ORIGINAL RESEARCH ARTICLE

Impact of bundle nursing intervention on jaundice index and development in neonates with hyperbilirubinemia

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Abstract

Neonatal hyperbilirubinemia (NHB) management often suffers from fragmented conventional nursing approaches, which may compromise treatment efficacy and delay intervention. This prospective randomized controlled trial evaluated the effects of a novel bundle nursing intervention on jaundice index and developmental outcomes in 100 NHB neonates. Participants were randomized to a research group (n=50, bundle nursing) or a control group (n=50, standard care). The research group exhibited significantly accelerated meconium passage and jaundice resolution compared to the control group. Additionally, milk intake improved in the research group compared with the control group, with significantly greater improvements in body weight (3592.92±231.29 g) and body length (46.28±3.94 cm) after the intervention. Dynamic monitoring of serum total bilirubin (TBIL) revealed lower levels in the research group on treatment days 3, 5, and 7, with no cases of severe hyperbilirubinemia. These findings suggest that bundle nursing intervention effectively mitigates hyperbilirubinemia through comprehensive care strategies, promotes neonatal growth. *(Afr J Reprod Health 2025; 29 [11]: 57-64).*

Keywords: Bundle nursing, Neonatal hyperbilirubinemia, Development, Complications, Satisfaction

Résumé

La prise en charge de l'hyperbilirubinémie néonatale (HNB) est souvent fragmentée en soins infirmiers conventionnels, ce qui peut compromettre l'efficacité du traitement et retarder l'intervention. Cet essai contrôlé randomisé prospectif a évalué les effets d'une nouvelle intervention de soins infirmiers sur l'indice d'ictère et le développement de 100 nouveau-nés atteints d'HNB. Les participants ont été randomisés en un groupe de recherche (n = 50, soins infirmiers) ou un groupe témoin (n = 50, soins standard). Le groupe de recherche a présenté une accélération significative du passage du méconium et de la résolution de l'ictère par rapport au groupe témoin. De plus, la consommation de lait s'est améliorée dans le groupe de recherche par rapport au groupe témoin, avec des améliorations significativement plus importantes du poids corporel (3 592,92 ± 231,29 g) et de la taille corporelle (46,28 ± 3,94 cm) après l'intervention. La surveillance dynamique de la bilirubine totale sérique (BLT) a révélé des taux plus faibles dans le groupe de recherche aux jours 3, 5 et 7 de traitement, sans aucun cas d'hyperbilirubinémie sévère. Ces résultats suggèrent que l'intervention de soins infirmiers axés sur les soins atténue efficacement l'hyperbilirubinémie grâce à des stratégies de soins globales et favorise la croissance néonatale. *(Afr J Reprod Health 2025; 29 [11]:57-64).*

Mots-clés: Soins infirmiers axés sur les soins, hyperbilirubinémie néonatale, développement, complications, satisfaction

Introduction

Neonatal hyperbilirubinemia (NHB) represents one of the most prevalent clinical conditions during the neonatal period, affecting approximately 60%-80% of newborns.[1] While the majority of cases manifest as physiological jaundice, which typically resolves spontaneously and has favorable prognoses, certain instances may progress to pathological hyperbilirubinemia. This progression carries significant risks, including the potential development of bilirubin encephalopathy and kernicterus, which can cause permanent neurodevelopmental sequelae such as hearing loss, dyskinesia, and cognitive developmental delays.[2] Current clinical interventions primarily involve phototherapy, pharmacological treatment, or in severe cases, exchange transfusion to reduce total serum bilirubin (TBIL) levels.[3] However, conventional nursing approaches often adopt a fragmented perspective, emphasizing isolated treatment methods while neglecting the systematic integration of essential components such as early risk assessment, continuous monitoring, optimal feeding strategies, and parental guidance. Such limitations may compromise treatment efficacy or delay critical intervention opportunities in some infants.[4] Compounding these challenges, many parents lack sufficient awareness of jaundice-related risks and possess limited capabilities for home-based monitoring, thereby increasing the likelihood of severe complications. Consequently, it is imperative to develop more comprehensive and efficient nursing management approaches to proactively regulate TBIL levels while safeguarding neurodevelopmental outcomes, addressing a crucial gap in perinatal and neonatal care practices.

As an evidence-based integrated strategy, bundle nursing has been gradually applied in the field of neonatal jaundice in recent years.[5, 6] Despite its potential, the current application of BN in NHB faces significant challenges that limit its effectiveness and widespread adoption. These include: (1) marked heterogeneity exists in intervention protocols, ranging from exclusive tactile stimulation to feeding-focused approaches, without consensus on evidence-based combinations;[7, 8] (2) approximately 90% of studies primarily assess total bilirubin (TBIL) levels as the primary outcome, with limited evaluation of neurodevelopmental outcomes beyond three months;[9,10] and (3) parental involvement remains inadequately addressed in care protocols, lacking systematic strategies to empower active family participation in care.

These limitations substantially constrain the clinical translation of bundle nursing in NHB management.

To overcome these limitations, we developed an integrated bundle of care program. The intervention's key innovation involves transforming conventional single-modality approaches into an integrated, evidence-based care bundle that synergistically combines dynamic TBIL monitoring, optimized feeding management with precise intake quantification, and structured family engagement protocols.

