Management of Neonates With Hyperbilirubinemia: Improving Timeliness of Care Using a Clinical Pathway

abstract

BACKGROUND: Neonatal hyperbilirubinemia is a common reason for neonates to present to the emergency department (ED). Although clinical practice guidelines provide recommendations for evaluation and therapy, few studies have evaluated ways to apply them effectively in the ED setting. The primary objective of this study was to compare time to phototherapy in neonates presenting to the ED with jaundice before and after implementation of a nursing-initiated clinical pathway. Secondary outcomes included time to bilirubin result and ED length of stay in neonates.

METHODS: We performed a retrospective historical control study comparing neonates presenting to the ED with jaundice during 9-month periods before and after initiation of the pathway. Charts were abstracted for times of assessment and treatment and final disposition.

RESULTS: Three hundred neonates were included in this study: 149 before and 151 after pathway implementation. Median time to phototherapy (historical control: 128 minutes vs postintervention group: 52 minutes; \( P < .001 \)), median time to bilirubin result (157 vs 99; \( P < .001 \)), and median ED length of stay (268 minutes vs 195 minutes; \( P < .001 \)) were shorter for neonates treated after the implementation of the clinical pathway. No complications were reported during the study period.

CONCLUSIONS: After implementation of a clinical pathway for the management of neonates with jaundice in the ED, we observed a reduction in time to phototherapy, time to bilirubin measurement, and overall length of stay. Pediatrics 2012;130:e1688–e1694

AUTHORS: Margaret Wolff, MD,1 Dana Aronson Schinasi, MD,2 Jane Lavelle, MD,3 Naomi Boorstein, RN,3 and Joseph John Zorc, MD3

1Department of Emergency Medicine, University of Michigan, Ann Arbor, Michigan; 2Division of Emergency Medicine, Feinberg School of Medicine, Northwestern University, Chicago, Illinois; and 3Division of Emergency Medicine, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, Pennsylvania

KEY WORDS hyperbilirubinemia, jaundice, infant, emergency department

ABBREVIATIONS

AAP—American Academy of Pediatrics
ED—emergency department
IQR—interquartile range
IV—intravenous line
LOS—length of stay
RN—registered nurse

Dr Wolff designed the study, performed the initial analysis and interpretation of data, drafted the initial manuscript, and approved the final manuscript as submitted; Drs Schinasi and Lavelle conceptualized and designed the study, interpreted the data, revised the article for important intellectual content, and approved the final manuscript as submitted; Ms Boorstein performed data collection, reviewed and revised the manuscript, and approved the final manuscript as submitted; and Dr Zorc analyzed and interpreted the data, reviewed and revised the manuscript, and approved the final manuscript as submitted.

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Address correspondence to Margaret Wolff, MD, University of Michigan Hospital and Health Systems, Department of Emergency Medicine, 1500 E. Medical Center Drive, Ann Arbor, MI 48109. E-mail: wolffm@med.umich.edu

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In 2009, 38,390 patients were evaluated in emergency departments (ED) nationwide for neonatal jaundice and hyperbilirubinemia. Although the majority of neonates presenting with jaundice have a benign, self-limited condition known as physiologic jaundice of the newborn, approximately one-third of neonates presenting to the ED have levels of bilirubin that result in admission. High levels of bilirubin are associated with kernicterus, a chronic form of bilirubin encephalopathy characterized by permanent neurologic damage. Although kernicterus is rare, recent cases demonstrate the need for adherence to recommendations to prevent complications.

