Association of Transcutaneous Bilirubin Testing in Hospital with Decreased Readmission Rate for Hyperbilirubinemia

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Background: Newborns are being discharged from hospitals within 1–2 days of birth, before hyperbilirubinemia usually becomes clinically evident. We investigated the use of transcutaneous bilirubin (TcB) before discharge to determine whether it affects the use of laboratory bilirubin testing or decreases the number of neonates readmitted for hyperbilirubinemia within 7 days of initial discharge.

Methods: We retrospectively searched a clinical laboratory and hospital database to determine the number of births, newborn readmission rates for hyperbilirubinemia, length of stay, and the number of bilirubin measurements in the clinical laboratory ordered for all babies in the newborn unit at the University of Texas Medical Branch from August 2002 to March 2003 (before TcB testing) and from May 2003 to December 2003 (after TcB).

Results: Between August 2002 and December 2003, 8974 newborns (both vaginal and cesarean births) were admitted to the newborn nursery. Babies who did not fit the diagnosis-related group criteria of “normal newborn” were removed, leaving 6933 babies who were included in the study. April was considered a transition month and was not included in the study, leaving 6603 newborns to be included. Of these, 446 (6.8%) required phototherapy for treatment of hyperbilirubinemia before discharge. For the 8 months before and 8 months after initiation of TcB testing, the number of laboratory bilirubin measurements ordered per newborn did not change, nor did the mean (SD) length of stay for normal newborns [2.15 (1.1) days vs 2.12 (1.1) days; P = 0.53], nor days of treatment with phototherapy before discharge [2.9 (1.3) days vs 2.9 (1.3) days; P = 0.67]. By contrast, the number of readmissions per 1000 newborns per month for clinically significant hyperbilirubinemia decreased significantly (Wilcoxon rank-sums two-sample test, P = 0.044), from 4.5 (2.4) to 1.8 (1.7) after TcB testing was initiated.

Conclusion: Access to TcB testing is associated with a reduction in the hospital readmission rate for hyperbilirubinemia within 7 days of the initial discharge.

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The most common cause of jaundice in newborns is increased unconjugated bilirubin in the blood that is in large part attributable to immaturity of hepatic uptake, conjugation, and secretion of bilirubin. Neonatal hyperbilirubinemia is usually a benign condition, peaking 2–4 days after birth, that requires no intervention. However, severe neonatal hyperbilirubinemia (bilirubin >308–342 μmol/L) occurs in 4–10% of newborns (1–3) and requires treatment with phototherapy or, in extreme cases, exchange blood transfusion. If not treated promptly and efficiently, hyperbilirubinemia can lead to kernicterus. This staining of the basal ganglia is associated with severe and irreversible brain damage, including athetoid cerebral palsy and sensori-neural hearing loss. Although preventable, kernicterus has been increasing in prevalence in the United States (4). One possible reason for this increase is that, to reduce healthcare costs, babies are being discharged from hospitals within 1–2 days of birth (2, 3), before the time that hyperbilirubinemia usually becomes clinically evident or significant. Thus, early discharge has been associated with increased readmissions attributable to hyperbilirubinemia (1, 2, 5).

It appears critical to identify, before discharge, those
newborns who are at risk of developing hyperbilirubinemia that will require treatment. Indeed, the newly revised clinical practice guideline of the American Academy of Pediatrics (6) recommends that all infants who are jaundiced in the first 24 h should have bilirubin measurement, either serum or transcutaneous, and that all infants should be assessed for risk of significant hyperbilirubinemia before nursery discharge.

Bhutani et al. (3) and others (7) have attempted to identify babies at risk of developing severe hyperbilirubinemia by developing hour-specific curves of normal bilirubin values within the first 5 days of life. High, intermediate, and low risk zones are designated along the curves according to risk of developing hyperbilirubinemia that will need follow-up.

