

Accuracy of transcutaneous bilirubinometry compare to serum microbilirubin measurement in Naresuan University Hospital

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- Background** : *Hyperbilirubinemia is a common problem in the neonatal period. The gold standard for the diagnosis of hyperbilirubinemia is not only time consuming but also a painful intervention to the infant.*
- Objective** : *To determine the accuracy of transcutaneous bilirubinometer and to determine an hour-specific nomogram.*
- Material and Method** : *Transcutaneous bilirubin was performed on 195 healthy term neonates of gestational age greater than 37 weeks and birth weight greater than 2,500 grams using a transcutaneous bilirubinometer (Minolta, JM-103). The values of bilirubin obtained by 2 different methods were compared: transcutaneous bilirubinometer and direct spectrophotometry, at Naresuan University Hospital. We recorded transcutaneous bilirubin at the age of 8 to 96 hours in an hour-specific nomogram.*
- Design** : *Cross section prospective descriptive study*
- Setting** : *Naresuan University Hospital, Phitsanulok.*

- Result** : *One hundred and ninety-five neonates were recruited into this study; 117 values of simultaneous transcutaneous bilirubin and microbilirubin were recorded. The mean transcutaneous bilirubin (TCB) was 9.5 ± 2.4 mg/dL and the mean serum microbilirubin (MB) was 10.5 ± 2.5 mg/dL. The correlation coefficient was 0.784. The hour-specific nomogram was performed at the relative risk of the 40th, 75th and 95th percentiles.*
- Conclusion** : *The transcutaneous bilirubinometer has been shown to be useful for the screening of hyperbilirubinemia in neonates. An hour-specific transcutaneous bilirubin nomogram is helpful to predict hyperbilirubinemia.*
- Keywords** : *Transcutaneous bilirubinometer, microbilirubin, nomogram.*

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- เหตุผลของการทำวิจัย** : ภาวะตัวเหลืองเป็นภาวะที่พบบ่อยในทารกแรกเกิด วิธีมาตรฐานในการวินิจฉัยภาวะตัวเหลืองคือการเจาะเลือดเพื่อวัดระดับความเหลืองในเลือดแต่วิธีนี้ใช้เวลาและทำให้ทารกเจ็บ
- วัตถุประสงค์** : เพื่อศึกษาความแม่นยำของเครื่องตรวจบิลิรูบินทางผิวหนังและสร้างกราฟสำหรับการตรวจบิลิรูบินทางผิวหนัง
- รูปแบบการวิจัย** : การศึกษาวิจัยเชิงพรรณนาแบบเก็บข้อมูลไปข้างหน้า
- สถานที่ทำการศึกษา** : โรงพยาบาลมหาวิทยาลัยนเรศวร จังหวัดพิษณุโลก
- ตัวอย่างและวิธีการศึกษา** : เด็กทารกแรกเกิดครบกำหนด อายุครรภ์ ≥ 37 สัปดาห์ จะได้รับการวัดระดับบิลิรูบินทางผิวหนังทุกวัน เป็นเวลา 4 วัน หากพบว่าตัวเหลืองด้วยวิธีการสังเกต ทารกจะได้รับการตรวจระดับบิลิรูบินทางผิวหนังเพื่อเปรียบเทียบระดับบิลิรูบินทางผิวหนัง และในเลือด
- ผลการศึกษา** : จำนวนตัวอย่างค่าบิลิรูบินทางผิวหนัง (Transcutaneous bilirubin, TCB) และ ค่าบิลิรูบินที่วัดทางเลือด (Microbilirubin, MB) จำนวน 117 คู่ พบว่าค่าเฉลี่ยของค่าบิลิรูบินทางผิวหนัง (TCB) เท่ากับ 9.5 ± 2.4 mg/dL และค่าบิลิรูบินที่วัดทางเลือด (MB) เท่ากับ 10.5 ± 2.5 mg/dL ค่าบิลิรูบินที่วัดทางเลือด มีค่ามากกว่าค่าบิลิรูบิน ทาง ผิวหนัง 1mg/dL ($SD \pm 1.6\text{mg/dL}$, 95% CI: 0.6885 - 1.2799 mg/dL) พบว่าทั้งสองค่า มีความสัมพันธ์ไปในทิศทางเดียวกันอย่างมีนัยสำคัญ และมีจำนวนทารกที่เข้าการศึกษาเพื่อทำ nomogram ทั้งหมด 195 ราย นำมาสร้างกราฟความเสี่ยงต่อภาวะตัวเหลืองเป็น 40, 75 และ 95 เปอร์เซนต์ไทล์
- สรุป** : การตรวจค่าบิลิรูบินทางผิวหนังมีค่าใกล้เคียงกับค่าบิลิรูบินในเลือด จึงสามารถใช้การตรวจคัดกรองก่อนการเจาะเลือดได้
- คำสำคัญ** : เครื่องตรวจค่าบิลิรูบินทางผิวหนัง, ค่าบิลิรูบินในเลือด, bilirubin.