The American Academy of Pediatrics (AAP) Subcommittee on Hyperbilirubinemia published guidelines for the care of neonates with hyperbilirubinemia that emphasized standardized screening and timely initiation of therapy when indicated. At our institution, we experienced 2 cases for whom treatment of clinically significant hyperbilirubinemia was delayed in the ED. Review of these cases identified potential areas for improvement in the processes of care to meet the goals set by the AAP Guidelines. In response to this review, a multidisciplinary team developed a clinical pathway that stresses rapid nursing assessment and initiation of phototherapy, early serum bilirubin collection by heel stick, and expedited transfer of high-risk patients to the NICU to receive definitive therapy. The primary objective of this study was to compare time to phototherapy in neonates with jaundice or known hyperbilirubinemia presenting to the ED before and after implementation of the clinical pathway. The secondary objectives were to compare time from arrival to bilirubin result and ED length of stay (LOS) before and after implementation of the pathway.

### METHODS

#### Setting

This study was performed in an urban academic pediatric ED with an annual census of 86,000 patients.

#### Study Population

Neonates presenting with the chief complaint of jaundice or hyperbilirubinemia to the ED were eligible for the hyperbilirubinemia clinical pathway if they were >24 hours of age and ≤21 days of age, born ≥35 weeks’ gestation, and normothermic (≥36°C and <38°C). Triage nurses identified the patient chief complaint based on parental report or referral from the primary care provider for jaundice or documented hyperbilirubinemia. If jaundice was observed in a neonate presenting for another concern, jaundice was also listed as a chief complaint. Patients were eligible for study inclusion on their first ED visit; subsequent visits were not included in the analysis.

#### Definitions and Data Collection

Neonates were identified through an electronic tracking system of all patients seen in the ED (Wellsoft, Somerset, NJ). Before pathway implementation and periodically after pathway implementation, a query was performed to identify neonates ≤21 days of age who presented with jaundice or hyperbilirubinemia as a chief complaint. Data were provided to the ED care team throughout the process. Patient ED arrival and discharge times were obtained from the ED tracking system. We abstracted temperature, gestational age, times of nursing evaluation, laboratory results, and phototherapy initiation from the patient medical record.

Our primary outcome was time to phototherapy as defined by arrival time to documentation of phototherapy initiation. Our secondary outcome measures were time to bilirubin result, defined by arrival time to bilirubin result being reported by the laboratory, and LOS defined by arrival to ED discharge times. Process measures were related to pathway adherence: proportion of bilirubin tests performed by heel stick and proportion of infants receiving unnecessary intravenous (IV) placement. The balance measures of this project were parental satisfaction and complications of phototherapy defined as temperature instability after initiation of phototherapy or retinal exposure to phototherapy.

### Intervention: Clinical Pathway Development

Two patient safety events occurred at our institution that resulted in delay of definitive therapy. The first neonate presented with jaundice and dehydration, and venipuncture by several ED providers was unsuccessful. Five hours after presentation, a skilled IV nurse from the hospital-wide vascular access service obtained venous blood. Clinically significant hyperbilirubinemia was diagnosed 6 hours after presentation. The second patient was referred from the primary care doctor for jaundice. After several attempts, the bedside registered nurse (RN) placed an IV line and obtained a small amount of venous blood. Given the small volume, the physician ordered an unconjugated bilirubin level. This error was recognized after the sample was processed, necessitating an additional blood draw. This led to a delay in the recognition of clinically significant hyperbilirubinemia, and phototherapy was not initiated until NICU admission 6 hours after presentation.

These events led to the formation of a multidisciplinary team charged with developing a strategy to improve timeliness of therapy (phototherapy or exchange transfusion) for neonates.
presenting to the ED with the chief complaint of jaundice or hyperbilirubinemia. The multidisciplinary team consisted of nurses, nurse practitioners, and physicians from the ED, NICU, and general pediatrics divisions. Given the importance of prompt phototherapy initiation, the team decided the intervention should focus on the initiation of phototherapy within 1 hour of arrival to the ED for all neonates presenting with the chief complaint of jaundice or hyperbilirubinemia.