Visual inspection of the skin, sclera, and mucous membranes is frequently inaccurate (6), particularly in a population of mixed ethnicity. A noninvasive alternative to visual inspection is the use of instruments that measure bilirubin transcutaneously (8–20). Transcutaneous bilirubin (TcB)3 concentrations correlate with laboratory measurement, but they may underestimate the serum bilirubin, particularly when concentrations are >171 μmol/L (13, 14). Despite this shortcoming, the use of TcB to screen newborns for hyperbilirubinemia has been suggested as a fast, reasonable alternative to laboratory-based bilirubin testing (8–10, 13, 14, 18).

In April of 2003, we started using a TcB test (BiliCheck) to screen jaundiced newborns in our nursery. We were interested in determining the effect, if any, of the use of TcB testing on resource utilization in the newborn unit. Specifically, we were interested in determining the effect on the number of bilirubins sent to the laboratory and whether the readmission rate within 7 days of initial discharge attributable to hyperbilirubinemia changed.

Materials and Methods

With Institutional Review Board approval, we retrospectively searched a clinical laboratory and hospital database from the University of Texas Medical Branch, Galveston, TX, to compare the number of births; numbers of vaginal and cesarean deliveries; ethnicity and gender distributions; newborn readmission rates for hyperbilirubinemia unrelated to other causes, such as sepsis and heart disease, within 7 days of nursery discharge; length of stay (LOS); and the number of serum (laboratory) bilirubins for all babies in our newborn unit from August 2002 to March 2003 (before TcB) and from May 2003 to December 2003 (after TcB). Because TcB testing (BiliCheck; Respironics) was formally initiated in April 2003, we considered the information for this month a transition period that may not reflect the effects of TcB testing and thus excluded this month from the comparison. Babies were included in the study if the diagnosis-related group (DRG) designation indicated “normal newborn”. Babies requiring treatment for hyperbilirubinemia were identified by the procedure description of “phototherapy”. The decisions to measure TcB or serum bilirubin and to initiate phototherapy were determined by the attending physician leading the nursery team if clinically significant jaundice was suspected. The decision to start phototherapy or obtain additional bilirubin measurements was made using the curves developed by Bhutani et al. (3) as a reference. The TcB measurements were performed by skilled nursing staff who were trained and educated in its use. The cost of stay was determined from the newborn unit mean for the period from January 2002 to September 2003.

All results are reported as the mean (SD). Because of the limited number of data points, we used the Wilcoxon rank-sums two-sample test (t approximation; SAS, Ver. 8.2; SAS Institute Inc.) to determine the statistical significance of the differences between groups. A two-tailed $P$ value $<0.05$ was considered the criterion for statistical significance. We calculated the estimate of the sample size necessary to reject the null hypothesis using nQuery Advisor 5.0 (Statistical Solutions) with the power set at 80% at a statistical significance of 0.05.

Results

From August 2002 to December 2003, 8974 babies were delivered at the University of Texas Medical Branch. Removal of babies from the study who did not fit the criteria of the DRG designation of normal newborn and were not delivered within the study time frame, August 2002 through March 2003 (before TcB) and May 2003 through December 2003 (after TcB), left 6603 to be included in the study. Of these, 2240 (34.3% of total) had 3443 serum bilirubin measurements ordered, for a mean of 1.54 serum bilirubin measurements per newborn tested. During this same time period, 446 (6.8%) newborns had clinically significant hyperbilirubinemia requiring phototherapy treatment. None of the newborns was treated with home phototherapy or required exchange transfusion. The three time periods (total, pre-TcB, and post-TcB) were similar with regard to both gender and ethnicity (Table 1).

