# Comparative study between plasma and transcutaneous bilirubin measurements in newborns

*Estudo comparativo entre a medida plasmática e transcutânea de bilirrubina em recém-nascidos*

*Estudio comparativo entre la medida plasmática y transcutánea de bilirrubina en recién nacidos: ¿la medida transcutánea es confiable?*

*Patrícia Povaluk[1], Evanguelia Athanasio Shwetz[2], Rubens Kliemann[2]*


## ABSTRACT

**Objective:** To compare transcutaneous and plasma bilirubin measurements before and during phototerapy, on exposed and covered body areas, and to verify the association of the obtained levels with neonatal characteristics.

**Methods:** This cross-sectional study enrolled 44 newborn infants from April to October 2008. Simultaneous plasmatic and transcutaneous (frontal and sternal regions) bilirubin assays were performed before and 24 hours after the beginning of phototerapy. On frontal and sternal regions, a small cover was placed and transcutaneous measurement was obtained from covered and exposed adjacent areas. The association between the measurements and neonatal weigh, sex, race, gestational and postnatal ages and risk factors for severe hyperbilirubinemia was calculated.

**Results:** There was a strong correlation between plasma and transcutaneous bilirubin assays measured in the frontal and sternal regions before the phototerapy, with narrow 95 and 99% confidence intervals. The covered sternal area presented the strongest correlation index 24 hours after phototherapy (r=0.86; $p<0.001$). No neonatal characteristic was significantly associated to the bilirubin levels.

**Conclusions:** Transcutaneous measurements of frontal and sternal areas closely correlate with plasma bilirubin levels before starting phototerapy. After 24 hours on phototerapy, the transcutaneous sternal measurement on the covered area showed better correlation.


**Key-words:** jaundice; hyperbilirubinemia, neonatal; phototherapy; infant, newborn.


## RESUMO

**Objetivo:** Comparar as medidas transcutânea e plasmática da bilirrubina antes e durante a fototerapia, em área de pele exposta e coberta, analisando-se a associação com variáveis do recém-nascido (RN).

**Métodos:** Estudo de corte transversal, que avaliou 44 RN entre abril e outubro de 2008. Realizaram-se dosagens transcutâneas (região frontal e esternal) e plasmáticas da bilirrubina antes e 24 horas após o início da fototerapia. Tanto na região frontal como na esternal, ocluiu-se pequena região de pele e obteve-se a medida transcutânea da área coberta e de área adjacente exposta. Calculou-se a associação entre as medidas e variáveis do RN (peso, sexo, raça/cor, idade gestacional e pós-natal) e presença de fatores de risco para hiperbilirrubinemia significativa.

**Resultados:** Houve forte correlação entre a bilirrubina plasmática e a transcutânea, no momento da indicação e após 24 horas de fototerapia, nas regiões frontal e esternal, com intervalos de confiança estreitos tanto a 95 como a 99%. Observou-se que, com relação à medida transcutânea na área coberta, 24 horas após o início da fototerapia, a medida


Instituição: Hospital Universitário Evangélico de Curitiba, Curitiba, PR, Brasil
[1]Neonatologista da Unidade de Terapia Intensiva Neonatal (UTIN) e Serviço de Neonatologia do Hospital Universitário Evangélico de Curitiba, Curitiba, PR, Brasil
[2]Professor Assistente de Pediatria da Faculdade Evangélica do Paraná; Chefe do Serviço de Neonatologia e UTIN do Hospital Universitário Evangélico de Curitiba, Curitiba, PR, Brasil

Endereço para correspondência:
Patrícia Povaluk
Rua São Vicente, 95 – Juvevê
CEP 80030-470 – Curitiba/PR
E-mail: ppovaluk@yahoo.com.br

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esternal apresentou correlação mais forte com a plasmática (r=0,86; $p$<0,001). As variáveis do RN analisadas não interferiram nas medidas de bilirrubina.

Conclusões: As dosagens transcutânea e plasmática apresentam correlação forte antes da fototerapia nas regiões frontal e esternal. Após 24 horas de fototerapia, a medida transcutânea esternal em área coberta apresentou melhor correlação.

