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Abstract: AIM: We aimed to find the correlation between bilirubin levels measured spectrophotometrically and transcutaneously by an icterometer and investigate if the number of serum bilirubin measurements can be reduced by using an icterometer during phototherapy on a bilibed.

METHODS: The study group consisted of 52 babies with total serum bilirubin values less than 18 mg/dl, who were treated by phototherapy at the bilibed in the Neonatology Unit of Marmara University Hospital. Eighty-nine measurements were made from the study population. During phototherapy on the bilibed, the face of the baby was not affected by phototherapy light, allowing transcutaneous bilirubinometry to be more accurate. Serum bilirubin was measured spectrophotometrically on capillary blood in all subjects. A simultaneous transcutaneous bilirubin measurement with the icterometer was done by a pediatrician who was blind to the serum bilirubin levels.

RESULTS: The mean gestational age was 38±2.2 (34-41) weeks, birth weight 2979±505 (1500-3900) g and the serum bilirubin of the study group was 14.9±1.6 (10.4-18) mg/dl. Although the comparison of the icterometric measurements and the serum bilirubin levels showed a statistically significant relation ($p<0.0001$) in the whole group, the correlation was moderately strong ($r=0.59$). The correlation was weaker in infants whose bilirubin levels were more than 15 mg/dl ($r=0.32$).

CONCLUSION: We concluded that spectrophotometric bilirubin measurements cannot be replaced by measurements obtained transcutaneously from babies whose bilirubin values are more than 15 mg/dl.

Key Words: bilibed, icterometer, hyperbilirubinemia

Introduction

Hyperbilirubinemia is a commonly encountered problem in the neonatal period. Serum bilirubin levels are followed frequently during phototherapy by several methods, of which the most common is the spectrophotometric method (1). Several noninvasive methods have been developed recently to assess the jaundice of an infant and its correlation with serum bilirubin levels was investigated. The Ingram icterometer, which was first put into the practice in 1960 by Gossett, was approved as a screening test for hyperbilirubinemia due to its low price and good reliability in showing serum bilirubin levels (2-4). However the accuracy of transcutaneous bilirubinometry was found to be low during phototherapy (5, 6).

In our study, the bilirubin levels of babies who underwent phototherapy on a bilibed were measured both spectrophotometrically and with an Ingram icterometer simultaneously, since the face was not exposed to the phototherapy light and the correlation between these values was studied. We aimed to investigate if the number of serum bilirubin measurements can be reduced by using an icterometer during phototherapy should a strong correlation prove to exist.

Materials and Methods

The study group consisted of 24 male and 28 female neonates who were over 34 weeks of gestational age and treated with phototherapy on the bilibed in the neonatology unit of Marmara University Hospital between February and June 2000. Eighty-nine measurements were obtained from the study population. Babies who had bilirubin levels greater than 18 mg/dl (thus needing double phototherapy) and who had taken phototherapy before admission were excluded from the study.

A bilibed is a phototherapy device that is a bed containing two blue and two white fluorrescent lamps of 420 nm in wave length (Bilitron 444). It is different from conventional phototherapy in that the face of baby is not affected by the phototherapy light. Hence, this may allow icterometric measurements to be obtained from the face more accurately. The lamps are only 10 cm away from the skin of the infant; thus this type of phototherapy is more effective in reducing the serum bilirubin.

The Ingram icterometer is a plexiglass ruler that has a color scale with different tones of the color yellow (S. A. Ingram & Co Ltd, Birmingham, England). Measurements may be obtained from the nose, forehead, sternum or heel in daylight. In this study, transcutaneous measurements were obtained by pressing the icterometer against the tip of the baby's nose. The yellow color of the skin is then matched with the yellow stripes on the scale. In Table 1, the bilirubin values corresponding to the icterometer color scale are given.

Table 1. Bilirubin values corresponding to the icterometer color scale

ICTEROMETER READING (SCALE)	SERUM BILIRUBIN MEAN	+2 SD
2	5.55	8.7
2.5	7.57	12.11
3	10.03	14.58
3.5	12.31	17.31
4	15.73	21.8
4.5	19.06	26.8
5	22.1	28.1

All patients were investigated to determine the etiology of hyperbilirubinemia. The work-up for hyperbilirubinemia included a complete blood count and the differential, blood group, reticulocyte count, direct Coomb's test and serum total as well as direct bilirubin levels. A pediatrician who was blind to the serum bilirubin levels took measurements with an icterometer from the nose of the infant simultaneous to capillary blood bilirubin measurements.

The correlation between icterometric measurements and serum bilirubin levels were determined using Spearman correlation coefficient test.