Hyperbilirubinemia is a common problem in the neonate. Physiologically, the highest serum bilirubin level is found at the age of 3 - 4 days; the serum bilirubin level may remain high for the first 1 - 2 weeks of life.⁽¹⁾ Asian newborns, however, have higher levels of serum bilirubin than those in Europe or America.⁽²⁾ The gold standard method for the diagnosis of hyperbilirubinemia is not only time consuming but also painful for the infant. The treatment of hyperbilirubinemia is phototherapy.

In 1960, Gosselt found a cutaneous bilirubin measurement technique that causes no pain; it is also highly reliable and cheap.⁽³⁾ Subsequently, a newly developed transcutaneous bilirubinometer made by Minolta, Ingram and Bilicheck were demonstrated to be highly reliable. Minolta showed the same reliability as Ingram.⁽⁴⁾ Transcutaneous bilirubin was measured on the forehead and had higher reliability than the sternum.⁽⁵⁾ Studies in newborns showed that Bilicheck bilirubinometer had high reliability and could be used for the screening of hyperbilirubinemia.⁽⁶⁾ Maisels *et al.* demonstrated that the Minolta JM-103 was highly reliable if the serum bilirubin levels were under 15 mg/dL.⁽⁷⁾ In Thailand, one study on the Minolta device found it more highly specific than Bilicheck. In this study we chose Minolta JM-103 to determine transcutaneous bilirubin and establish a transcutaneous bilirubin nomogram in healthy term infants by comparing them to serum bilirubin measurements.^(8, 9)

Material and Method

This trial was a cross section prospective descriptive study that included full term newborn infants of gestational age higher than 37 weeks and

birth weight greater than 2,500 grams. All the infants were born at Naresuan University Hospital and had no acute illnesses. Their parents also signed informed consent forms before recruitment. The recorded demographic data of the infants included the mode of delivery, birth weight, and gestation age. Transcutaneous bilirubin was measured daily in the first 4 days after birth (8 - 96 hours of age). The attending physicians checked the serum microbilirubin level in noticeably jaundiced newborns and transcutaneous bilirubin in these jaundiced infants were measured within 30 minutes, and both transcutaneous bilirubin and serum microbilirubin were compared. If the infants displayed pathological jaundice, they underwent standard phototherapy protocol according to the Naresuan University Hospital's protocol. The infants who received phototherapy were excluded from the study.

Transcutaneous bilirubin measurement

In this study, Minolta JM-103 was used to measure transcutaneous bilirubin. The calibration was performed daily for long wavelengths -2.3 to -0.3, and short wavelengths -1.9 to 0.1. Before the measurement, the infant's forehead was cleansed with alcohol and was then probed by a bilirubinometer. The measurement was performed twice, and the average values were recorded.

Microbilirubin measurement

Blood was taken from the infant's heel in a hematocrit tube. The tube was spun at 12,000 - 15,000 cycles per minute for five minutes. The serum microbilirubin was measured by a direct spectrophotometer.

Statistical analysis

The relationship between transcutaneous bilirubin and serum microbilirubin was analyzed by Pearson's correlation coefficient. An hour-specific nomogram of transcutaneous bilirubin was established in 8-hour periods for 96 hours. The curve of the transcutaneous bilirubin level was calculated into 40th, 75th and 95th percentile graphs using program R.