**Palavras-chave:** icterícia; hiperbilirrubinemia neonatal; fototerapia; recém-nascido.

**RESUMEN**

**Objetivo:** Comparar las medidas transcutánea y plasmática de la bilirrubina antes y durante la fototerapia, en área de piel expuesta y cubierta, analizando la asociación con variables del recién nacido (RN).

**Método:** Estudio de corte transversal que analizó a 44 RN en el periodo de abril a octubre de 2008. Se realizaron dosificaciones transcutáneas (región frontal y esternal) y plasmática de bilirrubina antes y 24 horas después del inicio de la fototerapia. Tanto en la región frontal como en la esternal se ocluyó la pequeña región de piel y se obtuvo la medida transcutánea del área cubierta y del área adyacente expuesta. Se calculó la asociación entre las medidas y variables del RN (peso, sexo, raza/color, edad gestacional y postnatal y presencia de factores de riesgo para hiperbilirrubinemia significativa).

**Resultados:** La asociación entre bilirrubina plasmática y transcutánea, en el momento de la indicación y después de 24 horas de fototerapia en las regiones frontal y esternal fue muy homogénea, debido a la fuerte correlación y los intervalos de confianza estrechos, tanto a 95% como a 99%. Se observó, además, respecto a la medida transcutánea en el área cubierta, 24 horas después del inicio de la fototerapia, la medida en el área esternal presentó correlación más fuerte con la plasmática (r=0,8599; p=0,0001). Las variables del RN analizadas no interfirieron significativamente en las medidas de bilirrubina.

**Conclusión**: Las dosificaciones transcutánea y plasmática presentan correlación fuerte antes de la fototerapia en las regiones frontal y esternal. Tras 24 horas de la fototerapia, la medida transcutánea esternal en área cubierta presentó mejor correlación.

**Palabras-clave:** ictericia; hiperbilirrubinemia neonatal; fototerapia; recién nacido.

## Introduction

Jaundice is one of the most common problems during the neonatal period and is the clinical expression of hyperbilirubinemia. It is generally benign, but, due to the potential toxicity of bilirubin, newborn infants who are at risk of developing significant hyperbilirubinemia should always be monitored in order to prevent severe neonatal hyperbilirubinemia and, in a small number of cases, bilirubin encephalopathy[1,2].

The Neonatology Department of the Brazilian Society of Pediatrics recommends that for all newborns (NB) who have jaundice at 35 weeks or more of gestational age it is necessary to determine the epidemiological factors involved and assay total bilirubin (TB) with the objective of identifying the level of risk (minimal, intermediate or major) of development of significant hyperbilirubinemia. This must always occur before discharge from the maternity unit, which should take place after 48 hours of life[3].

The most important element in neonatal jaundice management is assessment of bilirubinemia. A great deal of progress has been achieved in terms of modernizing and improving the reliability of assay methods. The first transcutaneous measurement device, the Minolta Bilirrubinometer (Minolta Camera Co, Japan), was launched during the 1980s and simply correlated intensity of the yellow coloration of the skin with bilirubinemia. Later developments led to more precise systems that offered greater accuracy in determination of the bilirubin content in subcutaneous tissues of an NB, minimizing the influence of melanin and of the maturity of the skin[4]. These improvements contributed to reduce the number of blood samples needed and the potential risk of infection, reducing the amount of blood letting and the number of painful procedures to which newborns are subjected.

Transcutaneous bilirubin measurement in NB and its correlation with plasma assay before phototherapy has been started is well-documented in the literature[4-9]. However, after phototherapy has been used, transcutaneous measurement through skin that has been exposed to the light is no longer indicated. The objective of this study is to compare transcutaneous bilirubin measurements with plasma assay results before and after the start of phototherapy, both through skin that has been exposed and through skin protected from the light, and to test for associations between the measurements taken and the characteristics of the NB.

## Methods

This was a descriptive, cross-sectional study conducted at the neonatal intensive care unit at the *Hospital Universitário Evangélico de Curitiba*. The study was designed to comply with the directives and guidelines regulating research involving human beings and was approved by the hospital's Research Ethics Committee.

Free and informed consent was provided by one of the parents of each participant.

