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Evaluation of a Transcutaneous Bilirubinometer with Two Optical Paths in Chinese Preterm Infants

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Abstract

Objective: To evaluate the reliability of Minolta JM-103 Jaundice Meter as a screening tool for neonatal jaundice in preterm Chinese neonates on day 0-14. ***Methods:*** This prospective study studied the correlation between the total serum bilirubin (TSB) measurements and the paired transcutaneous bilirubin measurements obtained at the forehead (TcB_F) and sternum (TcB_S) between April and September 2009. ***Findings:*** 110 pairs of TcB_F, TcB_S and TSB measurements were evaluated in 30 preterm newborns. Both TcB measurements were significantly correlated with TSB, with a correlation coefficient of 0.81 and 0.83 for TcB measurements obtained at the forehead and sternum, respectively. The mean of the difference of the pairs (TcB_F minus TSB) and (TcB_S minus TSB) were 9.30 and 20.18 μmol/L, respectively. The corresponding standard deviation measured 27.10 and 27.46 at $p<0.01$, respectively; the JM-103 tended to overestimate TSB. ***Conclusion:*** TcB correlates significantly with TSB in preterm neonates and JM-103 appears to be useful as a screening tool in preterm (<35 weeks) neonates.

Key words Hyperbilirubinemia; Neonatal jaundice; Preterm infants; Transcutaneous bilirubinometer; Very low-birth weight infant

Introduction

Neonatal jaundice is one of the most common diseases during the early neonatal period. Hyperbilirubinaemia is a dangerous condition, especially for preterm infants, because of the immature blood-brain barrier, which allows better bilirubin diffusion into the brain. Therefore, accurate determination of total serum bilirubin (TSB) levels is important in order to recognise those at risk of bilirubin encephalopathy. However, taking blood is painful and repeated sampling may lead to significant blood loss, especially in preterm infants. Therefore, different methods for transcutaneous bilirubin (TcB) measurement have been developed, which are faster, more convenient and painless.

The Minolta Jaundice Meter (JM-103) determines the yellowness of the subcutaneous tissue of a newborn infant by measuring the difference between optical densities for light in the blue (450 nm) and green (550 nm) wavelength regions.[1] The principle of operation includes the formation of two optical paths, one of which reaches only the shallow areas of the subcutaneous tissue while the other penetrates the deeper layers. The differences between the optical densities are detected by blue and green photocells. The measurement of bilirubin accumulated primarily in the deeper subcutaneous tissue should decrease the influence of other pigments in the skin such as melanin and haemoglobin. Yasuda et al found an excellent correlation

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(r=0.94) between the JM-103 and TSB for all subjects, including preterm subjects with gestational age(GA) down to 25.4 weeks and birth weight (BW) down to 761 grams.[1]

Ho et al reported that combining the use of the JM-103 and the 75th centile in Bhutani's nomogram as cut-off level can identify all cases of significant hyperbilirubinaemia in term or near-term Chinese newborns.[2] His findings concurred with the findings of Maisels et al.[3] Maisels et al showed that there was an overall significant correlation between TcB and TSB (r=0.915) in newborn >/= 35 weeks of gestation. Thus, the role of the JM-103 in facilitating bilirubin screening and avoiding unnecessary blood tests in term or near-term newborns is well established both locally and internationally.

However, the accuracy of the JM-103 in preterm infants was only studied overseas. Studies performed in Asia,[1,4,5] Europe[6-8] and United States[9] had reported close correlation between TcB and TSB and recommended the use of the JM-103 as a screening tool to identify preterm neonates in need of TSB laboratory assessment. As similar studies in our locality is lacking, we find evaluation in the use of the JM-103 in Chinese preterm babies necessary.

Methods

This prospective study was approved by the New Territories West Cluster Clinical & Research Ethics Committee in April 2009. Preterm Chinese infants with gestational age <35 weeks were enrolled in the study if they required TSB level measurement on clinical indication within the first two weeks of life and their parents agreed. Gestational age was determined by the best obstetric estimate on the basis of last menstrual period and prenatal sonographic evaluation. If the pediatric estimate differed by >2 weeks, this value was used to assign gestational age.[10] The exclusion criteria were (i) major congenital malformations/obstructive jaundice/haemolysis; (ii) during phototherapy and the immediate 24 hours post phototherapy; (iii) prior exchange transfusion; (iv) poor skin condition/circulation (capillary refill time >3 seconds)/ oedematous/cyanotic; and (v) non-Chinese ethnicity.