Result

From April 2009 to April 2011, 195 infants were recruited into the study. Among the 195 infants, 780 transcutaneous bilirubin values were acquired,

including 117 values of simultaneous transcutaneous bilirubin and serum microbilirubin. The demographic data are shown in Table 1.

Within the 117 values of simultaneous transcutaneous bilirubin and serum microbilirubin, the means of transcutaneous bilirubin (TCB) and serum microbilirubin levels were 9.5 ± 2.4 and 10.5 ± 2.5 , respectively ($P < 0.001$). Serum microbilirubin level was 1.0 mg/dL more than transcutaneous bilirubin ($SD \pm 1.6 \text{ mg/dL}$, 95% CI : 0.6885 -1.2799 mg/dL). The linear correlation between transcutaneous bilirubin and serum microbilirubin level was calculated as: $MB = 2.612 + 0.819 \text{ TCB}$ with statistical significance ($r 0.784$, $P < 0.001$). By

Table 1. Demographic characteristics of 195 infants.

| Demographic data | N | Percent |
|-------------------------|-----|---------|
| Gender | | |
| Male | 110 | 56.4 |
| Female | 85 | 43.6 |
| Mode of delivery | | |
| Normal delivery | 86 | 44.1 |
| Vacuum extraction | 23 | 11.8 |
| Forceps extraction | 1 | 0.5 |
| Cesarean section | 85 | 43.6 |
| Gestational age (weeks) | | |
| 37 -38 | 51 | 26.2 |
| 38 1/7 -39 | 75 | 38.5 |
| 39 1/7 -40 | 49 | 25.1 |
| 40 1/7 - 41 | 20 | 10.3 |
| Birth weight (gm) | | |
| 2,500-3,000 | 100 | 51.28 |
| 3,001-3,500 | 74 | 37.95 |
| 3,501-4,000 | 19 | 9.74 |
| 4,001-4,500 | 2 | 1.03 |
| | 195 | 100 |

using this equation, we were able to predict serum microbilirubin level at 61 % accuracy. ($r^2 = 0.61$) We established an hour-specific transcutaneous bilirubin nomogram by plotting 780 recordings of the

transcutaneous bilirubin level at 8 hour periods within a 96-hour period (4 days). These results are shown in Figure 1. The data were calculated into the 40th, 75th and 95th percentile as shown in Figure 2.

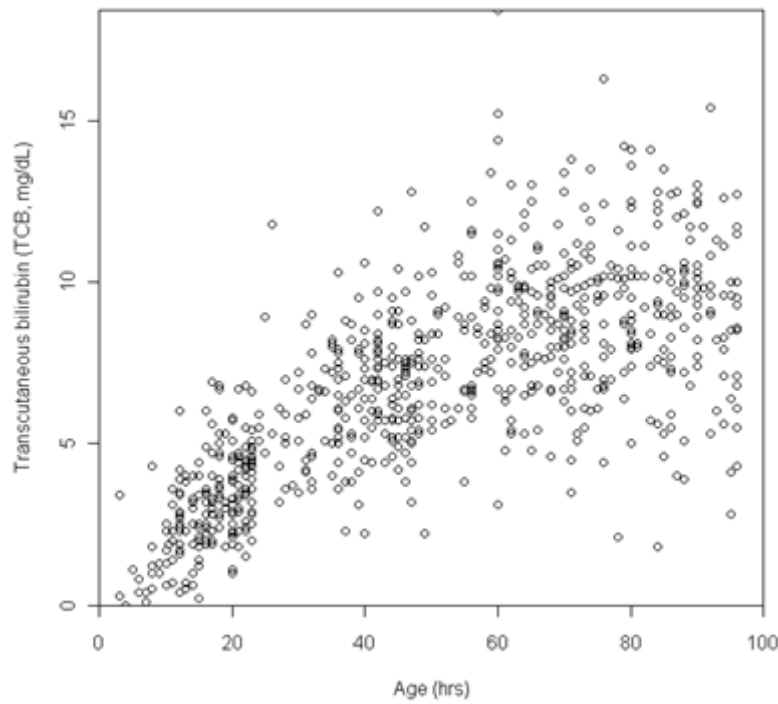


Figure 1. The distribution of transcutaneous bilirubin levels at 8 - 96 hours.

