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RESEARCH ARTICLE

Transcutaneous Bilirubinometer as a Non-Invasive Tool for Monitoring Neonatal Jaundice: A Correlation Study with Serum Bilirubin

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Abstract: ***Background***: Neonatal jaundice affects over half of newborns, and early bilirubin monitoring is crucial. Serum bilirubin estimation is invasive; transcutaneous bilirubinometry offers a safer non-invasive alternative. ***Objectives:*** To determine TcB–TSB correlation, assess the influence of neonatal factors including gestational age, birth weight, feeding type, and skin tone, and evaluate TcB's role in monitoring neonatal jaundice. ***Methods:*** A prospective observational study included 400 neonates with visible jaundice. TcB was measured at forehead and sternum, compared with TSB using paired t-tests, Pearson correlation, and 95% confidence intervals. **Results:** Mean TcB decreased significantly post-management (forehead: 15.22±1.82 to 10.10±1.65; sternum: 15.23±1.84 to 10.65±1.68; p<0.0001). Strong TcB–TSB correlations were observed (forehead r=0.826, p=0.001; sternum r=0.772, p=0.011). ***Conclusion:*** TcB strongly correlates with TSB, reliably tracks bilirubin decline, and offers accurate, non-invasive monitoring of neonatal jaundice, though confirmatory serum testing remains essential in critical decision-making.

Keywords: Neonatal jaundice, transcutaneous bilirubin, total serum bilirubin, non-invasive monitoring, correlation, hyperbilirubinemia.

INTRODUCTION

Neonatal jaundice is one of the most frequent clinical conditions encountered in newborns, resulting from the physiological immaturity of hepatic bilirubin metabolism. Bilirubin, a breakdown product of hemoglobin, requires efficient hepatic uptake, conjugation, and excretion for clearance; disruption at any of these steps predisposes to hyperbilirubinemia (1). While most cases are benign and transient, severe or untreated hyperbilirubinemia can lead to acute bilirubin encephalopathy or kernicterus, conditions associated with irreversible neurodevelopmental impairment and mortality (2).

Globally, neonatal jaundice affects approximately 60% of term and 80% of preterm infants, with higher incidence in Asian and African populations (3). In India, the burden is substantial due to a high prevalence of preterm births, inadequate screening resources, and delayed care-seeking behavior (4). Although serum bilirubin measurement is considered the diagnostic gold standard, it requires invasive blood sampling, laboratory infrastructure, and causes discomfort and risk of infection (5).

Recent advances have introduced transcutaneous bilirubinometry and optical diagnostic tools that allow rapid, non-invasive assessment of bilirubin levels (6). These devices provide point-of-care evaluation, reduce repeated blood sampling, and improve compliance in resource-limited settings. However, their accuracy can vary with skin pigmentation, gestational age, and device calibration, necessitating validation in different populations (7). Moreover, large-scale adoption in Indian clinical practice is limited by affordability and lack of local validation studies (8).

Despite international studies demonstrating reliability, there is a paucity of region-specific data from Tier-II Indian hospitals, where neonatal jaundice contributes significantly to NICU admissions. Establishing the diagnostic accuracy and reliability of non-invasive bilirubin estimation tools in this context is therefore crucial. This study aims to address these gaps, providing evidence for safer, rapid, and cost-effective jaundice screening tailored to the Indian neonatal population, ultimately strengthening early detection and management.

MATERIAL AND METHODS

Study Area: B.R.D. MEDICAL COLLEGE, GORAKHPUR
Study Design: Prospective observational study
Study population: Neonates (both term and preterm) admitted in the neonatal intensive care unit (NICU) and postnatal ward with clinical jaundice.
Study duration: From March 2024 to Feb 2025
Sampling procedure: Purposive sampling – all neonates presenting with jaundice
Sample Size: 400
Sample Selection
Inclusion Criteria:

1. . Neonates with visible jaundice within the first seven days of life.

2. Both term and preterm infants (gestational age ≥32 weeks)

Exclusion Criteria:

1. Infants with congenital anomalies affecting the liver or skin.
2. Neonates who have received phototherapy or blood transfusion before the initial assessment.

Statistical Analysis:

Statistical analysis was conducted using SPSS software (version 27.0; SPSS Inc., Chicago, IL, USA). Descriptive statistics (mean, SD, frequencies, percentages) summarized demographic and clinical variables. Paired t-tests compared initial and follow-up transcutaneous bilirubin (TCB) readings (forehead, sternum) with total serum bilirubin (TSB). Pearson correlation assessed relationships between TCB and TSB. A p-value <0.05 was considered significant, with <0.001 highly significant; 95% confidence intervals were calculated.

RESULTS

Out of the total neonates enrolled, 228 (57.0%) were male and 172 (43.0%) were female.