The study population comprised 44 full term and preterm newborns being treated with phototherapy at the aforementioned hospital between April and October of 2008. All new cases of jaundice in full term and preterm newborns who were prescribed phototherapy were included; including newborn infants with hemolytic disease. Patients were excluded if they had already received phototherapy or if they had cholestatic jaundice. Patients were considered lost from the sample if the barrier became dislodged from the forehead or sternum during phototherapy or if the laboratory requested that a repeat sample be sent, since blood samples were taken simultaneously with the transcutaneous bilirubin measurements.

Transcutaneous bilirubin measurements, at the forehead and sternum, were taken as soon as phototherapy was prescribed for the patient. Simultaneously, a blood sample was taken for plasma bilirubin assay. The maximum interval of time between transcutaneous measurement and collection of the blood sample for plasma assay was 30 minutes. Transcutaneous bilirubin measurement was performed using a Minolta JM-103 and plasma assay was performed by the hospital laboratory using the spectrophotometric method.

After the transcutaneous measurement had been taken, two small patches of skin, one on the forehead and the other on the sternum, were covered using a circular barrier of around 2.5 cm in diameter, made from a Maxicor electrode covered in aluminum foil and sticking plaster. Twenty-4 hours after starting phototherapy, more transcutaneous measurements were taken, through the skin that had been shielded from the light, at the forehead and sternum and around 1 cm above each covered patch of skin. At the same time, another blood sample was taken for plasma bilirubin assay.

The phototherapy machines used were the conventional phototherapy systems Fanem Mod 006, Fanem Bilitron$^{R}$ 3006, Fanem Bilispot$^{R}$ Mod 006- BP or Fanem Biliberço$^{R}$ 2006 SL, depending on availability and patient need.

In addition to the transcutaneous bilirubin measurements and the plasma bilirubin assays, the following variables were also analyzed: postnatal age of patient, birth weight, sex, gestational age calculated by the Parkin method[10] and appropriateness of weight for gestational age. Patient race/color and risk factors for phototherapy, according to risk bands, were also analyzed. Risk was classified as follows, **high** risk (plasma or transcutaneous TB above the 95th percentile before hospital discharge): jaundice within first 24 hours of life, ABO or Rh incompatibility or other hemolytic diseases, prematurity, prior history of sibling given phototherapy; **intermediate** risk (plasma or transcutaneous TB between percentiles 40 and 95 before hospital discharge): gestational age [GA] from 37 to 38 weeks, visible jaundice before hospital discharge, diabetic mother, maternal age over 34 years and male sex NB; **low** risk: (plasma or transcutaneous TB below the 40th percentile before hospital discharge): GA over 40 weeks, black skin, exclusively fed on formula, hospital discharge after 72 hours[3].

Data were collected on a dedicated chart and analyzed statistically. The following methods were employed to achieve the study objective: analysis of correlation using Pearson's correlation coefficient, linear regression analysis , analysis of variance for repeated measures (ANOVA-MR) and analysis of covariance for repeated measures (ANCOVA-MR, software: *Bioestat 5.0*) and the Wilcoxon nonparametric tests for related measures and for comparison

**Table 1 -** Plasma bilirubin and bilirubin measurements in taken transcutaneously (TransC) at the forehead and sternum, through skin that had been covered and skin that had been exposed during phototherapy, before and 24 hours after starting phototherapy (mg/dL).

| | N | Mean | SD | Minimum | Maximum | Median | p-value |
|---|---|---|---|---|---|---|---|
| Bilirubin TransC Forehead | | | | | | | |
| On prescription | 40 | 9.7 | 3.4 | 3.3* | 17.4 | 9.1 | |
| After 24h (Covered) | 40 | 8.5 | 3.3 | 1.6 | 17.5 | 7.7 | 0.025 |
| After 24h (Exposed) | 40 | 6.7 | 3.3 | 0.3 | 15.0 | 6.6 | <0.001 |
| Bilirubin TransC Sternum | | | | | | | |
| On prescription | 40 | 9.9 | 3.5 | 2.5* | 16.0 | 10.0 | |
| After 24h (Covered) | 40 | 8.7 | 3.7 | 1.6 | 18.1 | 8.6 | 0.043 |
| After 24h (Exposed) | 40 | 4.3 | 2.7 | 0.0 | 12.1 | 4.3 | <0.001 |
| Total Plasma Bilirubin | | | | | | | |
| On prescription | 39 | 10.0 | 3.9 | 2.5* | 19.8 | 9.7 | |
| After 24h | 39 | 9.4 | 3.3 | 4.5 | 20.7 | 8.7 | 0.058 |

between two proportions (software: "Primer of Biostatistics"). The significance level was set at less than 5% ($p<0.05$)[11-12].

