The challenge of preventing neonatal bilirubin encephalopathy: a new nursing protocol in the well newborn nursery

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Jaundice is common in healthy newborn infants. It is the result of normal adaptive physiological processes and generally peaks in severity between 3 and 5 days after birth and then resolves over the next 7 to 10 days. When bilirubin rises to toxic levels, bilirubin encephalopathy and subsequent kernicterus can occur. Phototherapy is a well-established and safe treatment of neonatal jaundice. A recent increase nationwide in the number of infants with kernicterus has made prevention of severe hyperbilirubinemia a national priority. Clinical estimation of jaundice severity is notoriously inaccurate. This fact coupled with early discharge of newborns, often before bilirubin levels have peaked, makes hospital-based risk assessment an essential intervention before discharge.

In 1994, the American Academy of Pediatrics (AAP) first published a clinical practice guideline to provide a framework for the prevention and management of hyperbilirubinemia (1). The guideline, however, has not reduced the number of cases of bilirubin-induced neurological damage (2, 3). Consequently, in 2004, the AAP published new guidelines for the management of hyperbilirubinemia in newborn infants of 35 or more weeks of gestation. Key recommendations of the guideline include the following:

2. Establish nursery protocols for the identification and evolution of hyperbilirubinemia. . . .
4. Recognize that visual estimation of the degree of jaundice can lead to errors, particularly in darkly pigmented infants.
5. Interpret all bilirubin levels according to the infant's age in hours.
6. Recognize that infants at less than 38 weeks' gestation, particularly those who are breastfed, are at higher risk of developing hyperbilirubinemia and require closer surveillance and monitoring.
7. Perform a systematic assessment on all infants before discharge for the risk of severe hyperbilirubinemia. . . .
9. Provide appropriate follow-up based on the time of discharge and the risk assessment (4).

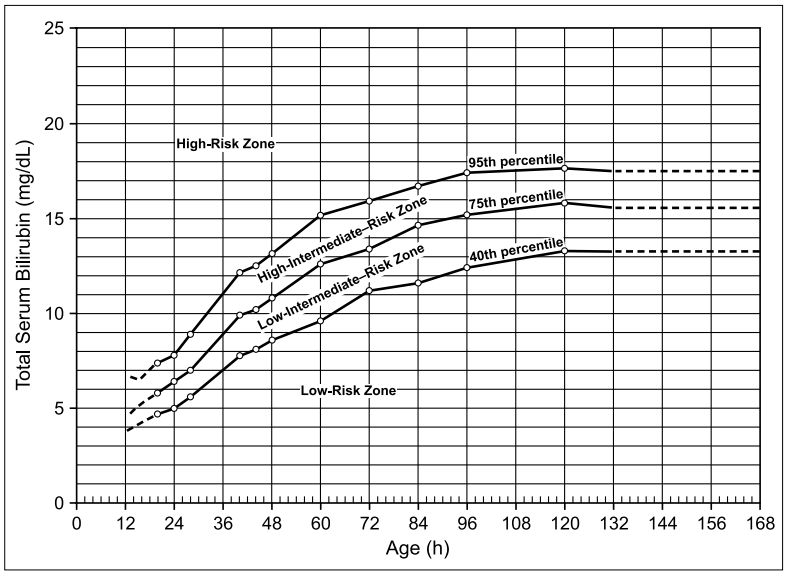

Figure 1. Risk designation of term and near-term well newborns based on their hour-specific bilirubin values. The high-risk zone is designated by the 95th percentile track. The intermediate-risk zone is subdivided to upper- and lower-risk zones by the 75th percentile track. The low-risk zone has been electively and statistically defined by the 40th percentile track. Reprinted from Bhutani VK, Johnson L, Sivieri EM. *Pediatrics* 1999;103:6–14 with permission of the American Academy of Pediatrics.

DEVELOPMENT OF PROTOCOL

A protocol was developed at Baylor University Medical Center to identify newborns at risk of severe hyperbilirubinemia and to assess physiologic and clinical risk factors associated with neonatal jaundice. The protocol was specifically developed for implementation by registered nurses in the well newborn nursery.

The protocol requires the following:

1. All infants receive a transcutaneous bilirubin (TcB) measurement within 12 to 24 hours of birth or any time the infant appears jaundiced.
2. The nurse plots the TcB level on the Bhutani curve, assigning a risk designation category for developing severe hyperbilirubinemia based on the infant's hour-specific bilirubin level *(Figure 1)* (2).
3. If the TcB level is ≥6 mg/dL within 24 hours or plots at or above the 75th percentile, the nurse obtains a total serum bilirubin test (TSB). In addition, the nurse obtains a direct Coombs' test if the mother's blood type is O and the infant's

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Table. Clinical manifestations of acute bilirubin encephalopathy and kernicterus*

Condition	Phase	Clinical manifestations
Acute bilirubin encephalopathy	Early	Lethargy Hypotonia Poor suck
	Intermediate	Moderate stupor Irritability Hypertonia manifested by backward arching of the neck (retrocollis) and trunk (opisthotonos) Fever and high-pitched cry, which may alternate with drowsiness and hypotonia
	Advanced	Pronounced retrocollis and opisthotonos Shrill cry No feeding Apnea Fever Deep stupor to coma Sometimes seizures and death
Kernicterus	NA	Athetoid cerebral palsy Auditory dysfunction Dental-enamel dysplasia Paralysis of upward gaze Some or all of the signs listed in the advanced phase of bilirubin encephalopathy

*From 2004 clinical guidelines (reference 4). NA indicates not applicable.

blood type is A or B. (Initially, the protocol also called for the nurse to obtain a complete blood count and reticulocyte count; however, this guideline was met with much physician resistance. It was physicians' impression that the protocol was allowing the nurses to obtain too many laboratory tests without physician notification.)

