ORIGINAL ARTICLE

Evaluation of a point-of-care transcutaneous bilirubinometer in Chinese neonates at an accident and emergency department

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Objective To evaluate the use of a point-of-care transcutaneous bilirubinometer, JM-103 Minolta, for estimation of the serum bilirubin level in the management of neonatal jaundice in term or near-term Chinese neonates.

Design Prospective correlation study.

Setting Accident and Emergency Department of a regional hospital in Hong Kong.

Patients All term or near-term Chinese neonates aged 3 to 7 days, who attended the Accident and Emergency Department because of jaundice between September and November 2007.

Main outcome measures Paired transcutaneous bilirubin measurements by the JM-103 Minolta and the total serum bilirubin measurement by a direct spectrophotometric method in the laboratory.

Results The mean age of the 113 neonates at the time of data collection was 5 days (range, 3-7 days). Transcutaneous bilirubin showed a good correlation with total serum bilirubin; the highest correlation coefficient was 0.83 ($P<0.001$). Transcutaneous bilirubin cutoff values of 230 µmol/L and 298 µmol/L could have 100% sensitivity and specificity respectively, to predict a total serum bilirubin level of higher than 250 µmol/L (the accepted threshold for treatment). The mean difference between transcutaneous and total serum bilirubin was 14 µmol/L (standard deviation, 28 µmol/L; $P<0.001$); the JM-103 tended to overestimate total serum bilirubin. The 95% limits of agreement were between -40 and 69 µmol/L.

Conclusion The new point-of-care transcutaneous bilirubinometer, JM-103 Minolta, demonstrated good correlation with the serum bilirubin measurement in Chinese neonates aged 3 to 7 days. Thus, it is a useful screening device to facilitate quick decisions on disposal of jaundiced neonates presenting to accident and emergency departments or in out-patient clinic settings.

Key words
Bilirubin; Hyperbilirubinemia, neonatal; Jaundice, neonatal; Neonatal screening

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Introduction

The American Academy of Pediatrics issued clinical practice guidelines in 2004 on management of neonatal jaundice and stated that visual estimation of the degree of jaundice could lead to errors. The degree of jaundice should be measured as the total serum bilirubin (TSB) or the transcutaneous bilirubin (TcB), and interpreted according to the infant's age in hours.[1,2]

Prompt management of neonatal jaundice was the key to reducing the incidence of bilirubin-induced neurological dysfunction and permanent sequelae (kernicterus). The initiation of treatment such as phototherapy depended on the level of serum bilirubin, which in the past required invasive blood sampling and time-consuming laboratory testing. A reliable, non-invasive, point-of-care device to estimate TSB would be an ideal method to screen or monitor the progress of neonatal hyperbilirubinaemia, especially in out-patient settings like Maternal and Child Health Centres (MCHCs) or Accident and Emergency Departments (AEDs).

A new device, Minolta JM-103 Jaundice Meter (Draeger Medical Systems Inc, Telford, US), was a refinement of previous transcutaneous models (including the Minolta Air Shields Jaundice Meter JM-102). The new model (JM-103) measured the yellowness of the subcutaneous tissue of newborns based on the difference between optical densities for light in the blue (450 nm) and green (550 nm) wavelength regions.[3] Its dual optical path system enables the machine to measure the bilirubin accumulated in the deeper subcutaneous tissue, whilst reducing the influence of melanin pigment and skin maturity.[3] However, ethnicity and skin pigment influences were still reported. The performance and correlation curve of JM-103 applied to Chinese neonates could be very different from those reported in overseas studies based on Caucasian populations. Ho et al[4] reported a good correlation (r=0.83) with the TcB meter, using the Minolta JM-103, in Chinese neonates. However, it was conducted at a postnatal nursery and most of the studied neonates were tested within the first 3 days of life. The usefulness of this new device in Chinese neonates older than 3 days of life and in out-patient settings was unknown.

We aimed to evaluate the usefulness of JM-103 to estimate serum bilirubin for term or near-term Chinese neonates who presented to the AED because of neonatal jaundice at day 3 to 7 of life.

