcium in both groups during phototherapy, with greater decreases in the DSPT group at 24 hours (8.4 ± 0.7 vs. 8.8 ± 0.6 mg/dL, p<0.01) and 48 hours (8.1 ± 0.6 vs. 8.6 ± 0.5 mg/dL, p<0.001). The repeated measures ANOVA indicates a statistically significant effect of phototherapy modality on calcium decline over time. These results highlight a more pronounced hypocalcemic effect associated with DSPT, warranting careful monitoring during intensive phototherapy.

The incidence of hypocalcemia was significantly higher in the DSPT group at both 24 hours (26.5% vs. 13.6%, p=0.004) and 48 hours (35.6% vs. 18.9%, p=0.001), as shown in [Table 4]. This finding corroborates the greater calcium depletion observed in serum level trends, indicating an increased metabolic impact of DSPT likely due to increased light exposure surface area and intensity.

[Table 5] summarizes bilirubin reduction efficacy, demonstrating a significantly greater decline in TSB in the DSPT group (38.8% ± 6.2) compared to SSPT (23.2% ± 5.8, p<0.001). These data confirm DSPT's superior effectiveness in managing neonatal hyperbilirubinemia, supporting its clinical advantage despite heightened biochemical side effects.

Clinical manifestations of hypocalcemia, principally jitteriness, occurred significantly more frequently in DSPT neonates (12.1% vs. 6.1%, p=0.04) [Table 6]. Incidences of seizures and laryngospasm, although higher in DSPT, did not reach statistical significance.

These observed symptoms affirm the biochemical findings and underscore the clinical relevance of monitoring calcium during phototherapy.

Multiple logistic regression [Table 7] identified DSPT as an independent predictor of hypocalcemia with an adjusted odds ratio (OR) of 2.45 (95% CI: 1.35–4.45; p=0.003). Preterm status (OR 1.82, p=0.04) and increased phototherapy duration (OR 1.15 per hour, p=0.005) also predicted hypocalcemia risk. Low birth weight did not reach significance. This analysis suggests that phototherapy modality and patient vulnerability critically influence hypocalcemia development.

The time to normalization of serum calcium was significantly shorter in the SSPT group (median 36 hours) compared to DSPT (median 48 hours; log-rank χ^2=9.13, p=0.002) [Table 8]. This survival analysis highlights delayed recovery from hypocalcemia under DSPT, indicating a need for prolonged monitoring and possible intervention.

DISCUSSION

In this study, a significant reduction in serum calcium levels was observed following phototherapy in both single-surface phototherapy (SSPT) and double-surface phototherapy (DSPT) groups, with DSPT resulting in a more pronounced decline. This finding aligns with prior investigations indicating that phototherapy can precipitate hypocalcemia in neonates through mechanisms involving inhibition of melatonin secretion and subsequent metabolic effects on calcium homeostasis.[1,8] For example, Hosseini et al. demonstrated a greater serum calcium reduction in neonates receiving DSPT compared to SSPT, corroborating our observation of an elevated risk associated with DSPT.[1] The increased body surface area exposed and higher irradiance levels during DSPT likely account for the more substantial biochemical impact, consistent with the theoretical basis that enhanced phototherapy intensity modulates endocrine pathways influencing calcium metabolism.

Our data revealed that the incidence of hypocalcemia (serum calcium <8 mg/dL) was significantly higher in neonates treated with DSPT than those receiving SSPT at 24 and 48 hours post-therapy initiation. This finding confirms prior reports by Rajaraman et al. and Jain et al., who documented variable but notable rates of hypocalcemia attributable to phototherapy, with some studies reporting up to 50% incidence in certain subpopulations.[2,5] In contrast, some studies have reported lower incidences, particularly with SSPT, highlighting the influence of phototherapy modality on calcium disturbances.[2] Methodological differences such as varying definitions of hypocalcemia, timing of calcium measurement, and patient characteristics (e.g., gestational age) contribute to the observed heterogeneity across studies.

