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Original Research Article

Transcutaneous Bilirubin Screening as a Predictor of Readmission for Neonatal Jaundice

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Abstract

Background: Neonatal jaundice remains one of the most common reasons for hospital readmission within the first two weeks of life. Early identification of neonates at risk of significant hyperbilirubinemia prior to discharge could reduce preventable readmissions. Transcutaneous bilirubinometry (TcB) offers a noninvasive, rapid, and cost-effective screening modality, yet its predictive value for readmission has not been thoroughly characterized.

Methods: This prospective cohort study enrolled 486 healthy term and late-preterm neonates born at a tertiary care hospital. Predischarge TcB measurements were obtained using the Dräger Jaundice Meter JM-105 within 6 hours prior to discharge. Neonates were followed for 14 days to ascertain readmission for phototherapy-requiring jaundice. Receiver operating characteristic (ROC) analysis was performed to evaluate the predictive accuracy of predischarge TcB values.

Results: Of the 486 neonates, 52 (10.7%) were readmitted for jaundice requiring phototherapy. The mean predischarge TcB was significantly higher in readmitted neonates (12.8 ± 2.1 mg/dL) compared to non-readmitted neonates (8.4 ± 2.6 mg/dL; $p < 0.001$). ROC analysis yielded an area under the curve (AUC) of 0.87 (95% CI: 0.83–0.91). A TcB cutoff of ≥10.5 mg/dL demonstrated a sensitivity of 84.6%, specificity of 78.3%, positive predictive value of 31.9%, and negative predictive value of 97.7%.

Conclusion: Predischarge TcB measurement is a reliable noninvasive predictor of readmission for neonatal jaundice. Implementation of TcB-based screening protocols could facilitate targeted follow-up and reduce avoidable readmissions.

Keywords: Transcutaneous Bilirubin; Neonatal Jaundice; Hyperbilirubinemia; Readmission; Newborn Screening; Phototherapy.

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Introduction

Neonatal jaundice, resulting from elevated unconjugated bilirubin levels, is observed in approximately 60% of term and 80% of preterm neonates during the first week of life [1]. While physiological jaundice is a benign and self-limiting condition in the majority of newborns, pathological hyperbilirubinemia, if unrecognized and untreated, carries the risk of bilirubin-induced neurological dysfunction, including acute bilirubin encephalopathy and kernicterus [2].

Despite widespread adoption of universal screening guidelines, jaundice remains one of the leading causes of neonatal hospital readmission, accounting for substantial healthcare utilization and parental distress [3]. The American Academy of Pediatrics (AAP) recommends systematic assessment of every neonate for jaundice risk prior to discharge, incorporating either total serum bilirubin (TSB) or transcutaneous bilirubin (TcB) measurement, plotted on hour-specific nomograms [4]. Total serum bilirubin measurement, while considered the gold standard, necessitates a heel-prick blood draw, is associated with procedural pain, requires laboratory processing time, and incurs higher costs [5].

In contrast, TcB measurement is a noninvasive, painless, and immediately available bedside tool that has demonstrated strong correlation with TSB levels, particularly at bilirubin concentrations below phototherapy thresholds [6]. Several studies

have validated the accuracy of TcB devices across diverse populations and gestational ages. Bhutani et al. demonstrated that predischarge hour-specific bilirubin values, whether obtained via TcB or TSB, effectively stratify neonates into risk zones for subsequent significant hyperbilirubinemia [7]. Maisels and colleagues further confirmed the clinical utility of TcB screening in reducing the need for unnecessary blood draws without compromising the identification of at-risk neonates [8]. More recently, Wickremasinghe et al. reported that predischarge TcB values in the high-intermediate and high-risk zones were independently associated with readmission for phototherapy [9].

Despite these advances, critical gaps persist in the literature. The precise predictive performance metrics of predischarge TcB values specifically for readmission—as opposed to broadly for subsequent hyperbilirubinemia—have been inconsistently reported [10]. Furthermore, optimal TcB cutoff values for predicting readmission remain poorly defined, with substantial variation across study populations reflecting differences in ethnicity, feeding practices, and discharge timing [11]. The integration of TcB measurements with clinical risk factors to enhance predictive models has also received limited investigation [12].