Methods

We conducted a prospective correlation study to evaluate the performance of a TcB meter (Minolta JM-103) to estimate serum bilirubin in term or near-term (>35 weeks' gestation) Chinese neonates in a regional AED in Hong Kong. The regional hospital serves a population of over one million and has a diversified clientele, with a daily attendance of around 600 patients. All neonates presenting to our department because of jaundice during September 2007 to November 2007 were included in this study, irrespective of whether they were referred or non-referred cases. Patients aged less than 3 days or more than 7 days were excluded, as were pre-term, sick-looking, or high-risk neonates. Eligible cases were registered by Emergency Physicians and targeted information was recorded on standard data collection forms, which were subsequently sorted and reviewed by the investigators.

A total of six measurements of TcB by JM-103 were obtained for each eligible case, and included three measurements over mid-sternum and three over the forehead region. All readings were taken by the same JM-103 device. Paired serum bilirubin readings were taken within 5 minutes of the TcB measurement, all from neonates who had not received phototherapy. The TSB assay was performed in the hospital chemical laboratory, using the Unistat Bilirubinometer, Model 10311C (Leica Inc, Buffalo, New York), a direct spectrophotometer subject to daily quality testing and having an upper measurable value of 684 μmol/L. Disposal of the patient was determined by the serum bilirubin level according to the Bhutani Nomogram.[5]

Four TcB parameters, namely mean TcB reading, maximum forehead TcB reading, maximum sternum TcB reading, and overall maximum TcB (maxTcB) reading (the highest reading among the six measurements taken, that is, three on forehead and three on sternum) were calculated for each patient. We performed correlation tests on all four parameters of TcB with TSB and derived the Pearson's correlation coefficient. The parameter yielding the highest correlation coefficient was taken as the best TcB parameter and used for further analysis. Total serum bilirubin at the level of 250 μmol/L was taken as a threshold for admission and initiation of phototherapy.[6] The receiver operating characteristics (ROC) curve was employed for predicting sensitivity and specificity of different cutoff TcB values to estimate whether the TSB was 250 μmol/L or higher. The 95% limits of agreement and degree of error distribution were analysed by the Bland and Altman method.[7] Statistical Package for the Social Sciences (Windows version 15.0; SPSS Inc, Chicago [IL], US) was used for statistical analysis.

Results

One hundred and thirteen eligible cases were

評估急症室應用快速測試經皮膽紅素測定器對華裔新生兒的效用

目的 評估快速測試經皮膽紅素測定器(JM-103 Minolta)對足月及接近足月的華裔新生兒，用作量度血清膽紅素來治療新生兒黃膽病的效用。

設計 前瞻性相關研究。

安排 香港一所地區醫院的急症室部門。

患者 2007月9月至11月期間，因黃膽病到急症室求診的足月或接近足月、3至7天大的華裔新生兒。

主要結果測量 分別用JM-103 Minolta量度經皮膽紅素值，和在實驗室用直接分光光度法量度血清總膽紅素值。

結果 研究對象為113個介乎3至7天大的新生兒，求診時平均年齡為5天。經皮膽紅素值與血清總膽紅素值有好相關性；最高相關係數為0.83 (P<0.001)。要達至可接受的治療閾值，即血清總膽紅素預測值高於250 μmol/L，經皮膽紅素臨界值為230 μmol/L可有100%敏感性，而臨界值為298 μmol/L可有100%特異性。經皮膽紅素和血清總膽紅素的平均差為14 μmol/L（標準偏差：28 μmol/L；P<0.001）。JM-103略微高估血清總膽紅素值。95%信賴區間介乎 –40和69 μmol/L之間。

結論 新的快速測試經皮膽紅素測定器(JM-103 Minolta)用作量度3至7天大的華裔新生兒的血清膽紅素有良好相關性，顯示此測定器可有效應用於因黃膽病到急症室求診或門診的3至7天大的新生兒，加快篩選程序。

TABLE. Correlation coefficients between different paired transcutaneous bilirubin (TcB) parameters and total serum bilirubin

	Mean TcB	Max forehead TcB	Max sternum TcB	Overall max TcB
Correlation coefficient	0.80	0.79	0.80	0.83