4. The nurse notifies the attending physician of the infant's risk category and existing risk factors.
5. TcB levels are obtained every 12 hours on infants who plot at or above the 75th percentile on the Bhutani curve. All bilirubin levels (TcB and TSB) obtained throughout the infant's hospital stay are plotted on the curve to monitor the trend.
6. The nurse also notifies the attending physician of the infant's risk designation category upon discharge, thereby providing the information necessary to ensure a timely follow-up appointment.

Figure 1 shows the importance of plotting bilirubin levels in a time-specific manner. Even single-digit bilirubin levels in the first 24 hours can predict severe hyperbilirubinemia over the next 24 to 48 hours. For example, an infant born at 35 weeks' gestation had a TcB value of 8.5 mg/dL. This infant may not have been identified as at risk without the Bhutani curve percentiles.

The protocol was implemented in four phases: 1) the nursing staff was educated on hyperbilirubinemia; 2) the nursing staff was educated on the proposed protocol; 3) the nursing staff was trained to use the transcutaneous bilimeter; and 4) a pilot study was conducted comparing the accuracy of TcB testing with that of TSB testing. To provide a better understanding of the pathophysiology of hyperbilirubinemia, education addressed bilirubin metabolism and the causes, risk factors, consequences, and treatment of hyperbilirubinemia. A very important aspect of the educational program was the viewing of Dr. Lois Johnson's video depicting infants and children who were neurologically devastated as a result of hyperbilirubinemia (5). This video had a great impact on the staff. It was difficult to observe the extent of neurological damage caused by inadequate monitoring, treatment, and follow-up. The *Table* lists the clinical manifestations of acute bilirubin encephalopathy and kernicterus (4).

Figure 2. Transcutaneous bilirubin monitoring using the BiliChek system, which allows the procedure to be done without disturbing the infant. Photo used with permission of Respironics, Inc., Murrysville, PA.

The BiliChek system (Respironics, Inc., Murrysville, PA) was the bilimeter selected for transcutaneous bilirubin monitoring *(Figure 2)*. The BiliChek works by directing white light into the skin of the newborn and measuring the intensity of the specific wavelengths returned. The major skin components that impact the spectral reflectance in newborns are dermal maturity, melanin, hemoglobin, and bilirubin. Because the spectral properties of the components within the skin are known, the interfering components can be factored out to determine the concentration of bilirubin. As a result, only the concentration of bilirubin in the subcutaneous capillary beds and subcutaneous tissue is measured (6).

DISCUSSION

Early detection of infants at risk of severe hyperbilirubinemia is a key step in preventing bilirubin encephalopathy and kernicterus. Although we experienced early resistance to the more aggressive monitoring of infants, both medical and nursing staff have now embraced this new approach. Measuring the TcB levels on all infants and plotting the levels on the Bhutani curve provides a noninvasive, universal screen, as well as a systematic assessment of an infant's risk of developing severe hyperbilirubinemia. The protocol also provides a guideline for the frequency of obtaining subsequent bilirubin levels, ensuring consistency and timeliness in monitoring. The nursing staff's increased awareness of the consequences of hyperbilirubinemia has led to

more extensive parent teaching on the importance of frequent feedings, especially in breastfed infants, and on changes in infant behavior. In addition, physician notification of the infant's risk designation category upon discharge has led to earlier follow-up appointments. The timing of the first visit after discharge should be based on the infant's risk category in relation to the time of discharge in hours (1). The benefits of this program include increased awareness of hyperbilirubinemia, earlier treatment, more timely follow-up, and decreased hospital readmissions for the treatment of hyperbilirubinemia.

Implications for practice

Although the trend for fewer hospital readmissions for hyperbilirubinemia has been noted, no statistics have been compiled. One would expect this trend to continue, given that infants at risk of developing severe hyperbilirubinemia are being identified and treated earlier. It would be of great benefit to track the number of readmissions for hyperbilirubinemia for the purposes of continuous quality improvement.

The cost of implementing the protocol was more than anticipated. The reimbursement rate for the disposable tips was slightly less than their cost. However, it can be assumed that the costs to identify and treat an infant before discharge are somewhat less than the costs of readmission and treatment after discharge, especially if neurologic damage has occurred. Most infants who suffer permanent damage from hyperbilirubinemia endure many years of physical therapy, and no price can be placed on the emotional stress the families endure. In the future, to offset the cost of screening each infant, a fee will be added to the hospital newborn admission charge. Additionally, the TSB test required when an infant plots at or above the 75th percentile will likely be eliminated since only the trend is being monitored. Eliminating the test at this step in the protocol appears to be safe and will result in fewer invasive procedures for the infants and lower cost for the families and/or hospitals.

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