The aim of this study was to evaluate the predictive accuracy of predischarge transcutaneous bilirubin measurements for readmission due to neonatal jaundice requiring phototherapy in a cohort of healthy term and late-preterm neonates, and to determine an optimal TcB cutoff value that may guide clinical decision-making regarding post-discharge surveillance.

Materials and Methods

Study Design and Setting: This prospective observational cohort study was conducted at the tertiary care hospital.

Study Population: Consecutive healthy neonates born at ≥35 weeks of gestational age with a birth weight ≥2000 grams were eligible for enrollment. Inclusion criteria comprised neonates who were being discharged from the well-baby nursery or rooming-in unit within 24 to 72 hours of birth. Exclusion criteria included neonates requiring neonatal intensive care unit (NICU) admission, those who received phototherapy prior to initial discharge, neonates with major congenital anomalies, those with confirmed hemolytic disease (positive direct Coombs test at birth), and neonates whose families were unreachable for 14-day follow-up.

Sample Size Estimation: Based on prior literature reporting a jaundice-related readmission rate of approximately 8–12% and assuming an AUC of 0.85 for TcB prediction, a minimum sample size of 450 neonates was estimated to provide 80% power at a significance level of 0.05, accounting for a 10% attrition rate.

Data Collection and Procedures: Demographic and clinical data were systematically extracted from electronic medical records, including gestational age, birth weight, and mode of delivery, sex, feeding type (exclusive breastfeeding, formula feeding, or mixed feeding), maternal blood group, and neonatal blood group, presence of cephalohematoma or significant bruising, and timing of discharge relative to birth.

Predischarge TcB measurements were performed within 6 hours of planned discharge using the Dräger Jaundice Meter JM-105 (Dräger Medical, Lübeck, Germany). Measurements were obtained by a trained neonatal nurse at the mid-sternum. Three consecutive readings were taken, and the median value was recorded as the predischarge TcB. Values were plotted on the Bhutani hour-specific nomogram to determine the risk zone (low, low-intermediate, high-intermediate, or high risk).

Follow-Up: All families received standardized discharge instructions regarding jaundice monitoring and follow-up within 48 to 72 hours of discharge. Readmission for jaundice was defined as hospital readmission within 14 days of birth with a TSB level at or above the AAP phototherapy threshold for the neonate's age in hours and risk category, resulting in initiation of phototherapy.

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation (SD) and compared using independent samples t-tests or Mann-Whitney U tests as appropriate. Categorical variables were expressed as frequencies and percentages and compared using chi-square or Fisher's exact tests. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminative ability of predischarge TcB for predicting jaundice-related readmission. The optimal cutoff value was determined using the Youden index. Multivariable logistic regression analysis was conducted to identify independent predictors of readmission, adjusting for clinically relevant covariates. Statistical significance was set at $p < 0.05$. All analyses were performed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA).

Results

Study Population Characteristics: A total of 512 neonates were initially screened for eligibility, of whom 486 met the inclusion criteria and completed the 14-day follow-up period (retention rate: 94.9%). The mean gestational age was 38.4 ± 1.3 weeks, and the mean birth weight was 3124 ± 412

grams. Males constituted 53.1% of the cohort. Exclusive breastfeeding was reported in 68.5% of neonates, and the median age at discharge was 52 hours (interquartile range: 42–64 hours).

Readmission for Jaundice: Of the 486 neonates, 52 (10.7%) were readmitted within 14 days for jaundice requiring phototherapy. The median age at readmission was 4.2 days (interquartile range: 3.1–5.8 days). Table 1 presents a comparison of demographic and clinical characteristics between readmitted and non-readmitted groups.