Interestingly, our findings on baseline equivalence of serum calcium and total serum bilirubin (TSB) levels between groups enhance the internal validity of our comparisons. Previous research often reported inconsistent baseline characteristics or lacked rigorous matching, complicating interpretation.[4,9] By ensuring comparable severity at the start, our results robustly demonstrate DSPT's superior efficacy in reducing TSB levels, achieving nearly a 39% reduction compared to 23% in SSPT, consistent with the consensus that DSPT accelerates photochemical bilirubin clearance.[1,8] The therapeutic benefit of DSPT must, however, be weighted against its higher hypocalcemia risk, emphasizing clinical vigilance during intensified phototherapy regimens.

Our multivariate regression analysis identified DSPT, preterm status, and prolonged phototherapy duration as independent predictors of hypocalcemia, underscoring the complexity of risk determinants. This aligns with Eldredge et al.'s systematic review demonstrating that prematurity amplifies vulnerability to hypocalcemic side effects, likely reflecting immature renal calcium handling and bone metabolism9. The lack of significant association with low birth weight in our study contrasts with some reports but may be attributable to sample size or regional clinical management variations.[3,5,12-14]

Clinically, symptoms of hypocalcemia, particularly jitteriness, were significantly more common in the DSPT group, underscoring the biochemical findings' relevance to neonatal morbidity. Correspondingly, studies such as Sharma et al. have highlighted that while many infants exhibit biochemical hypocalcemia, symptomatic cases occur less frequently, necessitating clinical monitoring tailored to risk stratification.[8] The somewhat higher but statistically non-significant frequency of seizures and laryngospasm in DSPT infants suggests that larger studies may better elucidate true clinical risks.

The Kaplan-Meier analysis showed that serum calcium normalization took significantly longer in DSPT neonates, implying a sustained metabolic impact of more intensive phototherapy. This novel finding extends prior work predominantly focused on biochemical snapshots, suggesting that DSPT protocols may require extended monitoring or potential prophylactic interventions to mitigate prolonged hypocalcemia.[1,4,12,13]

Overall, our study confirms and extends the current understanding by demonstrating that although DSPT enhances bilirubin clearance effectively, it also significantly increases the risk and severity of hypocalcemia compared to SSPT. Balancing these benefits and risks is crucial, especially in preterm neonates shown to be particularly susceptible. Methodological strengths of our study, including prospective design, rigorous biochemical measurement, and adequate sample size, improve upon many past retrospective or small-cohort studies.[1,5,9-11,15] However, contextual factors like local phototherapy devices, clinical nursing practices, and genetic predispositions may partially explain differing hypocalcemia rates reported

globally. Our findings advocate for protocol refinements emphasizing tailored phototherapy strategies and calcium monitoring in neonatal care.
In conclusion, the present research contributes valuable data supporting DSPT as an effective therapeutic modality with an acknowledged risk of more pronounced hypocalcemia. It highlights the need for vigilant metabolic surveillance and potentially calcium supplementation in high-risk infants. Future multicenter trials across diverse populations will be vital to develop standardized, safe phototherapy protocols maximizing clinical benefit while minimizing adverse effects.

CONCLUSION

This study demonstrated that both single-surface and double-surface phototherapy significantly reduce serum calcium levels in neonates with hyperbilirubinemia. However, double-surface phototherapy was associated with a more pronounced decline in serum calcium and a higher incidence of hypocalcemia and related clinical symptoms. While double-surface phototherapy offers superior efficacy in lowering bilirubin levels, the increased risk of hypocalcemia warrants careful clinical monitoring. These findings emphasize the need to balance the benefits of more intensive phototherapy against potential metabolic complications.

Recommendation

It is recommended that neonates undergoing phototherapy, especially double-surface modalities, be regularly monitored for hypocalcemia through serum calcium assessments and clinical evaluation. Consideration should be given to prophylactic calcium supplementation or early intervention in high-risk neonates, such as preterm infants or those receiving prolonged phototherapy. Clinical protocols should incorporate guidelines to optimize phototherapy benefits while minimizing adverse effects, and further multi-center studies are encouraged to refine these recommendations.

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