After establishing the overarching goal, the team reviewed these cases and determined that the major cause of delay was difficulty with neonatal venipuncture. The next step was to establish the usual care of these neonates to identify other potential areas for improvement. This was accomplished by interviewing nurses, attending physicians, and trainees in the ED. We learned that laboratories were drawn after physician evaluation and phototherapy was initiated after bilirubin results were available. IV lines were placed at the time of venous blood draw, and many patients required multiple attempts. Both nurses and physicians expressed confusion regarding the appropriate bilirubin test and indications for phototherapy. All of these factors were felt to contribute to delays in initiation of phototherapy and prolonged LOS. After considering various strategies, the team came to a consensus that creating a clinical pathway with accompanying order set and educational intervention would lead to prompt initiation of phototherapy.

The AAP guidelines suggest establishing standing nursing protocols for testing for hyperbilirubinemia in jaundiced neonates. Therefore, we developed a clinical pathway (Fig 1) that is initiated by the ED triage RN. The ED triage RN serves as the first provider to evaluate each patient and assigns a triage level based on patient acuity that determines priority level. To ensure that patients with clinically significant hyperbilirubinemia receive timely room placement, the pathway instructs triage nurses to assign all patients presenting with a complaint of jaundice or hyperbilirubinemia to either a triage level 1 or 2 out of 5 levels, where 1 represents the most acute patients. Triage level 1 was defined as total serum bilirubin >20 before presentation, ill appearance, clinical signs of severe dehydration, or altered mental status. All other neonates with jaundice or hyperbilirubinemia were triaged as a level 2. This triage assignment was reviewed with all nurses but was consistent with the triage protocol before pathway implementation.

The bedside RN continues the clinical pathway by beginning parent education and requesting a physician order to obtain a serum bilirubin level via heel stick before physician evaluation. Immediately after collection of the serum sample, the neonate is placed on phototherapy using a bilirubin blanket. The protocol directs the RN to place the neonate either supine on the bilirubin blanket or prone with eye shields to avoid retinal damage. The neonate and bilirubin blanket are then wrapped with a blanket to prevent hypothermia. Temperature is taken with initiation of phototherapy and every 2 hours thereafter.

The educational component consisted of a didactic session at a departmental
meeting for physicians and nursing leadership and separate online education modules for physicians and nurses. The education reviewed the evidence behind the recommendations and highlighted key changes in practice. The nurses received training on obtaining blood via heel stick instead of the traditional method of venipuncture, and routine IV placement was discouraged. The clinical pathway was posted on our institutional intranet and served as an educational tool with hyperlinks to information such as the nomograms for phototherapy and exchange transfusion, recommended laboratory studies, and standardized discharge instructions. An order set in our computerized physician order entry system accompanied the pathway to increase consistency in ordering.

Project Timeline
The study period of 21 months included 9 months of baseline data collection (historical control), a 3-month intervention period during rollout and education, and 9 months of follow-up (postintervention). We performed a retrospective historical control study comparing timeliness of care in neonates who were evaluated in our ED for a chief complaint of jaundice or hyperbilirubinemia, comparing the baseline historical control period with the postintervention period, which were both 9-month periods occurring at identical seasons to reduce other potential variation in ED volume. Compliance and performance data were shared with the ED staff at regular intervals after pathway implementation.

Data Analysis
We summarized study data using median and interquartile ranges for nonnormal distributions and means and standard deviations for normal distributions. Continuous variables were analyzed using an independent samples t test, and categorical data were analyzed by using Fisher’s exact test or \( \chi^2 \) analysis where appropriate. Nonparametric variables were analyzed with the Mann-Whitney U test. Statistical significance was designated at \( P \leq .05 \). Statistical analysis was performed by using Statistical Package for the Social Sciences (SPSS Version 19.0, Chicago, IL).

The institutional review board waived oversight for this quality improvement project and analysis.