## Results

A total of 44 newborn infants were analyzed, 73% were white, 16% were mixed race and 11% were black. The distribution of sexes was similar (24 males and 20 females). Mean gestational age was 35.1±3.4 weeks, and 29 (66%) were preterm and 15 (34%) were full term. Mean birth weight was 2151±889 grams, with 17 (39%) NB weighing 1500g to 2500g and 12 (27%) below 1500g. Mean postnatal age when phototherapy was prescribed was 2.4±1.4 days. With regard to appropriateness of weight for gestational age, 66% of the neonates analyzed were appropriate. At the time of bilirubin measurement, 75% were at high risk of phototherapy and 25% intermediate risk.

Mean total plasma bilirubin at the time phototherapy was prescribed was 10.1±3.8 mg/dL, mean forehead transcutaneous bilirubin was 9.7±3.5 mg/dL and mean sternum transcutaneous bilirubin was 9.9±3.6 mg/dL.

Table 1 lists the results for transcutaneous measurements at the forehead and sternum (exposed and covered skin) and plasma bilirubin at the start of treatment and 24 hours later. It will be observed that transcutaneous bilirubin measured at the forehead through covered skin was around 12.4% lower and through skin that had been exposed it was reduced by around 30.9%. For the sternum, transcutaneous bilirubin measured through covered skin reduced by around 12.1% and through exposed skin by around 56.6%. There was no significant reduction in plasma bilirubin after 24 hours of treatment.

Analysis of the correlation between plasma bilirubin and the transcutaneous measurements (Table 2), both at the time phototherapy was prescribed and 24 hours after starting treatment, demonstrated that, initially, the forehead and sternum measurements had a significant correlation with plasma assay - strong (up to 89.9%) and very strong correlations (90.0% and over) – at narrow confidence intervals, whether 95% or 99%. However, analysis of transcutaneous measurements 24 hours after starting phototherapy demonstrated a fall in the correlation with plasma bilirubin, for both exposed forehead and sternum areas measured transcutaneously. In the case of correlation between plasma bilirubin and transcutaneous measurements of covered areas, the sternum measurement exhibited a strong correlation ($r= 0.8599$; $p<0.0001$) and a smaller confidence interval, both at 95% and at 99% (Figure1).

When the mean differences between plasma bilirubin and the transcutaneous measurements were analyzed, it was observed that the sternum transcutaneous bilirubin measurement had the lowest mean difference at all times. At prescription of phototherapy, the mean difference between plasma and transcutaneous measurements was 0.4 mg/dL for the forehead and 0.2 mg/dL for the sternum. Twenty-4 hours after starting treatment, the mean difference between plasma and transcutaneous measurements through covered skin was 0.8 mg/dL for the forehead and 0.6 mg/dL for the sternum.

With relation to the analysis of differences in plasma and covered skin transcutaneous bilirubin, 24 hours after starting phototherapy, there were no significant differences between measures in terms of neonatal characteristics, namely, birth weight, race, gestational and postnatal age and phototherapy risk level, according to the analysis of covariance (Table 3). It will be observed from Table 3 that NB at intermediate risk had higher mean bilirubin, since the majority of the high risk NB were preterms of low weight, who typically have lower bilirubin levels at phototherapy prescription than full term NB, who predominated in the intermediate risk group.

**Table 2 –** Pearson's correlation coefficients for plasma bilirubin against transcutaneous measurements, on prescription and 24 hours after starting phototherapy