The study period was from April to September 2009. During the period, the JM-103 Minolta study information sheets (Appendix 1) were offered to the parents of eligible babies on admission to the Neonatal Special/Intensive Care Unit. As the risk involved in measurement of TcB is negligible and no extra blood taking is involved, only verbal agreements were obtained. Parents were informed of their right to opt out from the study and under all circumstances, their wishes were respected.

The study did not involve scheduled TSB check. All TSB were obtained on clinical indication. The JM-103 jaundice meter was calibrated by a reading-checker every morning during the study period. Nurses are instructed to wash their hands and use alcohol swab to wipe the JM-103 probe before every contact with a "new" baby. As the first of three measurements with the JM-103 provided results similar to their average, one TcB reading should suffice.[3] Within 30 minutes of TcB check on the baby's forehead and sternum, one paired TSB measurement was obtained.

All TSB check was performed by the doctors and phlebotomists. Either heel prick capillary samples, arterial or venous blood samples were sent to the clinical chemistry laboratory to proceed. The TSB assay was performed in the hospital chemical laboratory, using the Unistat Bilirubinometer, Model 10311 (Leica Inc, Buffalo, New York), a direct spectrophotometer subjected to daily testing and have an upper measurable value of 684 umol/L.

Statistical Package for the Social Science (Windows version 15.0; SPSS Inc, Chicago [IL], US) was used for statistical analysis. Pearson's correlation coefficient and linear correlation analyses and a multiple linear regression analysis were used to detect associations between TSB or TcB and the other variables. As Pearson's coefficient alone can be a poor indicator to estimate agreement between TSB and the two TcB measurements made at the forehead and sternum, we assessed it using the Bland-Altman technique.[11] Agreement between TcB and TSB values was determined with the paired-samples *t*-test. Correlation coefficients with *p*-values <0.01 were defined as statistically significant. Imprecision was determined by calculating the standard deviation of the difference between the two TcB values obtained.

An independent Student's *t*-test, analysis of variance (ANOVA) and multiple regressions were used for comparison of variables between subgroups. The results are presented as the means±SD. Statistical significance is implied by a *p*-value of less than 0.05.

Results

Patients

A total of 30 jaundiced preterm infants (14 males, 16 females) of Chinese race, including 3 extremely low birth weight (ELBW; birth weight less than 1000 g) and 9 very low birth weight (VLBW; birth weight 1000-1500 g) neonates were evaluated. The mean birthweight of all neonates was 1577±483 g, ranging from 860 g to 2160 g, mean gestational age was 31.1±6.0 weeks, ranging from 27 to 34 weeks. The mean postnatal age was 5.5±3.7 days, ranging from 0 to 14 days.

Excluded Subjects

During the study period, 59 preterm babies were eligible for inclusion into the study. Fifteen babies were critically ill and their parents were not approached to obtain for consent. The parents of another 5 babies opted out from the study. So, consent was obtained in 39 babies.

Among the 39 babies with consent, one baby was excluded because of poor circulation and another baby was excluded because of non-Chinese ethnicity. No baby was excluded because of congenital malformations/obstructive jaundice/haemolysis or prior exchange transfusion. However, five babies were excluded due to incomplete data. Two babies at gestational age of 34+6 weeks were discharged in the first 3 days and did not require TSB measurement. Thirty babies were thus recruited into the study.

One hundred and forty-four pairs of TcB-TSB data were collected from the studied population. Among them, 34 pairs were excluded as they were obtained during phototherapy and the immediate 24 hours post phototherapy. So, 110 pairs of TcB-TSB data were included into this study.