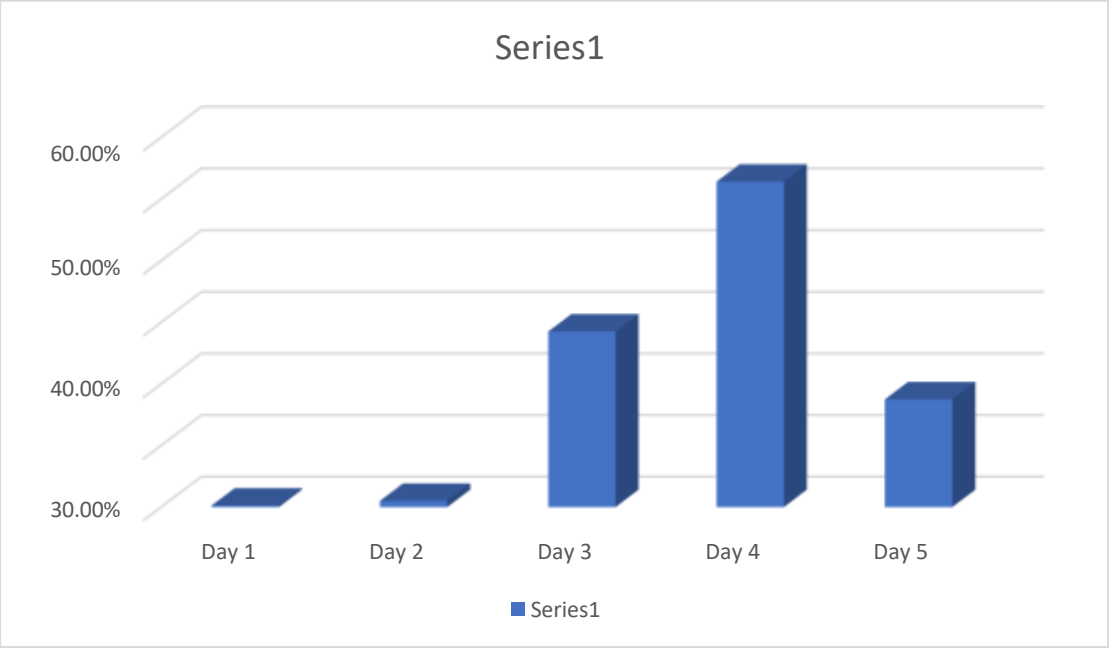

Figure 1 : Graphical representations of Distribution of neonates by the day jaundice was first observed.

Figure 1 shows, Visible jaundice was most commonly observed on Day 4 in 211 cases (52.8%), followed by Day 3 in 114 cases (28.5%), Day 5 in 70 cases (17.5%), Day 2 in 4 cases (1%), and Day 1 in a single case (0.25%).

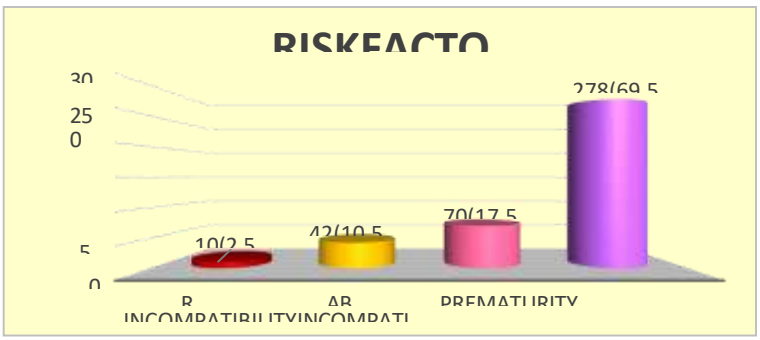

Figure 2 : Graphical representations of Distribution of neonates by identified risk factors for neonatal jaundice.

Figure 2 shows, the analysis of risk factors among the study participants indicates that 278 neonates (69.5%) had no identifiable risk factor for jaundice, suggesting a predominance of physiological jaundice in the cohort. Among those with risk factors, prematurity was the most common, present in 70 cases (17.5%), followed by ABO incompatibility in 42 cases (10.5%), and Rh incompatibility in 10 cases (2.5%).

TCBParameter	InitialMean± SD	Follow-upMean ± SD	P-VALUE
ForeheadTCB Reading	15.22±1.82	10.10±1.65	t=17.44 **p<0.0001***
SternumTCB Reading	15.23±1.84	10.65±1.68	t=15.38 **p<0.0001***

Table 1 : TCB Readings (Forehead & Sternum) – Initial and Follow-up

Table 1 is comparing initial and follow-up transcutaneous bilirubin (TCB) readings at the forehead and sternum sites demonstrates a statistically significant decline in bilirubin levels after clinical intervention. The initial forehead TCB reading averaged 15.22 ± 1.82 mg/dL, which reduced to 10.10 ± 1.65 mg/dL on follow-up, yielding a t-value of 41.684 and a p-value < 0.0001, indicating high statistical significance. Similarly, the sternum TCB reading declined from 15.23 ± 1.84 mg/dL to 10.65 ± 1.68 mg/dL, with a t-value of 36.764 and a p-value < 0.0001.