Results

The mean gestational age and postnatal age of the study group was 38 ± 2.2 (34-41) weeks, 5.8 ±3.4 (2.0-19.0) days respectively. The average birth weight was 2979 ± 505 (1500-3900) grams. A total of 57.9% of the babies were born by vaginal delivery, with 41.9% by caeserian section. Thirty-five percent of the babies were premature and 65% of the babies were full term.

The mean serum bilirubin level of the babies was 14.9±1.6 g/dl and the mean bilirubin value obtained by icterometric measurements was 3.8±0.6 (2-5) (Table 2). The relation between icterometric measurements and serum bilirubin levels is shown in Table 3.

Table 2. The demographics features of the patients (n=89)

	MEAN (SD)	RANGE
Gestational age (week)	38.±2.2	34-41
Birth weight (gram)	2979±505	1500-3900
Postnatal age (day)	5.8±3.4	2.0-19.0
Hematocrit (%)	51.3±6.1	40.0-64.0
Serum bilirubin (mg/dl)	14.9±1.6	10.4-18.0
Icterometric measurement (scale)	3.8±0.6	2.0-5.0

Table 3. Icterometer readings and corresponding total serum bilirubin values in the study population.

ICTEROMETER READING (SCALE)	NUMBER OF READINGS	TOTAL SERUM BILIRUBIN (MG/DL) MEAN (SD)	RANGE
2	1	10.4	10.4
2.5	8	13.8± 1.2	12.4-15.7
3	3	12.9±1.1	11.8-14
3.5	19	13.8± 1.5	10.5- 16.4
4	41	15.2±1.2	13-18
4.5	11	16.3±1.6	13.5-18
5	6	16.1± 0.5	15.5-16.8

The correlation coefficient of the spectrophotometric method and the Ingram icterometer was found to be 0.59 (p=0.0001).The correlation coefficients of the subgroups according to the gestational age, postnatal age and serum bilirubin levels are given in Table IV. The correlation between these two methods was weaker (r =0.32) in patients whose bilirubin values were more than 15 mg/dl (p=0.01).

Discussion

In newborns serum bilirubin levels are frequently measured by the spectrophotometric method using a cap-

Table 4. The relation coefficients of icterometer and serum bilirubin in different subgroups.

	NUMBER OF PATIENTS (N)	CORRELATION COEFFICIENT* (R)	P VALUE*
GESTATIONAL AGE (WEEK)			
≤ 37	32	0.69	<0.0001
> 38	57	0.53	<0.0001
BILIRUBIN VALUE (MG/DL)			
< 15	44	0.52	<0.0001
≥ 15	45	0.32	0.01
POSTNATAL AGE (DAY)			
≤ 7	75	0.59	<0.0001
> 8	14	0.59	0.025
TOTAL	89	0.59	0.0001

* r and p values were obtained from Spearman correlation coefficient test.

illary blood sample. In 1960, Gosset and Oxxon designed a plexiglass ruler having different tones of yellow color on it (Ingram icterometer) (1). The Ingram icterometer is simple, practical and reliable in determining serum bilirubin levels transcutaneously. In a study by Schumacher et al., the sensitivity and the specifity of the icterometer were found to be 82% and 74% respectively (7). In another study, by Bilgen et al., a high correlation (r = 0.78) was found between icterometer values and serum bilirubin levels in term hyperbilirubinemic subjects that did not receive phototherapy (8).

The icterometer has been used to detect hyperbilirubinemia in healthy newborns. Previous studies concluded that if the icterometric measurement is 3 or lower in a full-term infant serum bilirubin may not be measured (7-9).

Many authors have reported that the gestational and postnatal age, hematocrit value and bilirubin value and history of previous phototherapy are factors that affect transcutaneous bilirubin measurements (10, 11). The sensitivity of transcutaneous bilirubin measurements is found to be less in very high bilirubin levels and in subjects with a history of previous phototherapy (5, 6).

In our study, we examined the effectivity of the icterometer in following the bilirubin levels of the newborns taking phototherapy on a bilibed. As the faces of the patients taking phototherapy at the bilibed are not directly exposed, we hypothesized that the icterometric measurements would be accurate even during phototherapy. If we found a strong correlation, we could reduce the number of heel prick samplings to every other bilirubin measurement. In our series, the icterometer seems to be reliable in neonates who have bilirubin levels less than 15 mg/dl, but the serum bilirubin and transcutaneous measurements in the rest of patients do not correlate very well. Since there is little need to put term babies under phototherapy with bilirubin levels less than 15 mg/dl, we concluded that serum bilirubin should be measured spectrophotometrically in term infants requiring phototherapy, but an icterometer can reduce the number of heel prick blood samplings in borderline premature babies requiring phototherapy with bilirubin levels of less than 15 mg/dl.

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