Correlation Between TSB and TcB Measured Over the Forehead & Sternum

TSB values ranged from 42 to 239 µmol/L compared with 25 to 250 µmol/L for TcB forehead (TcB_F) and 20 to 278 µmol/L for TcB sternum (TcB_S) values. The overall correlation coefficients for TSB versus TcB measurements over forehead and sternum were 0.81 (Figure 1) and 0.83 (Figure 2), respectively.

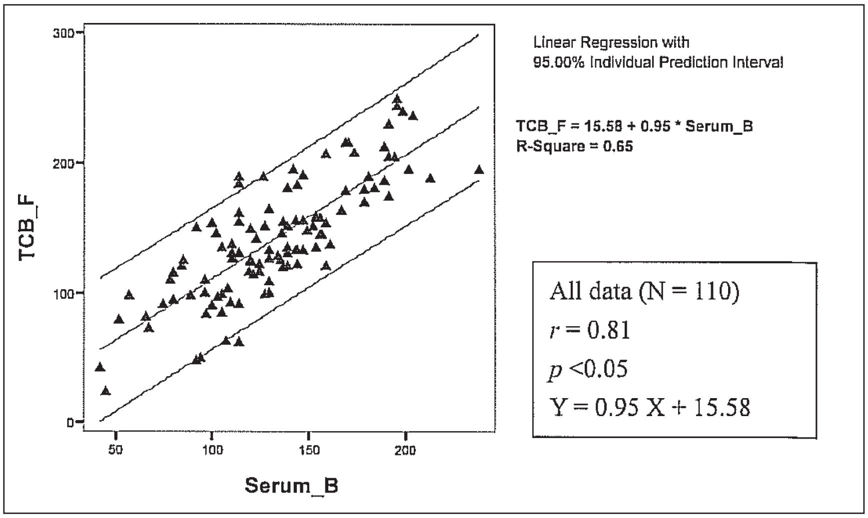

Figure 1 Correlation between total serum bilirubin (TSB) and transcutaneous bilirubin measured over forehead (TcB_F); 95% confidence limits are included.

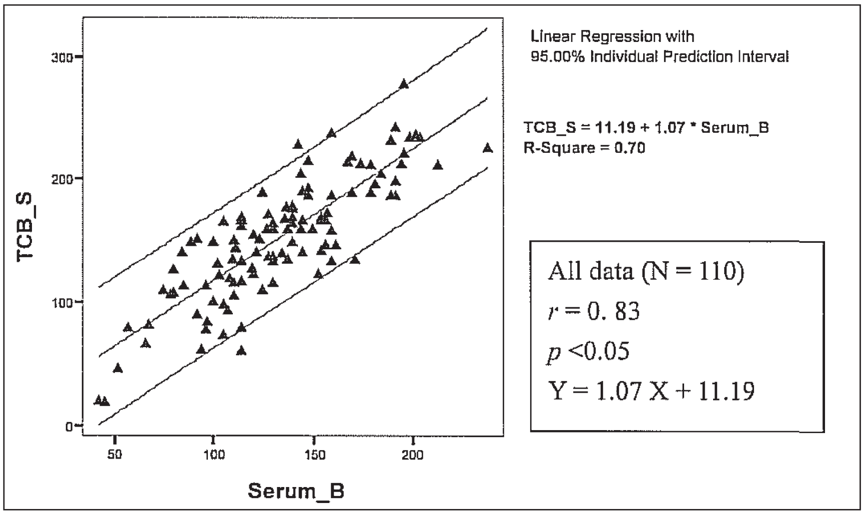

Figure 2 Correlation between total serum bilirubin (TSB) and transcutaneous bilirubin measured over sternum (TcB_S); 95% confidence limits are included.

Agreement Between TSB and TcB Values Measured Over the Forehead & Sternum

Figures 3 and 4 are the Bland-Altman plots for TcB_F minus TSB and TcB_S minus TSB respectively. The biases, which were estimated as the mean of the difference of the pairs (TcB_F minus TSB) and (TcB_S minus TSB) were 9.30 and 20.18 µmol/L, respectively. The corresponding standard deviation measured 27.10 and 27.46 at $p<0.01$, respectively and indicated a uniform tendency for JM-103 to overestimate TSB. The corresponding 95% limits of agreement were between -43.81 and 62.41 µmol/L for the forehead group (Figure 3) and between -33.64 and 74.00 µmol/L for the sternum group (Figure 4).

