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Comparison of the Transcutaneous Bilirubin Readings at the Forehead during Crying with Those during Quiet State in Neonatal Jaundice

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= Abstract = **We compared TcB readings at the forehead and the mid-sternum during crying with those during quiet state in 70 healthy full-term neonates in order to investigate the effect of crying on TcB readings by using a Minolta/Air-Shields Jaundice Meter. The average TcB reading at the forehead during quiet state was 18.37±2.41, while during crying the average reading were 17.07±2.20. TcB readings at the forehead during crying was significantly decreased compared with the TcB readings during quiet state with a difference of 1.30±0.96(r=0.78, P<0.01).**

The average TcB reading at the mid-sternum during quiet state was 17.07±1.66, while during crying the average reading was 16.80±1.66. TcB readings at the mid-sternum during crying were not significantly decreased compared with TcB readings during quiet state with the difference of 0.20±0.90(P>0.05).

The decreasing effect of crying at the forehead was more influential at the higher TcB reading(TcB≥20) than at the lower TcB reading(15≤TcB<20), while at the mid-sternum there was no crying effect on both the lower and the higher TcB readings.

As mechanisms of the effect of crying on TcB readings at the forehead, we suggest that wrinkling causes the scattering of light by poor contact between the TcB probe and the surface of the forehead skin and the hemodynamyc effect, that of hemoconcentration and changes of skin color during crying.

In conclusion, we should be careful when measuring TcB at the forehead because the babies often cry during measurements. We recommend that TcB measurements at the forehead should be taken during quiet state at the newborn nursery.

Key words: *Neonate, Hyperbilirubinemia, Transcutaneous bilirubinometer*

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INTRODUCTION

Yamanouchi *et al.*(1980) reported earlier that a transcutaneous bilirubinometer(TcB, Minolta/

Air-Shields Jaundice Meter) was very useful as a non-invasive screening device in neonatal Jaundice. Thereafter, many authors(Lucey *et al.*, 1980 ; Hegyi *et al.*, 1981 ; Hannemann *et al.*, 1982), including us(Ha *et al.*, 1988), have confirmed a good correlation between TcB readings and serum bilirubin concentration in full-term and preterm neonates in various populations.

But many clinical factors, such as skin color and character(related to race, gestational age, birth weight, weight for dates, and site for measurement) and therapeutic maneuvers(phototherapy and exchange transfusion), may influence the correlation coefficiency and intercept between TcB readings and serum bilirubin.

As the sites for measurement, two sites, the forehead and mid-sternum, are known to be suitable for TcB measurements because of easy accessibility and underlying bone to provide the resistance that triggers the monitor's light source(Yamanouchi *et al.*, 1980; Tudehope and Chang, 1982). The forehead is especially useful for TcB measurement in the early days of life (Yamanouchi *et al.*, 1980). Lucey *et al.*,(1980) and Yamanouchi *et al.*,(1980) have already pointed out that TcB measurements at the forehead during facial expression would fluctuate.

We investigated the effect of crying on TcB readings at the forehead by comparing them with those during quiet state.

MATERIALS AND METHODS

Our study population consisted of 70 healthy full-term neonates admitted to the Newborn Nursery of Seoul National University Hospital from January 1992 to December 1994. The babies had neither medical complications nor had taken drugs which could cause hyperbilirubinemia. The TcB measurements were obtained from the forehead and the mid-sternum during crying and during quiet state. Measurements were made in triplicate by one examiner(H. Y. Kang) at each state, crying and quiet, and the mean result was used. For crying state, we obtained TcB readings either during the baby's spontaneous crying or during crying sometimes induced by stimulating the heel of the baby. None was received phototherapy or exchange transfusion at the time of study.

We used a Transcutaneous Bilirubinometer (Minolta Camera Co., Japan & Air-Shields Vickers, Hatboro, PA, USA) for TcB measurements.

The Data were analyzed by utilizing mean±S. D., the coefficient of correlation with Chi-square and a comparison of paired data with Student's test.

RESULTS

To investigate the effect of crying on TcB readings, TcB was measured at the forehead in 70 neonates during crying and quiet state. The average TcB reading during quiet state was 18.37±2.41, while during crying the average reading was 17.07±2.20. TcB readings at the forehead during crying were significantly decreased compared with the TcB readings during quiet state with a difference of 1.30 ± 0.96 ($P<0.01$)(Table 1).