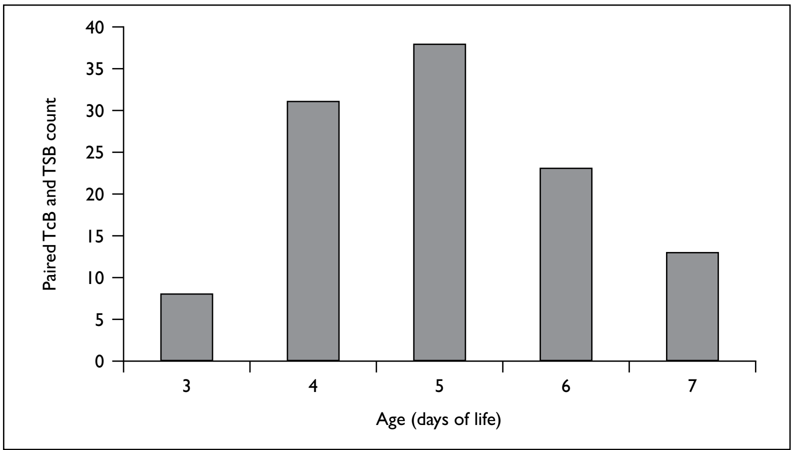

FIG 1. Age distribution of 113 neonates
TcB denotes transcutaneous bilirubin and TSB total serum bilirubin

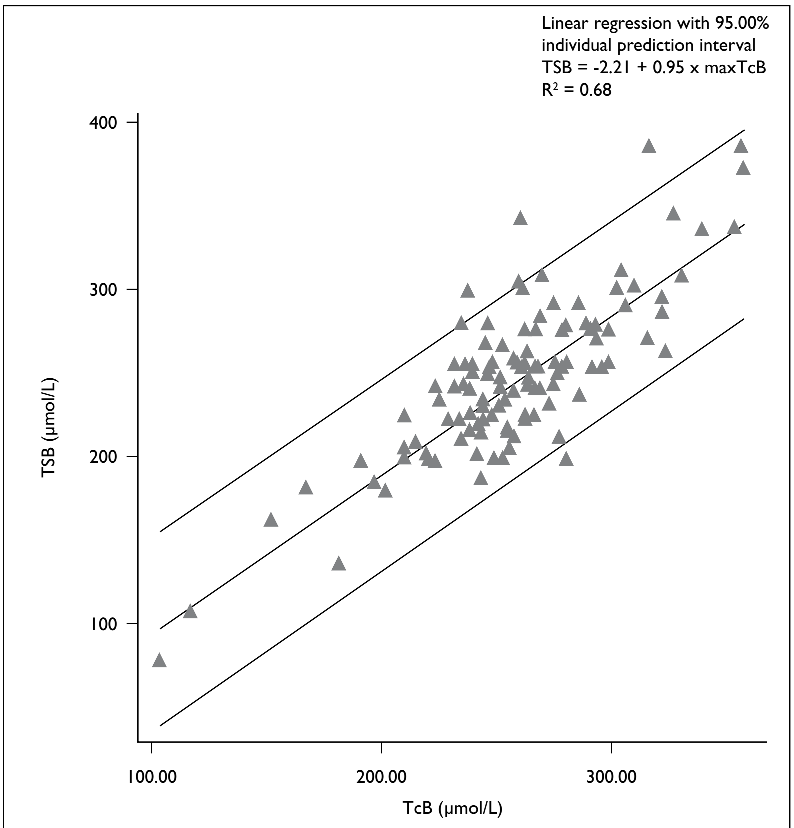

FIG 2. Maximum transcutaneous bilirubin (TcB) vs total serum bilirubin (TSB) scatter diagram

recruited during the study period. The mean age at the time of data collection was 5 days; the age distributions are shown in Figure 1. The TSB concentrations ranged from 73 to 383 μmol/L. Fifty-four neonates had serum bilirubin levels of 250 μmol/L or higher.

The correlation coefficients of different TcB parameters with TSB are shown in the Table. The overall maxTcB reading attained the highest correlation coefficient (0.83; P<0.001). The equation for the best-fit line was -2.21 + 0.95 x maxTcB (Fig 2).

The ROC curve was constructed to demonstrate the sensitivity and specificity of different cutoff TcB values used to estimate a TSB level of 250 μmol/L (ie the threshold to initiate treatment, Fig 3). A sensitivity of 100% can be achieved at a cutoff point for maxTcB of >230 μmol/L and a cutoff point of >298 μmol/L can achieve a specificity of 100%. The area under the curve was 0.822.