| | N | Linear Equation (y = ax + b) | Correlation (r) | 95%CI | | | IC 99% | | | p-value |
|---|---|---|---|---|---|---|---|---|---|---|
| **On prescription** | | | | | | | | | | |
| TcB Forehead | 44 | 0.8203x + 1.4218 | 0.8877 | 0.80 | a | 0.94 | 0.76 | a | 0.95 | < 0.0001 |
| TcB Sternum | 44 | 0.8271x + 1.5489 | 0.8794 | 0.79 | a | 0.93 | 0.75 | a | 0.94 | < 0.0001 |
| **After 24h** | | | | | | | | | | |
| TcB Forehead Covered | 39 | 0.7950x + 1.1339 | 0.7904 | 0.63 | a | 0.89 | 0.57 | a | 0.91 | < 0.0001 |
| TcB Sternum Covered | 39 | 0.9756x - 0.3862 | 0.8599 | 0.75 | a | 0.92 | 0.70 | a | 0.94 | < 0.0001 |
| TcB Forehead Exposed | 39 | 0.6991x + 0.2921 | 0.7209 | 0.52 | a | 0.84 | 0.45 | a | 0.87 | < 0.0001 |
| TcB Sternum Exposed | 39 | 0.3572x + 1.0517 | 0.4416 | 0.15 | a | 0.66 | 0.04 | a | 0.72 | < 0.0001 |

*Note: Analysis by Pearson's correlation. TcB = Transcutaneous Bilirubin

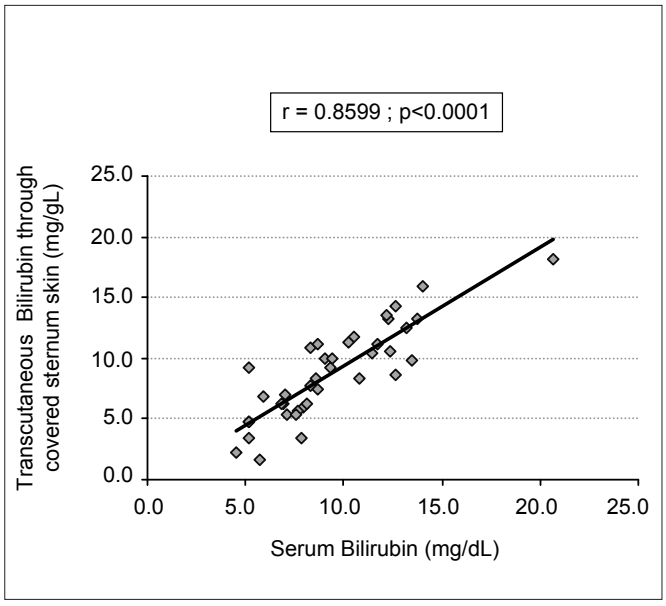


**Figure 1 -** correlation between plasma bilirubin and transcutaneous bilirubin through covered sternum skin 24 hours after starting phototherapy.

## Discussion

In this study, the mean difference between plasma and transcutaneous bilirubin measurement was 0.4 mg/dL for the forehead and 0.2 mg/dL for the sternum, at the time that phototherapy was prescribed. Twenty-4 hours after starting phototherapy, the mean difference for areas of skin duly protected from the light was 0.8 mg/dL for the forehead and 0.6 mg/dL for the sternum, respectively. It was observed that the sternum skin that was protected from the light exhibited a strong correlation (r=0.8599; p<0.0001) and the best confidence interval, both at 95% and at 99%. The difference in correlation may be the result of the degree of adherence between the barrier used to block the light and the sternum skin, compared with skin on the forehead, since the area is more convex.

Zecca *et al* conducted a similar study, occluding a certain part of the skin in order to measure transcutaneous bilirubin during phototherapy, and correlated the measurements with plasma bilirubin. They used Bilicheck for transcutaneous measurements

**Table 3 -** Comparison of bilirubin measurement methods according to study variables 24 hours after starting phototherapy (tcb through covered skin)