The average TcB reading at the mid-sternum during quiet state was 17.07±1.66, while the average reading during crying was 16.80±1.66. TcB readings at the mid-sternum during crying were not significantly decreased compared with TcB readings during quiet state with a difference of. 0.20±0.9($P>0.05$)(Table 1).

Table 1. Effect of crying on TcB readings at the forehead and the sternum.

Site	Forehead	Sternum
No. of patients	70	70
TcB readings		
Quiet	18.37±2.41	17.07±1.74
Crying	17.07±2.20	16.80±1.66
Difference	1.30±0.96	0.20±0.90
P value	<0.01	NS

There was also a good correlation between the degree of decrease of TcB readings at the forhead during crying and those during quiet state($r=0.78$, $p<0.01$, $n=70$).

To clarify the decreasing effect of crying on TcB reading at the forehead compared with those during quiet state, 70 neonates were divided into two groups according to TcB readings. One group was 45 babies with 15≤TcB< 20 and the other group was 25 babies with TcB≥20.

The average TcB reading at the forehead during quiet state was 16.84±1.26 and the average reading during crying was 15.78±1.21 in the group of 15≤TcB<20. TcB readings at the forehead during crying were significantly decreased compared with TcB readings during quiet state with a difference of 1.07±0.75 in the group of 15≤TcB<20(P<0.01)(Fig. 1).

The average TcB reading at the forehead during quiet state was 21.12±1.21 and the average reading during crying was 19.40±1.52 in the group of babies with TcB≥20. TcB readings at the forehead during crying were significantly decreased compared with TcB readings during quiet state with a difference of 1.72±1.07 in the group of TcB≥20(P<0.01)(Fig. 1).

These showed that the decreasing effect of crying was more influential at the higher TcB reading at the forehead.

The average TcB reading at the mid-sternum during quiet state was 16.76±1.36 and the average reading during crying was 16.58±1.29 in the group of 15≤TcB<20. TcB readings at the mid-sternum during crying were not significantly decreased compared with TcB readings on quiet state with a difference of 0.18±0.82 in the group of 15≤TcB<20(P>0.05)(Fig. 2).

The average TcB readings at the mid-sternum during quiet state was 21.00±0.71 and the average reading during crying was 20.50±1.12 in the group of TcB≥20. TcB readings at the mid-sternum during crying were not significantly decreased compared with TcB readings during the quiet state with a difference of 0.50±1.91 in the group of TcB≥20(P>0.05)(Fig. 2).

These showed that there was no crying effect on the lower and higher TcB readings at the mid-sternum during crying.

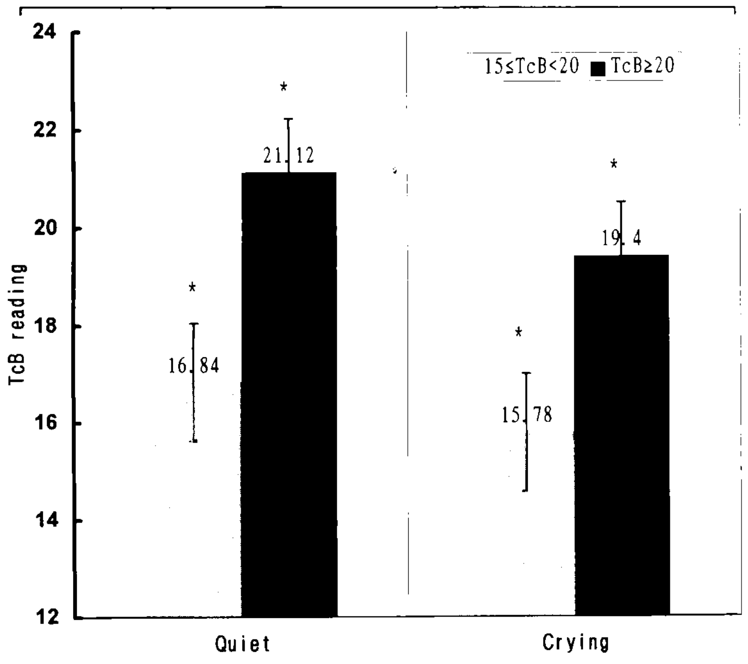

Fig. 1. Effect of crying on TcB readings at the forehead in two groups according to TcB readings
(□; 15≤TcB<20, n=45 and
■; TcB≥20, n=25),
*denotes P<0.01. Values are expressed as mean±S.D.