Results of the paired-samples *t*-test are given in Table 1. Correlations between TcB and TSB values varied between 0.81 and 0.83 and all were statistically significant. Both

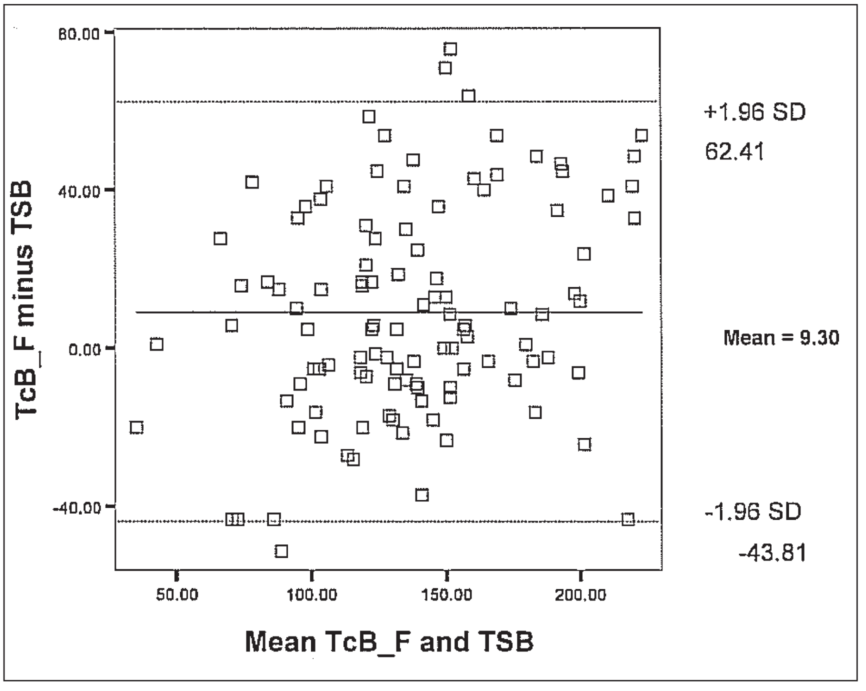

Figure 3 Bland-Altman plot showing agreement between total serum bilirubin (TSB) and transcutaneous bilirubin (TcB) values measured over the forehead.

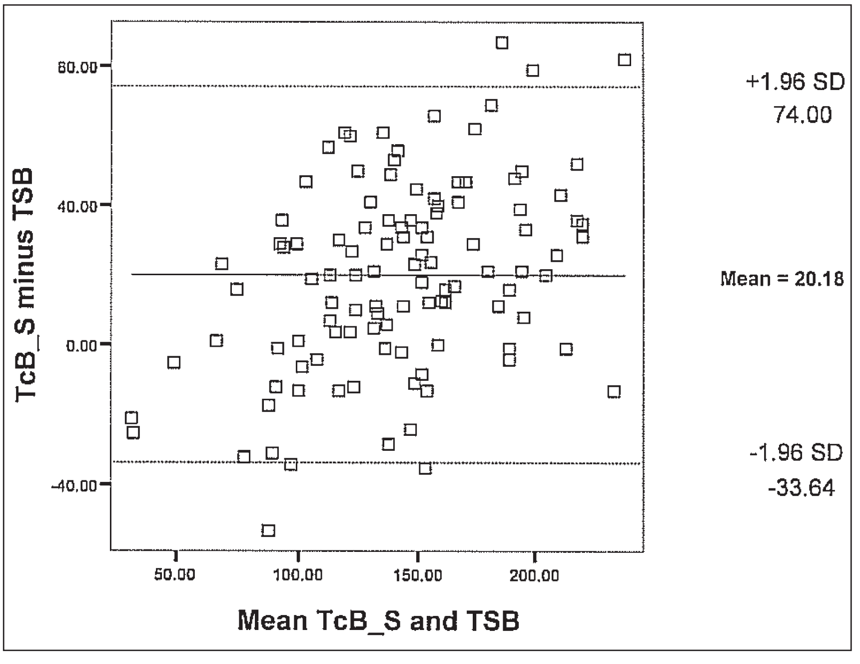

Figure 4 Bland-Altman plot showing agreement between total serum bilirubin (TSB) and transcutaneous bilirubin (TcB) values measured over sternum.