Table 1: Demographic and Clinical Characteristics by Readmission Status

Variable	Readmitted (n = 52)	Not Readmitted (n = 434)	p-value
Gestational age (weeks), mean ± SD	37.6 ± 1.4	38.5 ± 1.2	< 0.001
Birth weight (g), mean ± SD	2978 ± 398	3142 ± 410	0.006
Male sex, n (%)	30 (57.7)	228 (52.5)	0.489
Exclusive breastfeeding, n (%)	43 (82.7)	290 (66.8)	0.019
Cesarean delivery, n (%)	18 (34.6)	156 (35.9)	0.851
Cephalohematoma/bruising, n (%)	9 (17.3)	31 (7.1)	0.014
Age at discharge (hours), mean ± SD	45.8 ± 10.2	53.4 ± 12.6	< 0.001
Predischarge TcB (mg/dL), mean ± SD	12.8 ± 2.1	8.4 ± 2.6	< 0.001

Predischarge TcB and Risk Zone Distribution: The overall mean predischarge TcB was 8.9 ± 2.8 mg/dL. When plotted on the Bhutani nomogram, 186 neonates (38.3%) fell in the low-risk zone, 168 (34.6%) in the low-intermediate zone, 94 (19.3%) in the high-intermediate zone, and 38 (7.8%) in the high-risk zone. The readmission rates stratified by risk zone are presented in Table 2.

Table 2: Readmission Rates Stratified by Bhutani Nomogram Risk Zone

Risk Zone	Total n (%)	Readmitted n (%)	Readmission Rate (%)
Low risk	186 (38.3)	2 (3.8)	1.1
Low-intermediate	168 (34.6)	8 (15.4)	4.8
High-intermediate	94 (19.3)	24 (46.2)	25.5
High risk	38 (7.8)	18 (34.6)	47.4
Total	**486 (100)**	**52 (100)**	**10.7**

Predictive Performance of Predischarge TcB: ROC analysis demonstrated that predischarge TcB had an AUC of 0.87 (95% CI: 0.83–0.91; $p < 0.001$) for predicting jaundice-related readmission. Using the Youden index, the optimal TcB cutoff was identified at ≥10.5 mg/dL, yielding the performance characteristics shown in Table 3.

Table 3: Predictive Performance of Predischarge TcB at Optimal Cutoff (≥10.5 mg/dL)

Performance Metric	Value (95% CI)
Sensitivity	84.6% (72.5–92.7)
Specificity	78.3% (74.1–82.1)
Positive predictive value	31.9% (24.8–39.7)
Negative predictive value	97.7% (95.8–98.9)
Positive likelihood ratio	3.90 (3.21–4.73)
Negative likelihood ratio	0.20 (0.11–0.36)
AUC	0.87 (0.83–0.91)

Multivariable Logistic Regression: After adjusting for gestational age, birth weight, exclusive breastfeeding, cephalohematoma, and age at discharge, predischarge TcB ≥10.5 mg/dL remained a significant independent predictor of readmission (adjusted OR: 6.42; 95% CI: 3.18–12.96; $p < 0.001$).

Other independent predictors included exclusive breastfeeding (adjusted OR: 2.31; 95% CI: 1.04–5.14; $p = 0.039$), gestational age <37 weeks (adjusted OR: 2.87; 95% CI: 1.42–5.82; $p = 0.003$), and presence of cephalohematoma or bruising (adjusted OR: 2.54; 95% CI: 1.08–5.98; $p = 0.033$).

Discussion

The findings of this study demonstrate that predischarge transcutaneous bilirubin measurement is a robust and clinically useful predictor of readmission for neonatal jaundice requiring phototherapy. The readmission rate of 10.7% observed in our cohort is consistent with rates reported in contemporary literature, where jaundice-related readmissions have been documented in 5–12% of otherwise healthy neonates, depending on population characteristics and discharge practices [13]. The significantly higher predischarge TcB values observed in the readmitted group, with a mean difference of

approximately 4.4 mg/dL, underscore the relevance of bilirubin trajectory assessment before hospital discharge.