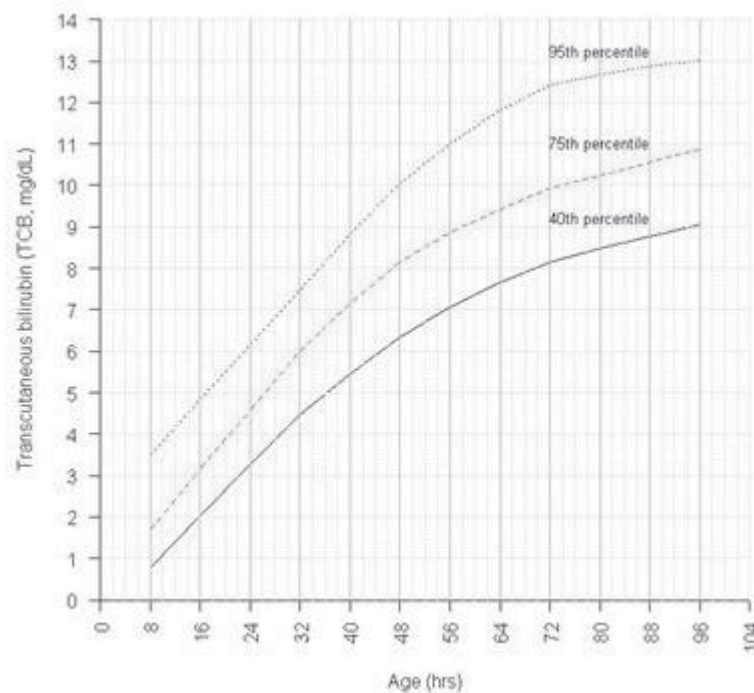


Figure 2. Nomogram showing the 40th, 75th and 95th percentile curve of transcutaneous bilirubin levels in the first 96 hours in healthy term newborns.

Discussion

The American Academy of Pediatrics has stated that noticeable jaundice in newborns detected by physicians can lead to erroneous evaluation, particularly in darkly pigmented infants. Therefore, the serum bilirubin or transcutaneous bilirubin level should be measured in the first 24 hours in noticeably jaundiced infants.⁽¹⁰⁾ The blood for the serum bilirubin level is taken from a heel puncture of the infants, which not only causes pain but also time consuming. Nowadays, newly developed technologies of transcutaneous bilirubinometer such as Bilicheck[®] and Minolta JM-103 have demonstrated that there was no significant difference in the early neonatal period between the transcutaneous bilirubin level and serum microbilirubin detected by the traditional method.^(7,9,11,12)

The study emphasized the previous report revealing in Europe and Asia a highly significant correlation of transcutaneous bilirubin level and serum microbilirubin level.^(7,8,13-16) The transcutaneous bilirubin level that is more than 12 mg/dL should be confirmed by the serum bilirubin method because it was less accurate.^(17, 18) The transcutaneous bilirubinometer is not reliable if there is no skin contact.⁽¹⁹⁾

In routine newborn care, a pre-discharge hour-specific serum bilirubin nomogram is notified to evaluate the risk of hyperbilirubinemia before the newborns were discharged from the hospital.⁽¹⁰⁾ Serum microbilirubin greater than 75th percentile is considered high risk. This study demonstrated that the 95th percentile of the transcutaneous bilirubin level was comparable to the serum microbilirubin level at 75th percentile. The serum microbilirubin level

should be taken in newborns with greater than 95th percentile on the hour-specific transcutaneous bilirubin nomogram.

This study and a previous study demonstrated that transcutaneous bilirubin is helpful for screening of hyperbilirubinemia. Since there are many devices in the market, limitations of the devices are the ethnicity and skin color of the newborns that makes the difference in the transcutaneous bilirubin nomogram.^(20 - 21)

The present study had some limitations, however. It had a small sample size and the represents data from a single center.

Conclusion

Transcutaneous bilirubinometer has been shown to be valuable when utilized for screening of hyperbilirubinemia in neonates. An hour-specific transcutaneous bilirubin nomogram is helpful in predicting hyperbilirubinemia.

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