RESULTS
During the study period, there were 2414 visits made by neonates \( \geq 24 \) hours of age and \( \leq 21 \) days of age to the ED. Of these, 446 visits were for the chief complaint of hyperbilirubinemia or jaundice; 81 visits were excluded for presence of fever or hypothermia, and 65 visits were excluded as repeat visits. Therefore, 300 neonates were included in the study: 149 neonates were in the historical control group, and 151 were in the postintervention group (Table 1). An additional 80 neonates were discharged with a diagnosis of hyperbilirubinemia or jaundice after presenting for a different complaint.

Median time to phototherapy after the clinical pathway initiation was 52 minutes (interquartile range [IQR]: 36–77; range: 10–250) compared with 128 minutes (IQR: 68–175; range: 18–374) in the historical control (\( P < .001 \)). This effect was sustained throughout the study period (Fig 2). Median time to bilirubin result was also shorter in the postintervention group (99 minutes, IQR: 79–136) compared with the historical control group (157 minutes, IQR: 126–204; \( P < .001 \); Fig 3). LOS decreased after the intervention from 268 minutes (IQR: 212–331) in the historical control group to 195 minutes (IQR: 144–281) in the postintervention group (\( P < .001 \); Fig 4).

Seventy-eight patients were admitted to the NICU during the study period: 51 in the historical control group and 27 in the postintervention group. Median time to phototherapy for patients being admitted to the NICU after the clinical pathway initiation was 44 minutes (IQR: 35–80; range: 11–169) compared with 133 minutes (IQR 76–180; range: 18–322) in the historical control (\( P < .001 \)). There was no significant difference in LOS between the groups: historical control 272 minutes (IQR: 226–338) versus 240 minutes (IQR: 182–332) in the postintervention group.

There was strong adherence to the pathway after initiation: 95.3% of patients in the postintervention group had bilirubin testing completed by a heel stick compared with 16.7% in the historical control (\( P < .0001 \)). After the intervention, IV placement decreased to 3.9% compared with 87.9% in the historical control (\( P < .0001 \)). There were no parental complaints regarding unnecessary phototherapy, and there were no complications observed during the study period.

DISCUSSION
The results of our study indicate that implementation of a clinical pathway for neonates presenting with hyperbilirubinemia or jaundice resulted in timely initiation of phototherapy. We achieved our goal of initiating phototherapy within an hour of presentation for the majority of neonates. In addition, there was a reduction in unnecessary IV placement and LOS decreased. These results are consistent with recent studies that have used clinical pathways in the ED to standardize care and decrease LOS in patients with septic shock and cerebrospinal fluid shunt malfunction.6,7

Implementation of this pathway required a change in the culture of our ED around the care of these patients. This was accomplished by empowering the
nursing staff to initiate the protocol and through sustained educational efforts. There were formal education sessions during project rollout and monthly after project initiation at departmental meetings and through an assigned online learning module for trainees. This educational effort was reinforced by enlisting the help of several nurses and physicians to become informal peer champions of the project, providing support and real-time feedback to colleagues when working in the ED. Additional reductions in time to care may be achieved by instituting standing nursing orders for laboratory testing in these patients. However, we were unable to overcome the resistance to standing nursing laboratory orders in our ED.

Another change in practice involved obtaining blood for bilirubin testing by heel stick. When obtaining blood for laboratory testing, the common practice in our pediatric ED is to leave an IV line in place in the event that additional diagnostic or therapeutic interventions are required. Because of the challenges in obtaining IV access in neonates, we found that time to successful venous blood draw before pathway implementation was extremely variable, ranging from 1 to 5 attempts and taking as long as 4 hours. Therefore, the team considered options that would yield earlier bilirubin results and decrease unnecessary IV placement. Screening

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<tr>
<td>Preintervention n = 149 (%)</td>
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<tr>
<td>Mean age (d) 5.25</td>
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* P < .05.