| | Nº | Plasma Bilirubin (mg/dL) | TcB forehead covered | | TcB sternum covered | |
|---|---|---|---|---|---|---|
| | | | (mg/dL) | p (1) | (mg/dL) | p (1) |
| Results (2) | 39 | 9.4 ± 3.3 | 8.6±3.3 | 0.298 | 8.8±3.8 | 0.446 |
| Birth weight | | | | 0.109 | | 0.098 |
| < 2,000 g | 21 | 7.6±2.1 | 6.6±2.5 | | 6.2±2.5 | |
| ≥ 2,000 g | 18 | 11.5±3.3 | 10.9±2.7 | | 11.7±2.7 | |
| Race/Color | | | | 0.641 | | 0.690 |
| White | 28 | 9.8±3.6 | 9.1±3.3 | | 9.2±3.9 | |
| Not white | 11 | 8.4±2.4 | 7.4±3.2 | | 7.7±3.5 | |
| Black | 05 | 7.3±2.0 | 6.4±3.3 | | 7.2±3.2 | |
| Mixed race | 06 | 9.4±2.4 | 8.2±3.1 | | 8.0±3.9 | |
| Gestational age | | | | 0.221 | | 0.269 |
| < 36 weeks | 22 | 8.1±2.7 | 7.1±2.8 | | 7.2±3.5 | |
| ≥ 36 weeks | 17 | 11.0±3.4 | 10.5±3.0 | | 10.8±3.1 | |
| Postnatal age | | | | 0.514 | | 0.620 |
| < 3 days of life | 12 | 7.2±1.8 | 7.8±2.8 | | 6.8±3.0 | |
| ≥ 3 days of life | 27 | 10.3±3.4 | 8.9±3.5 | | 9.6±3.8 | |
| Phototherapy | | | | 0.284 | | 0.281 |
| High risk | 30 | 8.4±2.6 | 7.8±2.9 | | 7.8±3.4 | |
| Intermediate risk | 09 | 12.7±3.5 | 11.1±3.6 | | 12.1±3.0 | |

*(1) Analysis of Covariance (ANCOVA); †(2) Analysis of variance (ANOVA).

and the skin occluded was on the forehead. They concluded that transcutaneous bilirubin measurement through an area of covered skin could be a reliable method for use during phototherapy, reducing blood sampling[13]. Jangaard *et al* also found a correlation between plasma bilirubin levels and (Bilicheck) transcutaneous bilirubin measurements during phototherapy, using a covered area of skin and with full term newborns[14].

In contrast, the same correlation is not observed with transcutaneous measures taken through skin that has been exposed to phototherapy. In this study, a statistically significant difference was observed between the transcutaneous measurements taken through skin that had been exposed to phototherapy and plasma measurements, demonstrating that one really shouldn't take transcutaneous measurements through skin that has been exposed to phototherapy.

A study conducted at *Unicamp* by Leite *et al*[4] compared plasma and transcutaneous bilirubin measurements in a sample of neonates, the majority of whom were white (67%), with 23% mixed race and 10% black newborns. Mean gestational age was 35.7±3.7 weeks, birth weight was 2330±930g and postnatal age was 3.25 ±1.73 days. Mean total plasma bilirubin was 8.10±4.17 mg/dL and mean transcutaneous bilirubin measured at the forehead with Bilicheck was 8.82±3.88 mg/dL. In that study, the authors did not observe any significant interference from gestational age, birth weight, race or use of phototherapy on transcutaneous bilirubin measurements and they pointed out that the measurement location had been conveniently shielded from the light. Only postnatal age of less than 3 days was associated with a small statistical difference (p=0.003) between plasma assay and transcutaneous bilirubin, with plasma results being higher. The authors state that this finding may be caused by the increase in bilirubin–albumin bonding and maturation of the skin as the days pass.

In the study described here, the majority of the 44 patients analyzed were also white (73%), 16% were of mixed race and 11% were black. Mean gestational age was 35.1±3.4 weeks, birth weight was 2151±889g and postnatal age was 2.4±1.4 days. Mean total plasma bilirubin was 10.1±3.8 mg/dL, forehead transcutaneous bilirubin through covered skin was 9.7±3.5 mg/dL and sternum transcutaneous bilirubin through covered skin was 9.9±3.6 mg/dL. In common with the study mentioned above, no significant interference was detected from gestational age, birth weight, race or phototherapy (with skin covered) on transcutaneous bilirubin measurements. However, our results differ from those of the *Unicamp* study, since we also failed to detect a statistically significant difference in the comparison between plasma and transcutaneous bilirubin related to post-natal age.

