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# Transcutaneous Bilirubin Assessment for Screening of Hyperbilirubinemia in Term- and Near-Term Neonates With Jaundice: A Comparative Study

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**Abstract**

**Introduction:** Hyperbilirubinemia is a common condition in neonates. In this study, we aimed to investigate the association of total serum bilirubin (TSB) with sternum transcutaneous bilirubin (TcB) level obtained by KJ-8000 Transcutaneous bilirubin meter (KEJIAN medical apparatus).

**Methods:** Eighty newborns were enrolled in the present prospective cross-sectional study. At first, blood sampling was performed for determination of TSB, and immediately after that, TcB levels were recorded at the sternum skin by KJ-8000 device. Data was analyzed by statistical software SPSS version 21.0.

**Results:** The mean gestational age of the infants was 38.2 ± 1.5 weeks. The mean level of TSB was 13.52 ± 4 mg/dL, while the mean value of TcB was 13.71 ± 3.53 mg/dL. Pearson correlation analysis showed a correlation coefficient of $r = 0.770$ between sternum TcB recorded by KJ-8000 device and TSB.

**Conclusion:** Given a strong correlation between TcB and TSB levels, it is advised the transcutaneous bilirubinometery be considered as the screening method in infant jaundice.

**Keywords:** Hyperbilirubinemia, Total serum bilirubin, Transcutaneous bilirubin, Neonates

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## Introduction

Hyperbilirubinemia is a common and often benign disorder in neonates, as few cases would require medical intervention. In the first week of life, about 60% of term and 80% of preterm infants develop jaundice.[1] Although bilirubin may promote a physiologic antioxidant role, elevated levels of indirect (non-conjugated) bilirubin can be potentially neurotoxic. Although direct (conjugated) bilirubin represent the minimum threat for the neurological system, direct hyperbilirubinemia may proclaim either a serious hepatic condition or a systemic disease and lead to permanent brain damage.

Screening for hyperbilirubinemia, either by measuring total serum bilirubin (TSB) or transcutaneous bilirubin (TcB) is a perquisite in jaundiced newborns.[2] Regardless of hyperbilirubinemia etiology, early diagnosis and treatment of this phenomenon is vital in preventing kernicterus and cerebral damage caused by bilirubin deposition. Evaluation of neonatal jaundice by visual examination of neonate's skin is a familiar routine in infants. Nonetheless, this method can be erroneous especially for unexperienced clinicians due to the effect of both natural neonates' skin color and hemoglobin level. Blood sampling from the heel for determining TSB is the gold standard method in neonates.[3] However, needle stick causes pain and anxiety, and may lead to long-term complications such as infections (i.e. osteomyelitis) and/or scar in the site of puncture. Furthermore, incessant blood samplings can be associated with iatrogenic anemia, especially in pre-term infants.[4]

Determination of bilirubin through

skin (i.e. TcB) is a proposed substitute for screening hyperbilirubinemia in term and near-term infants.[5,6] This method has the advantage of less need for blood sampling in newborns and therefore the least risk for trauma and infection in neonates. Recent studies have shown that using TcB reduced the need for blood sampling by 34%-38% in neonates with hyperbilirubinemia.[7,8] In addition, the procedure is time-saving because there is no need to wait for the results of routine laboratory tests.[6] Furthermore, using TcB strategy is financially more affordable in long-term; thereby rendering this method a suitable approach for large facilities.[9] And finally, the method is a non-invasive and pain-free procedure which makes it more attractive in clinical practice.

Regarding aforementioned statements, the assessment of accuracy and precision of TcB determination using medical devices is essential. Nevertheless, the current automated devices for this purpose are expensive and not affordable in low-income care-centers. There have been some reports on the correlation of TSB and TcB determined by multiple instruments such as Dräger Jaundice Meter (JM) models, and Bilichek meter.[1,10] These aside, the majority of studies on the correlation of TSB and TcB are retrospective leading to inconclusive results.[11-13] In the present study, we aimed to determine both the accuracy and reliability of KJ-8000 transcutaneous bilirubin meter (KEJIAN medical apparatus) in cutaneous bilirubin measurement in neonates, and to compare its measures with those of TSB.

## Methods

The population under study comprised neonates delivered above 35 weeks of gestation affected by jaundice. The study was done during January 2012-December 2012 in Imam Khomeini hospital of Ilam city in west of Iran.