mean TcB_F and TcB_S levels were significantly higher than TSB levels (142.2±45.7 µmol/LTcB_F and 153.1±49.5 µmol/LTcB_S vs 132.9±40.7 µmol/LTSB). This indicates that the agreement between TcB and TSB values diminished when measured at the sternum, as compared with the forehead.

Correlation Between TSB and TcB at Different Postnatal Days (Table 2a)

When comparing the data of both TcB_F and TcB_S groups, correlation coefficients between paired TSB and TcB were on the decreasing trend with increasing postnatal days.

Influence of Different Parameters on Coherence Between TSB and TcB

In a multiple regression analysis for the whole group, only history of phototherapy was found to be independently related to TSB – TcB_F correlation (beta -0.26, $p<0.05$) and TSB – TcB_S correlation (beta -0.27, $p<0.05$). Correlation coefficients between TSB and TcB_F and TcB_S in the group without phototherapy and with phototherapy and their significance levels and equations are shown in Table 2b. No substantial relationships were found for gestational age (β_{TcB_F} -0.27, p=0.223; β_{TcB_S} -0.14, p=0.549), birth weight (β_{TcB_F} 0.30, p=0.161; β_{TcB_S} 0.14, p=0.504), small for gestational age, SGA (β_{TcB_F} -0.01, p=0.936; β_{TcB_S} 0.07, p=0.602) and the need for mechanical ventilation, MV (β_{TcB_F} -0.15, p=0.203; β_{TcB_S} -0.09, p= 0.454).

Discussion

This study is the first in Hong Kong to assess the validity of the JM-103 in preterm babies <35 weeks of gestation. There are similar studies in Asia,[1,4,5] Europe[6-8] and United States[9] reporting good correlation between readings

Table 1 Results of the paried-samples *t*-test for the all TcB measurements and by group (TcB_F, TcB measurements over the forehead; TcB_S, TcB measurements over the sternum)

	Paired-samples correlation			Paired-samples *t*-test			
	N	***r***	***p*-value**	**Mean***	**SD**	**SEM**	***p*-value**
All TcB	220	0.82	$p<0.001$	14.74	27.76	1.87	$p<0.01$
TcB_F	110	0.81	$p<0.001$	9.30	27.10	2.58	$p<0.01$
TcB_S	110	0.83	$p<0.001$	20.18	27.46	2.62	$p<0.01$

N, number of datasets; *r*, correlation coefficient; SD, standard deviation; SEM, standard error of the mean

*Mean difference: value of transcutaneous bilirubin (TcB) minus value of total serum bilirubin (TSB).

Table 2a Correlation between total serum bilirubin (TSB) and transcutaneous bilirubin (TcB) values at different postnatal days (correlation coefficients, significance level and equation) for measurements taken at forehead (TcB_F) and sternum (TcB_S)

Postnatal days	**TcB at forehead (TcB_F)**			**TcB at sternum (TcB_S)**		
0-4	r=0.89	$p<0.05$	Y=1.00X + 22.38	r=0.89	$p<0.05$	Y=1.12X + 13.98
5-9	r=0.77	$p<0.05$	Y=1.03X - 4.60	r=0.79	$p<0.05$	Y=1.07X + 1.48
10-14	r=0.75	$p<0.05$	Y=0.75X + 24.71	r=0.79	$p<0.05$	Y=0.96X + 20.14

Table 2b Influence of history of phototherapy (PT) on correlation between total serum bilirubin (TSB) and transcutaneous bilirubin (TcB) values (correlation coefficients, significance level and equation) for measurements taken at forehead (TcB_F) and sternum (TcB_S)