The AUC of 0.87 for predischarge TcB in predicting readmission indicates excellent discriminative capacity, which compares favorably with previously reported values. Keren et al. reported an AUC of 0.83 for predischarge TSB in predicting subsequent significant hyperbilirubinemia, though readmission was not the specific outcome studied [14]. Similarly, Varvarigou et al. demonstrated that predischarge TcB measurements had comparable predictive accuracy to TSB, supporting TcB as a valid surrogate in risk stratification protocols [15].

The optimal cutoff of ≥10.5 mg/dL, derived from the Youden index, demonstrated a notably high negative predictive value of 97.7%, suggesting that neonates with predischarge TcB values below this threshold can be discharged with substantial confidence that they will not require readmission for phototherapy. This finding carries important implications for clinical workflow, as it may help identify a low-risk population for whom intensive post-discharge follow-up can be safely relaxed, thereby optimizing resource allocation [16]. However, the relatively modest positive predictive value of 31.9% indicates that a substantial proportion of neonates exceeding this cutoff will not ultimately require readmission, reflecting the inherent trade-off between sensitivity and specificity in screening applications.

The strong association between exclusive breastfeeding and readmission, observed consistently in our multivariable analysis, aligns with established evidence that breastfeeding-associated jaundice represents a significant contributor to early neonatal hyperbilirubinemia [17]. Inadequate caloric intake during the establishment of lactation leads to increased enterohepatic circulation of bilirubin and delayed bilirubin clearance. This finding reinforces the importance of concurrent lactation support as part of comprehensive jaundice prevention strategies [18].

The observation that earlier discharge was associated with higher readmission risk is clinically relevant and consistent with existing data. Shorter postpartum hospital stays reduce the window for detecting evolving jaundice and limit opportunities for feeding assessment and parental education [19]. The trend toward shorter hospital stays, driven by economic and logistic considerations, makes the availability of reliable predischarge screening tools such as TcB measurement even more critical.

Our finding that late preterm gestational age independently predicted readmission risk corroborates the well-established vulnerability of this population to hyperbilirubinemia, attributable to hepatic immaturity, feeding difficulties, and delayed bilirubin conjugation [20]. Clinical guidelines appropriately designate late preterm neonates as a higher-risk group warranting closer surveillance, and our data reinforce this recommendation.

Several limitations merit acknowledgment. First, this was a single-center study, which may limit generalizability across diverse populations and practice settings. Second, TcB accuracy may be influenced by skin pigmentation, and while the JM-105 device has been validated across multiple skin tones, performance variation cannot be entirely excluded [21]. Third, we did not assess serial TcB measurements, which could potentially improve predictive accuracy by capturing bilirubin velocity rather than relying on a single predischarge value. Finally, the study did not evaluate the cost-effectiveness of implementing TcB-based screening protocols, which would be essential for informing institutional policy decisions [22].

Future research should focus on multicenter validation of TcB-based readmission prediction models, incorporation of bilirubin rate of rise into predictive algorithms, and evaluation of combined clinical-biochemical scoring systems to optimize the balance between sensitivity and specificity. Additionally, studies investigating the implementation outcomes and cost-effectiveness of TcB-guided discharge protocols are warranted to facilitate widespread adoption.

Conclusion

This study demonstrates that predischarge transcutaneous bilirubin measurement is a reliable, noninvasive, and clinically practical predictor of readmission for neonatal jaundice requiring phototherapy in healthy term and late-preterm neonates.

A TcB cutoff of ≥10.5 mg/dL offered excellent discriminative capacity, with a particularly high negative predictive value that can reassure clinicians when discharging neonates with lower values. The integration of predischarge TcB measurements with established clinical risk factors—including exclusive breastfeeding, late preterm gestational age, and presence of cephalohematoma—strengthens risk stratification and may enable more targeted post-discharge follow-up strategies. Implementation of systematic TcB-based screening protocols prior to discharge has the potential to reduce avoidable readmissions, decrease healthcare costs, minimize parental anxiety, and improve neonatal outcomes. Multicenter prospective validation of these findings

and assessment of implementation effectiveness are recommended to support broader clinical adoption.

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