A Bland-Altman plot for all the cases is shown in Figure 4. The bias, which was estimated as the mean of the differences between maxTcB and TSB (ie maxTcB minus TSB) was equal to 14.4 μmol/L (standard deviation, 28.0; P<0.001), and indicated a uniform tendency for JM-103 to overestimate TSB. The 95% limits of agreement were between -40.4 and 69.2 μmol/L (Fig 4).

Discussion

This study was the first to evaluate the use of JM-103 in a Hong Kong AED. It provided new information on the use of the JM-103 device on Chinese neonates aged 3 to 7 days who had neonatal jaundice. It precisely filled the information gap left by a previous local study, which focused on subjects younger than 3 days old.[4]

Nowadays, more and more pregnant women from Mainland China deliver babies in Hong Kong. Most of them were discharged early (within 2 days post-delivery) due to financial reasons. The physiological jaundice in Chinese newborns was reported to peak at day 5 instead of day 2 or 3 of life (as in Caucasian newborns).[8] The bilirubin level of physiological jaundice in Chinese neonates was also reported to be higher than those in western countries.[9] As a result, a significant portion of the physiological jaundiced newborns would be kept in the community until they presented to the MCHC on day 4 or 5. Often, they would then be referred to AED for further management. As a result, both the AED and the MCHC in Hong Kong were playing an increasingly important role in screening and admitting jaundiced neonates with high TSB for initiation of treatment. In this study, we noted a good correlation between TcB measured by the JM-103 and the TSB measured by direct spectrophotometry among healthy, term, local Chinese neonates aged 3 to 7 days. The correlation coefficient (r=0.83) was the highest using the maxTcB, and was comparable to studies by Ho et al[4] and Maisels et al[10] in Chinese (r=0.83) and Caucasians (r=0.915) respectively.

We found that the JM-103 had a tendency to overestimate the TSB in Chinese neonates; the bias was around 14 μmol/L. This finding was contradictory to what was reported by Engle et al,[11] who reported that the JM-103 underestimated the TSB performed on Hispanic neonates. Ethnicity difference could be a possible explanation.

Based on the sample from this study, we determined that a maxTcB between 230 and 298 μmol/L was the 'grey' zone. We could neither 'confidently' admit nor discharge the patients based on such JM-103 readings alone. In which case invasive blood-taking to check the TSB should be used to guide clinical decisions on disposal.

In our study sample, 57 of 113 neonates were outside this 'grey' zone. This implied that around 50% of all cases could be either discharged or admitted according to TcB reading by the JM-103 alone, without blood checking in the AED, indicating that the JM-103 (a point-of-care device) could help to save a lot of time waiting for the result and avoid unnecessary invasive blood-taking procedures. One might argue that those with TcB levels of greater than 298 μmol/L still needed to have their TSB checked before initiation of phototherapy and doubt whether the blood sampling should be done in AED rather than in the paediatric ward. However, notably in our hospital the turnover time for a TSB level was about 60 minutes (and very likely the same in all Hospital Authority hospitals). The consequent wait in the AED is not a comfortable or convenient experience for the neonate and caretaker, because of the extremely crowded environment, risks of infection, and lack of breast-feeding and napkin-changing facilities. We believe it is preferable to undertake blood sampling and wait for the result in a ward rather than in an AED, as ultimately many of these patients would still need admission for phototherapy.

This study had a number of limitations. First, for the sake of simplicity, we opted to use the TSB treatment threshold of 250 μmol/L universally for all neonates aged 3 to 7 days. In fact, the threshold appears to vary according to the level indicated on Bhutani Normogram depending on the hours from birth. Second, the TSB was measured by a direct spectrophotometric method, which is not a gold standard (though demonstrated to have excellent correlation with the traditional diazo laboratory method [r=0.99][12]).Third, although we used the same JM-103 device to measure the TcB for all cases, the measurements were obtained by different operators (possibly introducing errors). Fourth, our neonates were mostly referred cases from the MCHC as having relatively high levels of jaundice (leading to a possible selection bias). The results, conclusions, or recommendations based on this study could be more relevant to neonatal jaundice seen in the AED than those in other health care settings.