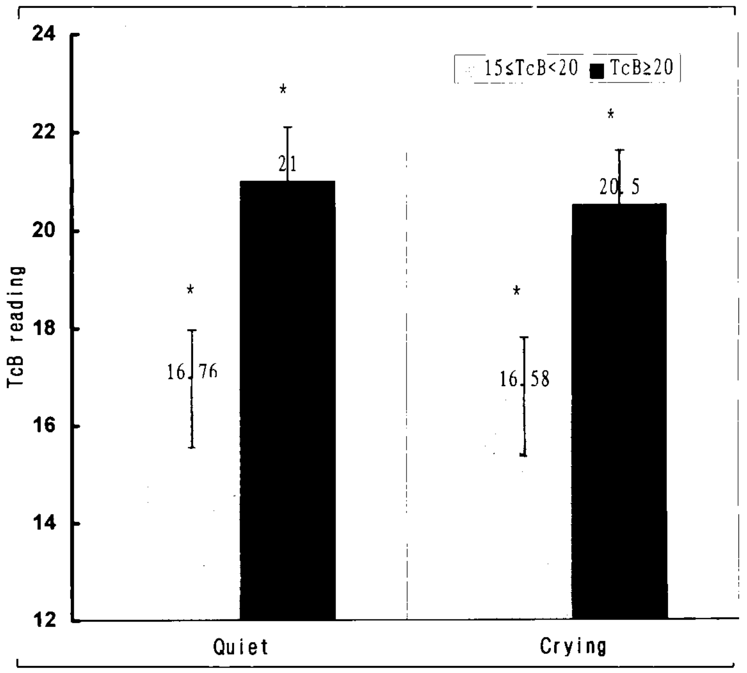

Fig. 2. Effect of crying on TcB readings at the mid-sternum in two groups according to TcB readings
(□; 15≤TcB<20, n=45 and
■; TcB≥20, n=25),
*denotes P>0.05. Values are expressed as mean±S.D.

DISCUSSION

The transcutaneous bilirubin measurement devices that have been used most commonly are the human eyes with and without the aid of a reference device and the Minolta/Air-Shields Jaundice Meter.

Kramer(1969) exploits the phenomenon of the cephalocaudal progression of jaundice by dividing the infant's body into dermal zones of jaundice and then assessing the spread of jaundice in the infant to one of the zones. This simple visual estimate of the presence or absence of jaundice is performed by nearly all practicing pediatricians.

The Tintometer by Rowntree and Brown(1925) and the Ingram Icterometer by Gosset(1960) were used as devices for measuring the depth of jaundice in newborn infants with a simple visual analysis of the color of the skin.

Yamanouchi *et al.*(1980) introduced the Minolta/Air-Shields Jaundice Meter, which is a more-sophisticated, non-invasive screening device for TcB measurement. This instrument is hand-held, battery operated, weighs about 9 oz, and is simple to use. When pressure applied to the meter from the newborn infant's forehead meets a resistance of 200 gm, a strobe light generated by a xenon tube is flashed through a fiberoptic bundle, penetrates the underlying blanched skin, and enters the subcutaneous tissue (Yamanouchi *et al.*, 1980; Strange & Cassady 1985; Schumacher 1990). The reflected light returns through a second fiberoptic bundle to the spectrophotometric module within the instrument where it is filtered at blue light(460 nm) and green light(550 nm) to correct for the influence of hemoglobin at these wavelengths. The intensity of yellowness of the reflected light is then translated into arbitrary units to be displayed. The number is not the same as the total serum bilirubin value, but is an index of that level. The TcB measurement of the yellow color of the skin by this instrument has been shown to correlate well with the total serum bilirubin in newborns by many reseachers(Yamanouchi *et al.*, 1980; Lucey 1980; Hegyi *et al.*, 1981; Hanneman *et al.*, 1982; Ha *et al.*, 1988).

However there may be many problems in the form of imprecision and intermeter and intrameter, interoperator and intraoperator, and intrasubject variability as well as bias, most of these problems are so minor that they are of little con sequence, or are recognizable and correctable from a practical standpoint.