Confidence Intervals				
TSB Levels vs.	Pearson Correlation	Sig. (2-tailed)	95% Confidence Intervals (2-tailed)[a]	
			Lower	Upper
Forehead TCB reading	.826	**.001***	-.073	.823
Sternum TCB reading	.772	**.011***	-.086	.710

Table 2 : Pearson correlation between TSB levels and TCB readings with 95% confidence intervals

Table 2 shows, the correlation analysis between Total Serum Bilirubin (TSB) levels and Transcutaneous Bilirubin (TCB) readings reveals a strong positive relationship. The forehead TCB reading showed a Pearson correlation coefficient of 0.826 with a significance level (p-value) of 0.001, indicating a statistically significant and strong correlation. The 95% confidence interval ranged from –0.073 to 0.823, though the lower bound suggests slight variability. Similarly, the sternum TCB reading had a Pearson correlation coefficient of 0.772 with a p-value of 0.011, also indicating a statistically significant and substantial correlation, with a 95% confidence interval from –0.086 to 0.710.

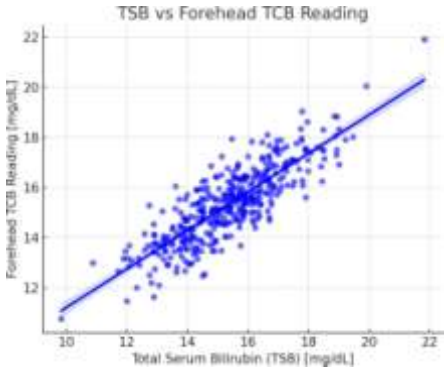

Figure 3 : Graphical representations of Pearson correlation between TSB levels and TCB readings with 95% confidence intervals.

DISCUSSION

The present study demonstrated a highly significant reduction in transcutaneous bilirubin (TcB) values measured at both the forehead and sternum following clinical intervention. Mean forehead readings declined from 15.22 ± 1.82 mg/dL to 10.10 ± 1.65 mg/dL ($t=17.44$, $p<0.0001$), and sternum readings from 15.23 ± 1.84 mg/dL to 10.65 ± 1.68 mg/dL ($t=15.38$, $p<0.0001$). This statistically robust decline supports the clinical responsiveness of TcB monitoring and aligns with Randhawa and Purohit, who reported that TcB reliably tracked bilirubin changes in neonates with significant concordance to serum bilirubin, thereby reducing repeated invasive sampling【3】. Similarly, Krishnan et al. showed that optical reflectance-based TcB meters produced accurate estimates compared with laboratory analyzers, reinforcing TcB's value as a dynamic monitoring tool【2】. Correlation analysis in this cohort revealed strong associations between TcB and total serum bilirubin (TSB), with Pearson coefficients of 0.826 ($p=0.001$) for forehead and 0.772 ($p=0.011$) for sternum readings. These values are consistent with Halder et al., who validated the AJO-Neo device and reported $r=0.79$ with serum bilirubin and clinically acceptable agreement limits【7】. Norman et al. also observed comparable performance of the JAISY device against JM105 ($r=0.94$, $p<0.001$), with reproducibility across forehead and chest readings【5】. Likewise, Kumari et al. demonstrated excellent correlation ($r=0.9808$) using a reflectance-based prototype, echoing the high values seen in the present analysis【1】. In contrast, Nihila et al. applied smartphone imaging and algorithm-based color analysis, identifying indirect markers such as higher energy and standard deviation in jaundiced infants without reporting direct correlation with TSB【6】. Kanamail and Periyasamy also noted good linear correlation in small-scale mock and serum samples ($n=8$), but their limited validation reduced generalizability compared to the larger cohort of 400 neonates in this study【8】. The unique strength of the present work lies in demonstrating both significant TcB decline after intervention and strong correlation with TSB, supporting TcB's dual role in diagnosis and follow-up monitoring.

CONCLUSION

The present study established that transcutaneous bilirubinometry (TcB) is a reliable, non-invasive tool for assessing and monitoring neonatal jaundice. TcB readings at both forehead and sternum sites showed highly significant declines after clinical intervention, closely mirroring therapeutic response. Strong positive correlations with total serum bilirubin ($r=0.826$, $p=0.001$ for forehead; $r=0.772$, $p=0.011$ for sternum) confirm TcB's accuracy in routine care. Forehead values demonstrated slightly better agreement, supporting its preferential use. While TcB cannot replace serum bilirubin for critical thresholds, it offers a safe, cost-effective, and practical adjunct for screening and follow-up, especially in resource-limited neonatal settings.

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