The mean number of laboratory measurements of serum bilirubin per newborn ($P = 0.33$; Table 2) did not change after introduction of TcB testing, but the total number of bilirubin measurements (TcB + serum) per newborn increased from a mean of 0.37 (0.08) to 0.61 (0.13) measurements ($P = 0.007$). The mean (SD) number of admissions to the newborn nursery did not change significantly [from 404.6 (33.2) to 420.7 (36.8) newborns per month; $P = 0.33$], nor did the number of newborns tested monthly for serum bilirubin [318.8 (6.4) vs 367.8 (8.7); $P = 0.21$] when expressed as a percentage of the monthly birth rate. In contrast, both the number and proportion of newborns treated by phototherapy in the

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3 Nonstandard abbreviations: TcB, transcutaneous bilirubin; LOS, length of stay; DRG, diagnosis-related group; and CI, confidence interval.
nursery increased significantly ($P = 0.0089$ and $0.021$, respectively; Table 3).

After initiation of TcB testing, the mean (SD) number of readmissions for hyperbilirubinemia decreased from $4.5 (2.8)$ to $1.8 (1.7)$ per 1000 births per month ($P = 0.044$; Table 3). None of the babies who received phototherapy before nursery discharge was readmitted for hyperbilirubinemia.

The mean LOS for normal newborns (vaginal and cesarean delivery) without complications was similar before and after introduction of TcB testing [2.2 (1.1) vs 2.1 (1.1) days, respectively; $P = 0.53$]. This was associated with a mean hospital and technical charge of $1901$ per discharge.

For babies identified with hyperbilirubinemia requiring phototherapy before discharge, the LOS before and after introduction of TcB testing was similar at 2.9 (1.3) days and 2.9 (1.3) days ($P = 0.67$), respectively. As expected, however, the LOS was significantly longer than for babies who did not require phototherapy ($P < 0.0001$). The mean hospital and technical charge for babies requiring phototherapy before discharge increased $592$, to $2493$.

Although the study was not designed to measure healthcare costs, we made preliminary estimates of the impact of TcB testing on hospital charges. For newborns who were discharged and subsequently readmitted for hyperbilirubinemia within 7 days of initial discharge, the mean LOS was (an additional) 2.5 days. For our hospital this was associated with a mean hospital and technical charge of $2401$. Thus, we estimate that the decrease in the number of babies readmitted for hyperbilirubinemia after TcB testing was initiated decreased the charges for readmission from $45,619$ to $19,208$, for a difference of $26,411$ [95% confidence interval (CI), $23,091–29,731$; $P = 0.049$] in the hospital and technical charges. After allowing for the increased charge for the TcB tests ($3685$) and increased use of laboratory bilirubin measurements ($772$), there was a net decrease in charges of $22,004$ (95% CI, $18,605–24,402$; $P = 0.052$). However, because of the increased number of newborns treated by phototherapy, with related costs of $111,888$ before and $152,144$ after initiation of TcB testing, there was in increase in phototherapy charges of $40,256$ (95% CI, $38,408–42,104$; $P = 0.003$). When this was taken into account, there was a small but statistically insignificant increase in charges of $18,252$ (95% CI, $14,428–22,026$; $P = 0.14$).

**Discussion**

In this study, initiation of selective TcB screening did not decrease serum bilirubin testing in the newborn nursery; in fact, there appeared to be a trend toward an increase in laboratory-based bilirubin testing, although the increase was not statistically significant. The most important finding of our study was that the number of hospital readmissions for clinically significant hyperbilirubinemia within 7 days of nursery discharge decreased. This decrease in readmission rate was most likely attributable to an increased number of babies undergoing phototherapy in the nursery (Table 3). Increased use of phototherapy in

<table>
<thead>
<tr>
<th>Time frames</th>
<th>Total monthly births, n</th>
<th>Newborns tested monthly, n</th>
<th>Newborns tested by serum bilirubin, % of total newborns</th>
<th>Serum bilirubin measurements/newborn</th>
<th>Total bilirubin measurements (serum + TcB)/newborn</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 2002 to March 2003</td>
<td>404.6 (33.2)</td>
<td>128.0 (26.1)</td>
<td>31.8 (6.4)</td>
<td>1.51 (0.09)</td>
<td>0.37 (0.08)</td>
</tr>
<tr>
<td>May 2003 to December 2003</td>
<td>420.7 (36.8)</td>
<td>152.1 (26.2)</td>
<td>36.7 (8.7)</td>
<td>1.56 (0.08)</td>
<td>0.61 (0.13)</td>
</tr>
<tr>
<td>$P^c$</td>
<td>0.42</td>
<td>0.10</td>
<td>0.21</td>
<td>0.33</td>
<td>0.007</td>
</tr>
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<td>Estimate of sample size$^e$</td>
<td>28</td>
<td>11</td>
<td>20</td>
<td>28</td>
<td>4</td>
</tr>
</tbody>
</table>