The sample size was determined as n = 80 considering type I error of 5%, strength of 90% and correlation coefficient (r) of 0.83. The patients were selected from those who were first-time visitors to the hospital diagnosed with jaundice. Demographical data (delivery age, neonates' sex, mother's age, birth weight, weight at visiting) were obtained by a questionnaire.

Exclusion criteria included (1) neonates with previous phototherapy, (2) those with previous blood exchange, (3) neonates with congenital disorders, (4) those who were diagnosed with sepsis or peripheral perfusion disorder, and (5) pre-term infants of <35 weeks delivery age.

At first, venous samples were drawn from the heel for the determination of TSB. Then, TcB level was determined using KJ-8000 transcutaneous bilirubin meter (KEJIAN medical apparatus) instrument at the skin of neonates' sternum. The TcB level was determined as a mean of three times performance.

Statistical analysis was done using SPSS software (version 21.0). Normal distribution of data was checked by Shapiro–Wilk test. Statistical tests were Pearson correlation coefficient, and independent samples *t* test for determination of any significant association between TSB and TcB, and any significant difference in TcB regarding different groups of patients, respectively. Simple regression model was used to determine if TSB level could be estimated by TcB.

## Results

In the present study, 80 neonates were recruited. The mean of gestational age was 38.2 ± 1.5 weeks, and the mean age of neonates was 6.8 ± 5 days (Table 1). The values obtained for TSB and TcB have been demonstrated in Table 2.

Significant associations were found between TSB and TcB levels ($r = 0.770$, $P < 0.0001$), as well as a significant difference between TSB and TcB with TcB value obtained by KJ-8000 device ($r = 0.519$, $P < 0.0001$) (see Figure 1 and Table 3 for details).

Linear regression model rendered the following relationship between TSB and TcB levels (Table 4):

$TSB_{mg/dL} = -1.31 + (0.981 \times TcB_{mg/dL})$.

## Discussion

TcB has been suggested by the American Academy of Pediatrics (AAP) as a replacement for routine TSB measurements. Depending on the device and target populations, TcB may either overestimate or underestimate bilirubin level in jaundiced neonates.[12,14,15] TcB screening in early hours of life may be a useful marker to foretell the possibility of hyperbilirubinemia in later days of life.[12,16-19] In the present study, we showed that TSB and sternum TcB levels were plausibly correlated with each other in full term and near term infants with hyperbilirubinemia. The correlation obtained between these 2 methods was $r = 0.770$ in our experiment. The correlation of TcB with

**Table 1.** Basic Characteristics of 80 Neonates With Jaundice

| Variables | Mean | SD |
|---|---|---|
| Gestational age (wk) | 38.24 | 1.5 |
| Neonate's birth weight (g) | 3134.32 | 506.95 |
| Neonate's weight at visiting (g) | 3032.84 | 528.72 |
| Neonate's age at visiting (d) | 6.89 | 5 |

Abbreviation: SD, standard deviation.

**Table 2.** Total Serum Bilirubin and Transcutaneous Bilirubin Levels Measured in 80 Jaundiced Neonates

| Variables | Mean (n=80) | SD |
|---|---|---|
| TSB (mg/dL) | 13.52 | 4.09 |
| TcB (mg/dL, KJ-8000 instrument) | 13.71 | 3.53 |
| Difference between TSB and cutaneous bilirubin of KJ-8000 | -0.185 | 2.64 |

Abbreviation: SD, standard deviation; TcB, transcutaneous bilirubin; TSB, total serum bilirubin.

**Table 3.** Correlation Coefficients Between Bilirubin Levels Assessed by Laboratory Biochemical Method (Total Serum Bilirubin) and KJ-8000-Measured Transcutaneous Bilirubin

| Variable | | TSB (mg/dL) | TcB (KJ-8000 instrument) | Difference Between TSB and TcB of KJ-8000 |
|---|---|---|---|---|
| TSB (mg/dL) | *r* | 1 | 0.770 | 0.519 |
| | *P* | NA | <0.0001 | <0.0001 |
| TcB (mg/dL, KJ-8000 instrument) | *r* | NA | 1 | -0.140 |
| | *P* | NA | NA | 0.1 |

Abbreviations: NA, not applicable; TcB, transcutaneous bilirubin; TSB, total serum bilirubin.