The Minolta/Air-Shields Jaundice Meter is reported to be "accurate" to within ±5%, "highly significantly correlated" ($r=0.95$, $p<0.001$), "good reproducible" (coefficient of variation; 0 to 4.90%) and "little technically dependent"(coefficient of variation; 2.13 to 4.98%) by Yamanouchi *et al.*(1980). Thereafter, many researchers reported similar results(Lucey 1980; Heygi *et al.*, 1981; Hanneman *et al.*, 1982, Palmer *et al.*, 1982; Maisels & Lee 1983). We also reported a good correlationship($r=0.78$), a good reproducibility and little technical dependence(coefficient of variation; 0 to 4.85% and 1.98 to 4.78%)(Ha *et al.*, 1988).

As the TcB measurement detects the skin reflectance, its value is influenced by many factors such as race, gestational age, birth weight, level of hemoglobin, therapeutic maneuvers(phototherapy and exchange transfusion), site for measurement, etc.

From the reports of Japanese, white, black, Chinese, Malay and Korean newborn infants (Yamanouchi *et al.*, 1980; Hegyi *et al.*, 1981; Maisels and Conrad 1982; Tan 1982; Ha *et al.*, 1988), we found that skin reflectance varies with the degree of pigmentation. The darker the race, the higher the intercept is on the regression line. But, correlation coefficients are statistically acceptable in each racial population if different regresssion lines are calculated for each race.

Gestational age and birth weight also affect the correlation of TcB and serum bilirubin through the changes in skin characteristics(skin thickness, vascularity, etc)(Goldman *et al.*, 1982; Tolentino *et al.*, 1982; Cashore 1983; Kim *et al.*, 1994). For a given serum bilirubin, TcB is higher with decreasing gestational age and birth weight. There is a decrease in the correlation coefficient with decreasing gestational age and birth weight. Postnatal age and sex have not been shown to effect the correlation coefficients(Tudehope and Chang 1982; Wu *et al.*, 1982).

For any given serum bilirubin, TcB is higher with decreasing hematocrit(Wu *et al.*, 1982).

Some researchers have noted a decrease in the correlation coefficient when infants were treated with phototherapy(Heygi *et al.*, 1981; Tan 1982; Tudehope and Chang 1982), others have reported a decreased, but continued statistically significant correlationship(Cifuentes *et al.*, 1982; Pasnick and Lucey 1982; Tolentino *et al.*, 1982).

There has been only limited testing of TcB and serum bilirubin correlation in infants undergoing exchange transfusions. Results to date indicate an unacceptable correlation, and the Minolta/Air-Shields Jaundice Meter(Tc Bilirubinometer) is not recommended in the follow-up of these infants(Yamanouchi *et al.*, 1980; Pereira and Gorman 1982).

From the evaluation of different sites(forehead, *mid-sternum, right upper abdomen, knee, sole,* elbow, palm, upper back, and lower back, etc) for TcB measurement, several sites give statistically significant correlation coefficients. The forehead and the mid-sternum have gained wide acceptance because of easy accessibility and underlying bone which provides the resistance that triggers the Tc Bilirubinometer's light source. The forehead has been more recommended as the site of choice for its measurement because: 1) it is usually acceptable; 2) the frontal bone structure offers the necessary resistance to activate the xenon tube mechanism; and 3) the skin surface of the forehead is taut and firm (Yamanouchi *et al.*, 1980; Hegyi *et al.*, 1981; Tudehope and Chang, 1982).

But, TcB measurement at the forehead is more variable from person to person. This variability can be in part explained by facial expressions, like crying, as shown in this study. TcB readings at the forehead, unlike those at the mid-sternum, may also be affected by ecchymosis or congestion from birth trauma, contributing to lower TcB readings at the forehead, than at the mid-sternum.

Lucey *et al.*(1980) and Yamanouchi *et al.* (1980) have also pointed out that TcB measurement at the forehead with facial expression were lower by 1-3 points than those during quiet state. In our study we could confirm that TcB readings at the forehead decreased significantly during crying with good correlation compared with those during quiet state and the effect of crying at the forehead was more influential at higher TcB readings($TcB \geq 20$) than lower ones($15 \leq TcB < 20$). There was no significant decreasing effect of TcB readings at the mid -sternum during crying and quiet state.

As the mechanisms of the effect of crying on TcB measurement at the forehead, we suggest that wrinkling causes the scattering of light by poor contact between the TcB probe and the surface of the forehead skin and hemodynamic effect, that of hemoconcentration and changes of skin color during crying. The depth and num ber of wrinkles on the forehead is dependent on the degree of crying.

In conclusion, we should be careful when *measuring TcB at the forehead because the* babies often cry during measurements. We recommend that TcB measurements at the forehead should be taken during quiet state at the newborn nursery.

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