PT	**TcB at forehead (TcB_F)**			**TcB at sternum (TcB_S)**		
No	r=0.91	$p<0.05$	Y=1.08X + 16.34	r=0.90	$p<0.05$	Y=1.18X + 8.38
Yes	r=0.79	$p<0.05$	Y=0.95X + 4.64	r=0.79	$p<0.05$	Y=1.03X + 9.01

obtained with JM-103 and TSB and the good correlation shown in our study, overall r=0.82, is coherent with these studies' findings. This finding is also in line with our local counterpart studies in term/near term newborns within the first week of life with the highest correlation coefficient of 0.83 (p<0.001).[2,12]

Site of TcB Measurement

In our study, though the correlation between TcB obtained at the sternum and TSB is better than that obtained with the TcB measured at the forehead, the agreement between the paired TSB and TcB readings were better when measured at the forehead.

In overseas studies, there are no predominating view of which site should be used for TcB check in preterm babies.

Studies Favouring TcB Measurement at the Forehead

Asian studies concerning JM-103's use in preterm babies so far had just used readings obtained at the forehead. Yasuda et al's study was the first of this kind comparing JM-102 with JM-103 in preterm babies.[1] In this study, the accuracy and precision of JM-103 was compared with JM-102 over the forehead in neonates with gestational age 27 to 36 weeks versus those with gestational age 37 to 41 weeks and the regression line in preterm infants between TcB measured by JM-103 and TSB was similar to that in term infants.

In another study in Japan, Namba & Kitajima also reported good correlation between TcB and TSB in 50 preterm infants (birthweight <1500 grams, or gestational age <34 weeks) when TcB measurement was obtained on the forehead.[4] In Thailand, JM-103 correlation study had been performed in preterm newborns whose birth weight was >1000 grams and gestational age <36 weeks by Sanpavat & Nuchprayoon.[5] Two hundred and forty-nine paired forehead TcB-TSB measurements from 196 premature neonates were obtained. The correlation coefficient between TcB and TSB was significant (r=0.79).

Beyond Asia in Holland, Willemsen & Korver performed JM-103 correlation study in 50 newborns with birth weight ranging from 1680-4600 grams and found close correlation coefficients at 0.88 and 0.91 between TSB and mean TcB measured at midfrontal and midsternal regions, respectively.[6] The negative predictive value of mean transcutaneous midfrontal and midsternal bilirubin measurement was 0.91 and 0.87, respectively. Based on the area under the receiver operating characteristics (ROC) curve, the authors reported that transcutaneous midfrontal bilirubin measurement was more reliable than the midsternal measurement.

Studies Favouring TcB Measurement at the Sternum

For studies favouring or recommending the use of JM-103 at the sternum came from Slovakia and the United States.[7-9] Stillova et al studied 44 infants, including 6 VLBW neonates born at gestational age 32-34 weeks with this jaundice meter.[7] They showed that the correlations between TcB and TSB were close and significant (r=0.85, 0.81 and 0.73 over forehead, sternum and abdomen, respectively). The same group of investigators repeated the prospective JM-103 correlation study in 32 preterm newborns of less than 32 weeks recently, including 10 ELBW neonates and found similarly close correlation (r=0.818, 0.933 and 0.875) existed between TSB and TcB measured over the forehead, sternum and abdomen, respectively.[8] In both studies, the authors found that in preterm newborns, transcutaneous measurements over forehead tend to underestimate serum bilirubin concentration and recommended measurements over sternum.

In United States, Schmidt et al reported correlations between TcB measured over the sternum and TSB ranged from 0.79 to 0.92 in ninety preterm neonates with gestational age ranging from 24 to 34 weeks.[9] The authors initially attempted both forehead and sternum measurements, but subsequently discontinued forehead measurements due to clinical concern regarding the pressure applied with the device.

Total Serum Bilirubin (TSB) Sampling

In our study, we used three methods for TSB sampling: arterial, venous and capillary sampling. It has been previously reported by Schlebusch et al that the determinations of bilirubin in capillary plasma and serum of venous blood samples showed good precision and accuracy.[13] Moreover, high correlation between capillary and arterial bilirubin values had been reported by Langbaum et al[14] (r=0.993) and Amato et al[15] (r=0.9) respectively. We, therefore, ignored the difference of TSB from different sampling sites and investigated the correlation.