**FIGURE 2**
Monthly median time to phototherapy from arrival in the ED.
with transcutaneous bilirubin testing was considered but ultimately was dismissed given that such testing only provides measurements within 2 to 3 mg/dL of the total serum bilirubin level.\(^5\) The majority of published data regarding the relationship between total serum bilirubin levels and kernicterus or developmental outcomes are based on capillary levels which can be obtained with a simple heel stick.\(^5,8\) Therefore, capillary testing emerged as the team's preferred method. The disadvantage of this method is that when the initial heel stick sample reveals clinically significant hyperbilirubinemia, additional laboratories must be obtained by an additional blood draw. However, patients with a reassuring bilirubin level only require the initial heel stick.

The decision to initiate phototherapy on every neonate with the chief complaint of jaundice or hyperbilirubinemia was initially questioned by members of the clinical team. The main value of phototherapy is that it reduces the risk that total serum bilirubin levels will reach the level where exchange transfusion is recommended.\(^5\) Therefore, it is prudent to initiate phototherapy quickly in neonates.
with clinically significant hyperbilirubinemia. Our team felt that to ensure that patients with clinically significant hyperbilirubinemia received phototherapy expeditiously, it was necessary to make phototherapy the standard of care for all patients presenting with the chief complaint of jaundice or hyperbilirubinemia. Each ED provider cares for only a few patients annually with clinically significant hyperbilirubinemia, making it difficult to maintain vigilance about prompt phototherapy initiation. In addition, by making phototherapy the standard of care for all of these patients, we were able to justify having phototherapy equipment dedicated to ED patients located in the ED for easier access. Some providers were concerned that initiation of phototherapy would make parents hesitant to hold and feed their child. After considering this, the team chose a blanket device that would still allow parents to hold and feed their child.

From an economic standpoint, there are costs associated with initiating phototherapy on every neonate presenting with jaundice or hyperbilirubinemia. However, the estimated lifetime cost of caring for a child with kernicterus is at least $900,000. Therefore, it is possible that there could be savings in an approach that aggressively treats neonates with phototherapy. Phototherapy is associated with a potential risk of temperature instability and retinal damage. However, these risks can be prevented with close attention to body temperature and the use of eye patches. After implementation of this clinical pathway, the majority of neonates were on phototherapy for ≤40 minutes before the result of the serum bilirubin was available. We believe the minimal risk associated with a brief period of phototherapy for patients who ultimately have bilirubin levels that do not require phototherapy is outweighed by the potential benefit of prompt initiation of phototherapy for patients with hyperbilirubinemia.

From a quality improvement standpoint, the success of this project hinged on the timely feedback provided to the medical providers regarding their compliance with the pathway and suggestions for improvement. One barrier that we faced initially was resistance on the part of a few clinicians to following the pathway. However, after direct feedback and continued reminders from peer champions of the project, the majority of the clinicians began using the pathway. In addition, aggregate data were presented to the ED clinical staff on a regular basis to show trends in care and to remind providers of the clinical pathway. Another key component of the success of this project was making the clinical pathway easily accessible to all providers of the care team by placing it on the hospital intranet, which was accessible from any patient room. An accompanying order set in the computerized physician order entry system preselected the recommended laboratories, which provided real-time decision support. The next cycle of our quality improvement project will focus on decreasing LOS for the patients requiring NICU admission.

Our study has several limitations. Ideally, we would have studied the effect of each of the components of the pathway by staggering the initiation of each component or by assessing the various components in different study groups as part of a randomized control trial. However, given the serious safety events that prompted the change in care for these patients, we felt it was necessary to implement these changes immediately for the entire patient population to maximize the likelihood that all patients received prompt therapy. In addition, the blunt measurement of our balance measures does not allow us to fully assess parental satisfaction. Finally, this study was conducted at a single institution and represents changes in practice that may vary in other settings.

**CONCLUSIONS**

Neonates with hyperbilirubinemia who were treated after the implementation of a clinical pathway in our ED received initiation of phototherapy earlier and had reduced length of stay.

**REFERENCES**

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