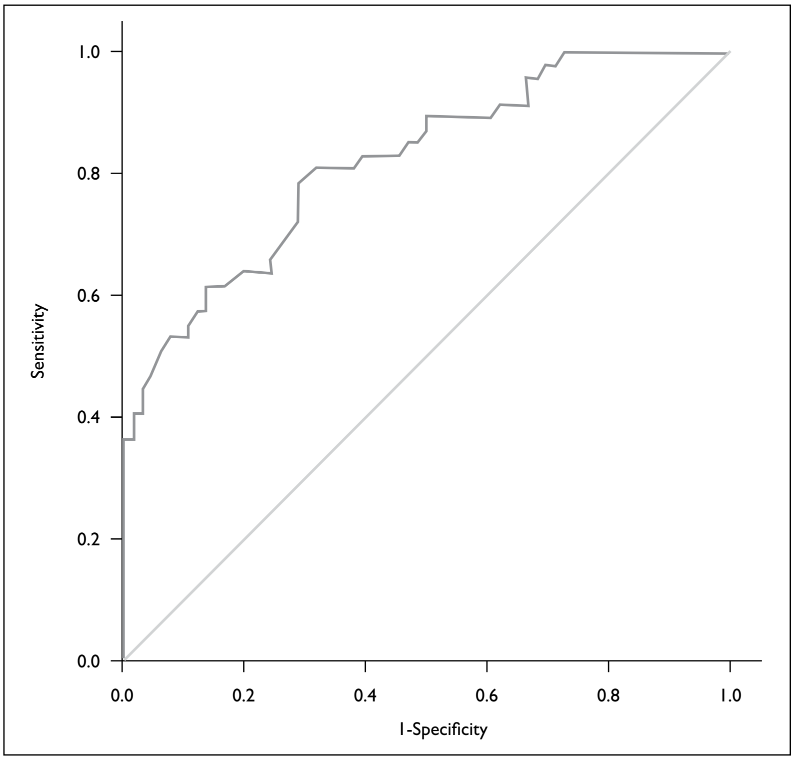

FIG 3. Receiver operating characteristics curve in predicting serum bilirubin concentration of 250 μmol/L or higher
Diagonal segments are produced by ties

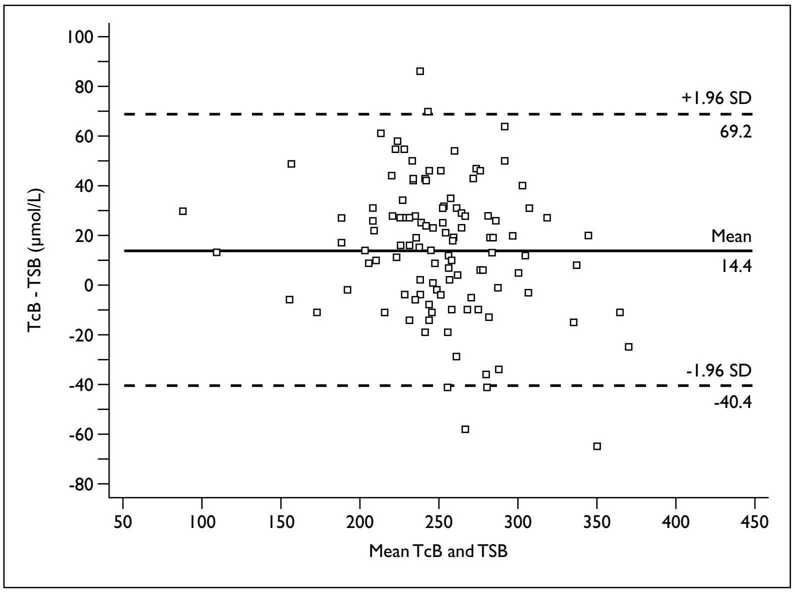

FIG 4. The Bland-Altman plot of transcutaneous bilirubinometer (TcB) and total serum bilirubin (TSB)

Conclusion

The new point-of-care TcB, JM-103 Minolta, demonstrated a good correlation with the serum bilirubin measurements in Chinese neonates aged 3 to 7 days. The maxTcB had the highest correlation coefficient. The JM-103 (as a point-of-care screening device) can be used safely in the AED or MCHC for healthy-looking neonates aged 3 to 7 days; a maxTcB of less than 230 µmol/L can be used to let the patient return home for follow-up. We suggest admitting those with a maxTcB of greater than 298 µmol/L to hospital, for treatment without the need to perform TSB laboratory blood assay in an AED. A serum bilirubin assay still appears necessary for neonates with a maxTcB within the 'grey' zone (230-298 µmol/L).

Declaration

No sponsorship or conflicts of interest were declared by the authors.

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