Racial Difference

In this study, like the counterpart studies in term or near term newborns in our locality, found the JM-103 tend to overestimate total serum bilirubin.[2,12] This tendency of overestimation was also noted in the studies performed in

Japan and Thailand.[1,4,5] Outside Asia, this overestimating tendency was not prevalent and underestimation was more commonly reported.[7-9]

In the two studies by Stillova et al in Slovakia, the measurements over forehead were found to have a tendency to underestimate TSB levels.[7,8] In the United States, Schmidt et al also found the TcB to underestimate the TSB in the majority of comparisons.[9]

Postnatal Days

In term or near term newborns, no evidence exists to support the use of transcutaneous bilirubinometer in infants more than one week old. In contrast, evidence is available to support the use of transcutaneous bilirubinometer in preterm babies beyond the first week of life. Studies conducted by Yasuda et al,[1] Namba & Kitajima,[4] Stillova et al[7] included preterm infants with postnatal age up to second to third weeks. However, they had not studied the effect of postnatal days on TcB-TSB correlation. Only in Sanpavat et al's study was this effect being studied and significant correlation (r=0.81, p<0.0001) between TSB and TcB values at postnatal age of more than 7 days was reported in that study.[5]

In Sanpavat et al's study, better TSB-TcB correlation was noted with advancing postnatal days,[5] in contrast with our findings of decreasing correlation noted with increasing postnatal days. Sanpavat & Nuchprayoon explained that the skin condition, such as peripheral oedema or transparency of the skin during the first couple of days might affect the skin measurement on day 1-2.[5] Better skin condition in our cases may explain our different findings as in our exclusion criteria, infants with poor skin condition were excluded.

Our finding of decreasing correlation with advancing postnatal age was in line with Knupfer et al's findings instead.[16] Knupfer et al studied 145 preterm children (23-26 weeks gestation) and found the diminishing trend in TcB-TSB correlation with increasing postnatal days exist in the group with history of phototherapy.[16] They explained this diminishing trend in TcB-TSB correlation by skin maturation with advancing postnatal ages after phototherapy exposure.

Phototherapy

Tan & Dong studied the reliability of transcutaneous bilirubinometry during and after phototherapy in 70 healthy, full-term Chinese infants with 240 controls.[17] They found that with cessation of exposure, a return of the jaundice colour to the skin improved the degree of correlation coefficient so markedly that by 18-24 hours, the correlation coefficient was no longer significantly different from that of the control group. Echoed with the findings of Tan et al, our study has included readings taken before or at least 24 hours after termination of phototherapy to assess whether in the preterm counterpart, similar recovery of TcB-TSB correlation would exist.

In our study, 59% of the data were obtained in babies that had been exposed to phototherapy and stronger correlation (0.90 versus 0.79) was found in the group without history of phototherapy. Among the seven JM-103 correlation studies performed in the preterm neonates, the effect of phototherapy had not been studied.[1,4-9] However, this effect had been studied in BiliCheck correlation study carried out in preterm neonates.[16] Knupfer et al showed a significantly stronger (p<0.05) correlation between TSB and TcB value (r=0.73) in preterm infants without phototherapy than infants with phototherapy (r=0.59).[16] So, our findings are coherent with theirs.

Other Variables

In our study, we have also studied the effect of gestational age, birth weight, small for gestational age and the need for mechanical ventilation on the TcB-TSB correlation.

A trend of improving correlation with greater gestation age (GA 27-30 weeks, r_{TcB_F-TSB} = 0.725, r_{TcB_S-TSB} = 0.791; GA 31-34 weeks, r_{TcB_F-TSB} = 0.809, r_{TcB_S-TSB} = 0.843) and birth weight (BW <1500g, r_{TcB_F-TSB} = 0.662, r_{TcB_S-TSB} = 0.729; BW ≥1500 g, r_{TcB_F-TSB} = 0.849, r_{TcB_S-TSB} = 0.857) can be seen, in line with the finding of worsening correlation in infants whose birthweights were lower than 1000 grams, or whose gestational ages at birth were shorter than 28 weeks noted in Namba & Kitajima's study.[4] However, one unexpected finding in our study was a trend of declining correlation for small for gestational age neonates (SGA, r_{TcB_F-TSB} = 0.552, r_{TcB_S-TSB} = 0.653; non SGA, r_{TcB_F-TSB} = 0.839, r_{TcB_S-TSB} = 0.853) and this effect may warrant larger studies to establish its significance.