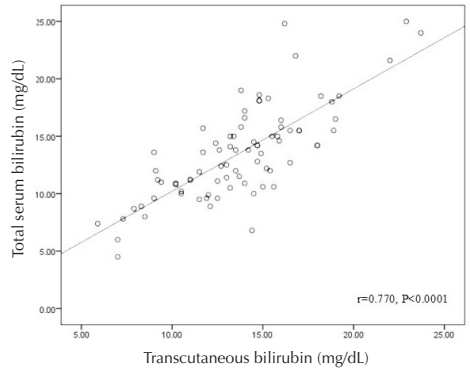


**Figure 1.** Pearson Correlation Coefficient Between Transcutaneous Bilirubin Recorded by KJ-8000 Bilirubinometer at the Sternum of Infants and Total Serum Bilirubin in Jaundiced Neonates.

**Table 4.** Regression Model Between Total Serum Bilirubin and KJ-8000-Measured Transcutaneous Bilirubin

| Variable | Regression Line Coefficient (β) | θ | *P* | *t* |
|---|---|---|---|---|
| TSB | 0.891 | 0.770 | <0.0001 | 10.72 |
| Constant | 1.31 | - | 0.269 | 1.114 |

Abbreviation: TSB, total serum bilirubin.

TSB using different medical instruments has been reported in the range of 0.550 to 0.918 in previous reports.[3,20-23] We believe that the difference between these coefficient values may be because of variable sensitivities of instruments recruited in these studies. In addition, some other factors may impart in this area such as the location of TcB record. The highest correlation between TcB and TSB was noted for forehead and sternum areas,[1,5] however, the sternum results were more accurate compared to forehead results.[1] Nevertheless, the values of TcB derived from forehead or sternum did not significantly differ in another study.[6] In the study of Badiee et al in Isfahan province of Iran, total serum and cutaneous (forehead and sternum) bilirubin were measured in 72 infants. In this study, correlation coefficient between TSB and cutaneous bilirubin recorded in sternum ($r = 0.55, P = 0.05$) was lower than the coefficient observed in the present study ($r = 0.77$). However, the correlation coefficient was obtained between TSB and cutaneous bilirubin in forehead ($r = 0.83$, $P = 0.05$).[23] Here, we used sternum to measure TcB which is used in majority of studies. The correlation index between TcB and TSB may also be affected by gestational age,[20] and age of neonates.[20] The correlation between TcB and TSB was reported to be lower (0.82) in infants older than 72 hours in comparison with the correlation (0.96) in younger (<72 hours) newborns.[20] In spite of this, El-Kabbany et al described a better correlation index between TcB and TSB in newborns older than 63 days.[1]

In the present study, positive correlation was observed between TSB and TcB levels and a significant difference of means between TSB and TcB was measured by KJ-8000 ($r = 0.519$, $P < 0.0001$). This result indicates that the difference between TSB and TcB estimated by KJ-8000 assay increases with elevation of TSB. In the study of Jones et al in the United States, correlation of TSB with sternum and forehead TcB was evaluated by JM-105 device.[2] Similar to our observation, the correlation of TSB and TcB was found to be less precise with increasing TSB level, as the correlation coefficient was reduced from $r = 0.82$ at TSB >10 mg/dL to $r = 0.52$ at TSB >15 mg/dL.[2] Accordingly, it is more appropriate to use TSB in elevated levels of bilirubin for deciding on strategic management (phototherapy or blood exchange).

We detected a regression model for predicting TSB levels based on TcB as "TSB mg/dL = -1.31 + (0.981 × TcB mg/dL)". In a study by Rubaltelli et al, 210 neonates in 6 different European hospitals were evaluated by TcB. For comparison, they used bilirubin level determined by HPLC-B method.[6] In the study of Tayaba et al, TSB level was measured for both term and pre-term neonates, and cutaneous bilirubin was also assessed by Colormate III instrument. They found a linear relationship between serum and cutaneous bilirubin with linear regression model of "TSB= -0.504 + (0.986 × TcB)."[24] In the study of Badiee et al, linear regression model of "TSB= 2.18+ (0.68 × forehead TcB)" was obtained.[23] The high regression coefficient of 0.981 indicates that TSB can be anticipated by TcB level recorded by KJ-8000 instrument, with excellent accuracy.

## Conclusion

In our study, the association of TSB with TcB measured by KJ-8000 instrument was acceptable (high regression coefficient, $\beta = 0.98$). This highlights the usefulness of TcB method of bilirubin determination as a reliable substitute

for screening jaundiced neonates.

## Ethical Approval

Our study was performed according to the ethical standards reported by the COPE (Committee on Publication Ethics) available at https://publicationethics.org. Informed consent was obtained from mothers' of the neonates before their inclusion in the research.

## Competing Interests

Authors declare no competing interests.

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