$^a$ All values are the mean (SD).

$^b$ Statistical significance of the differences between groups was determined by Wilcoxon rank-sums two-sample test ($t$ approximation; SAS, Ver. 8.2; SAS Institute Inc.). $P < 0.05$ was considered significant.

$^c$ Estimate of number of paired samples required to demonstrate statistical significance between groups (nQuery Advisor 5.0; Statistical Solutions).
the newborn nursery did not statistically significantly increase the overall LOS in the nursery. The most likely explanations for this are that the increase in the number of babies undergoing phototherapy was relatively small (8.5 babies per month, or 2.1% of newborns) and that our mean LOS is rather long because of the large number of Caesarian sections (33.1%) done in our high-risk obstetric population.

Identifying and treating newborns for hyperbilirubinemia does not require the use of a TcB screening device; a similar decrease in hospital readmissions would probably have been seen if these same babies had been screened by sending a serum sample to the laboratory. We can, however, speculate that the convenience and rapid turnaround time of TcB testing encouraged bilirubin screening and may have actually decreased by several hours the LOS for newborns tested who did not require phototherapy. In addition, although the racial demographics of our white and Hispanic neonatal population are somewhat atypical of the United States (21), we do not expect that this will adversely impact the conclusions dealing with the use of TcB because skin pigmentation has been found to have no effect on TcB measurement (8–10, 18).

Limitations of our study include its limited time frame and racial demographics, and the lack of uniform protocols for initiating phototherapy. We had no changes in nursery faculty during the study period, but it is expected that there was both intra- and interfaculty variation in practices during both the pre-TcB and post-TcB eras. Although our study covered only a limited time frame, if our results can be repeated in other facilities, we believe that our results support the use of TcB testing to screen newborns who are clinically jaundiced. Although this may increase the use of the clinical laboratory to monitor the course of the hyperbilirubinaemia, use of TcB testing should lead to increased quality of care, improvement in parent satisfaction, and an overall decrease in hospital charges. Implementation of the new guidelines of the American Academy of Pediatrics (6) will be simplified by use of TcB testing. Finally, from a societal standpoint, elimination of kernicterus and its devastating sequelae as a public health problem would more than compensate for a small increase in nursery charges even if this should occur.

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References


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Table 3. Number of newborns treated by phototherapy in the nursery.

<table>
<thead>
<tr>
<th>Time frame</th>
<th>Newborns treated by phototherapy*</th>
<th>Newborn readmissions for hyperbilirubinemia within 7 days of initial discharge,* n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>August 2002 to March 2003</td>
<td>23.6 (5.2)</td>
<td>5.9 (1.3)</td>
</tr>
<tr>
<td>May 2003 to December 2003</td>
<td>32.1 (3.9)</td>
<td>7.7 (1.3)</td>
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<tr>
<td>(P^b)</td>
<td>0.0089</td>
<td>0.014</td>
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<tr>
<td>Estimate of sample size*c</td>
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<td>6</td>
</tr>
</tbody>
</table>

*a Mean (SD).  
*b Statistical significance of the differences between groups was determined by Wilcoxon rank-sums two-sample test (t approximation; SAS, Ver. 8.2; SAS Institute).  
*c Estimate of number of paired samples required to demonstrate statistical significance between groups (nQuery Advisor 5.0; Statistical Solutions).  
\[P < 0.05\] was considered significant.