In Knupfer et al's study using BiliCheck, it was found that the BiliCheck gives reliable results only in newborns older than 30 weeks gestation, without phototherapy and artificial ventilation.[16] In our study, similar trend of better TcB-TSB correlation in the group without mechanical ventilation was noted (no MV, r_{TcB_F-TSB} = 0.955, r_{TcB_S-TSB} = 0.971; MV, r_{TcB_F-TSB} = 0.725, r_{TcB_S-TSB} = 0.772). We speculate that this finding may be explained by peripheral oedema. In neonates on mechanical ventilation, mild degree of peripheral oedema are usually present and this may contribute to the worsening in agreement between TcB and TSB values as shown in Willems et al's study.[18]

Limitation of the Study

Our study has several limitations. First, multiple samples were taken from the same infant and used in the analysis. This means that each of the TcB measurements were not independent. Second, among the five variables that we studied, statistical significant findings can only be observed in one parameter, phototherapy. In Knupfer et al's study,[16] they focused on the group without phototherapy because the TcB-TSB correlation of this group was found to be significantly stronger than the group with phototherapy. In this way, the gestational age and mechanical ventilation were found to be independently related to TcB-TSB correlation. In our case, similar findings might be observed; nevertheless, phototherapy appears to be a stronger predictor that masks the effects of weaker predictors, such as gestational age and mechanical ventilation. This problem might be overcome by recruiting more subjects to enable phototherapy to be used as a co-variant in analysis. In this way, the yield of the study can be enhanced. As preterm babies are a small study population, a larger sample might be recruited if multiple centers were included and the study period be extended. However, the inclusion of multiple study centers and the extension of study period would have introduced confounding effects of time and inter-center differences. Based on these considerations, this study focused on a single center in a five-month period.

Conclusion

This study is the first in Hong Kong to demonstrate that the JM-103 is useful as a screening tool in Chinese preterm babies <35 weeks of gestation to screen for hyperbilirubinemia. Our results are consistent with other JM-103 correlation studies performed in preterm neonates overseas.[1,4-9] The JM-103 device is particularly useful in those without prior history of phototherapy. However, the readings may be less reliable in those with ELBW, small for gestational age and on mechanical ventilation. In the future, more robust findings may be obtained if more subjects are recruited.

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Appendix 1.

參與經皮膚膽血素測定器（JM-103 Minolta）相關研究

新生兒黃膽是常見的，過往只能靠驗血來量度血清總膽血素值。近年來，以經皮膽血素測定器來診斷黃膽的可行性已被確立，但只限用於接近足月或已足月（≥35 週）的新生兒。

JM-103 是新一代的經皮膽血素測定器。在儀器的產源地日本，已有文獻報告其用於早產嬰的準確性。在其他地區，如捷克、泰國及荷蘭，也有相關文獻報告 JM-103 應用於新生早產嬰的準確性，現時，在香港尚未有此類數據。

故此，本研究的目的是探討 JM-103 用於早產兒（<35 週）的可行性。參與此項研究的嬰兒絕不用多抽一滴血。一向以來，早產嬰「照燈」的需要是單憑驗血的方法來判別的，參與此研究，貴寶寶只需在每次「驗黃」時，同時用 JM-103 輕觸前額及胸骨一次（圖 1/2），JM-103 錄得的及驗血量度出來的數值便能同步取得，以作相關研究。

此項研究的最終目的是減少嬰兒因要「驗黃」而需受之痛楚，我們誠邀貴寶寶參與，但若父母乃不認同，我們絕對會尊重你們的意願，請將退出的選擇告知病房姑娘。

圖 1/2