In this study we analyzed correlations between transcutaneous and plasma bilirubin measurements and the variables weight, race/color, gestational and postnatal age and risk of phototherapy, but no significant differences were observed in the correlations between measurements and variables. Sanpavat and Nuchpravoon[6] also correlated variables such as birth weight, gestational age and postnatal age with transcutaneous bilirubin measurement, taken with a Minolta bilirubinometer, and with plasma assay results, observing that only postnatal age had a statistically significant influence. They concluded that at low postnatal ages (1-4 days), transcutaneous measurement generally tended to overestimate the plasma measurements and that at postnatal ages greater than or equal to 5 days, transcutaneous measurements tend to underestimate plasma bilirubin levels[5]. This difference, which was also reported in the study by Leite, [4] using Bilicheck for transcutaneous measurements, was not observed in our study.

In another study[7], Sanpavat and Nuchpravoon compared total plasma bilirubin with transcutaneous bilirubin measured with both the Minolta and Bilicheck devices and found similar accuracy for both, observing that the Minolta tended to underestimate plasma TB, with a mean difference of 0.7 mg/dL, while the Bilicheck tended to overestimate, with a mean difference of 0.6 mg/dL.

In a study using the Minolta, conducted in Japan by Namba and Kitajima, results demonstrated a strong correlation between transcutaneous and plasma bilirubin, with transcutaneous tending to be higher than plasma bilirubin. However, the correlation was inadequate for patients lighter than 1000g or younger than 28 weeks' gestational age[8]. In our study, we compared transcutaneous and plasma bilirubin, classifying patients according to birth weight (<2000g and ≥ 2000g) and gestational age (< 36 and ≥ 36 weeks), but no statistically significant differences were observed in the plasma *vs.* transcutaneous bilirubin comparison. In this study few patients were analyzed who weighed less than 1000g or were younger than 28 weeks' gestational age, making it impossible to conduct an adequate statistical analysis of measurements in this subset.

Chinese researchers compared plasma and transcutaneous bilirubin measurements across strata defined as low, medium and high risk of phototherapy. They found that the correlation was similar for all three groups of patients[15]. No differences in measurements were observed in our study either when patients were stratified into low, medium and high risk of phototherapy. None of the patients in our study were classed as at low risk of needing phototherapy. This is probably because preterms predominated in the population analyzed and because these patients were recruited

from a neonatal ICU and it is normal that they be subject to more risk factors than the general population of neonates.

Several authors have conducted studies correlating plasma and transcutaneous bilirubin across patients of different races[16-19]. Bhutani *et al* compared transcutaneous bilirubin measured with Bilicheck with plasma bilirubin results in patients of different races and did not detect any differences. However, in that study 99% of TB results were below 15 mg/dL[16]. Maisels *et al* investigated a Minolta JM-103 and found that the correlation between transcutaneous and plasma bilirubin measurements was less strong for the black population than for other population groups and that in the black population the transcutaneous measurement tended to be higher than the plasma measurement[17]. Slusher *et al* compared transcutaneous bilirubin with plasma bilirubin in indigenous African neonates with varying degrees of skin pigmentation and found a good correlation between the plasma and transcutaneous measurements[18]. In our study, there was no difference in the comparison plasma *vs.* transcutaneous bilirubin related to the race/color of the patient, but the study population was predominantly composed of white patients and did not constitute a consistent sample for that particular statistical analysis.

Therefore, from the results of this study, it can be concluded that transcutaneous bilirubin measurements taken at the forehead and sternum were equivalent, exhibiting minimal differences. The mean difference between plasma and transcutaneous measurements taken before starting phototherapy was 0.4 mg/dL at the forehead and 0.2 mg/dL at the sternum. After 24 hours of phototherapy, the transcutaneous measure taken through skin on the sternum that had been protected from the light exhibited the best correlation with plasma measurements, with a mean difference of 0.6 mg/dL. There were no significant differences in correlation between plasma and transcutaneous bilirubin measurements when the population was stratified according to any of the following variables: weight, race/color, sex, gestational age, postnatal age or risk of hyperbilirubinemia. The most significant limitation of this study is the small sample size.

We were able to locate few studies in the literature that assessed the reliability of transcutaneous bilirubin measurement conducted with infants on phototherapy and measured through skin protected from the light. Studies with this type of design are needed, bearing in mind the benefits that could be offered for monitoring in neonatal jaundice cases, reducing risks to newborns, with less blood letting, lower risk of infection and fewer painful procedures, in addition to the fact that the transcutaneous measurement provides instantaneous results. Further studies are needed with larger patient samples in order to confirm the results described here.

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