By establishing this standardized protocol, our findings will contribute essential evidence for formulating clinical practice guidelines, ultimately promoting more comprehensive, coordinated, and family-inclusive neonatal care paradigms.

Methods

Research participants

Sample size was calculated based on an anticipated effect size of (d=0.8) for the primary outcome (time to jaundice resolution), with α=0.05 and β=0.20 (power=80%). This calculation indicated a requirement of 45 infants per group. Accounting for a potential 10% dropout rate. A cohort of 100 NHB neonates admitted between May 2024 and June 2025 were enrolled. Participants were randomly allocated into two groups via a computer-generated random number table: a research group receiving bundle nursing care and a control group receiving standard care, each comprising 50 infants. Inclusion criteria: (1) Term infants (gestational age ≥36 weeks and ≤41 weeks); (2) Birth weight 2500-4000 g; (3) Fulfillment of NHB diagnostic criteria;[11] (4) Jaundice onset within 1 month postpartum; (5) Geographic stability and willingness to participate in ≥6 months of follow-up. Exclusion criteria: (1) Major comorbidities (e.g., congenital anomalies, systemic infections, hemolytic disorders, or hypoxic-ischemic encephalopathy); (2) History of exchange transfusion treatment; (3) Phototherapy contraindications; (4) Significant maternal obstetric complications (e.g., preeclampsia, gestational diabetes). Elimination criteria: (1) Life-threatening complications (e.g., mortality) occurred during the study; (2) Parental request for discontinuation or consent withdrawal; (3) Diagnosis of neurodevelopmental disorders unrelated to jaundice (e.g., genetic disorders, cerebral palsy). The control group had an age of (4.24 ± 2.30) days and a gestational age of (38.20 ± 1.50) weeks, with 39 boys and 11 girls. The research group had an age of (4.52 ± 2.33) days and a gestational age of (38.46 ± 1.55) weeks, with 42 boys and 8 girls. Baseline data, including day age, gender, and mode of delivery, showed no significant differences (P>0.05) between the two groups, confirming their comparability. The study has been approved by the

Ethics Committee of Lixin County People's Hospital (No. kl2024012), and all guardians of the study subjects signed an informed consent form.

Therapeutic interventions

Both infant groups received standardized phototherapy using identical equipment, ward conditions, and physician-directed protocols. Routine nursing: Using a standardized communication method, the family members answered questions, informed the family members of the possible consequences if not treated in time and the effect of blue light therapy, so as to alleviate the anxiety and concerns of the family members of the children. Blue light irradiation (wavelength range: 425-475 nm) was administered to all neonates (6-12h) (SHE-LGP003-1 blue light irradiator, Beijing Sano Optoelectronics Technology Development Co., LTD., China).

Nursing interventions

Protective measures included the use of eye shields and specialized diapers, with repositioning performed every 2-3 hours. The temperature of the blue light box was adjusted at 30℃ to 32℃, and the body temperature of the child was maintained at 36.5-37.3℃. The sterilized soft sheets were placed around the child's body to create a bird's nest environment, to ensure that the child is in a comfortable lying position, the head of the bed is raised 15-20°, the indoor environment is quiet and comfortable, and the room temperature is maintained at 24-26℃. Standard nursing encompassed daily TBIL level assessments (via transcutaneous bilirubinometry) and hourly vital signs checks.

Bundle nursing: Performed on top of routine nursing. (1) The nursing team underwent a standardized 2-week training program. Training covered the core components of the bundle, including rationale, dynamic TBIL monitoring procedures and interpretation, optimal breastfeeding support techniques, abdominal massage protocol, recognition of feeding intolerance, family communication strategies, and the use of the adherence checklist. (2) A dynamic monitoring and early warning system was implemented to track the infant's condition. TBIL levels were measured every 8 hours. Throughout phototherapy treatment, vital signs were evaluated every hours.

An early warning protocol was in place, requiring immediate physician notification and intensive intervention if TBIL levels reached or exceeded the high-risk threshold (≥342 μmol/L or as per physician assessment based on infant's age in hours and risk factors). (3) Feeding and excretion management strategies were carefully executed. Obstetric nurses provided daily instruction (once per day) to mothers on proper breastfeeding techniques, ensuring infants were fed on demand at intervals no longer than 2.5 hours, with intake precisely recorded using an electronic scale. Additionally, infants received oral probiotics (baker's yeast, once daily, 0.25 g per dose), and abdominal massage sessions (five minutes each, three times daily) were administered 30 minutes after meals to promote digestion. The education program also emphasized the recognition of abnormal feeding behaviors or excretion patterns in newborns, along with establishing clear emergency response procedures. Both groups of infants received continuous nursing care for 4-10 days (from admission to discharge).

Outcome assessment

(1) Baseline infant data, including age (in days) and gender, were recorded at enrollment. (2) Clinical recovery metrics, such as the time to meconium passage (defined as the time from birth to first meconium passage), time to jaundice resolution (defined as the time from admission to TBIL falling below phototherapy threshold and skin jaundice visibly resolved), daily stool frequency (daily stool frequency was calculated as the total number of bowel movements recorded within a 24-hour period), daily milk intake (daily milk intake was measured using an electronic scale to record the weight difference of the feeding bottle before and after each feeding; the total intake over each 24-hour period was summed), and hospitalization time were documented. (3) Dynamic changes in TBIL levels were analyzed at baseline (pre-treatment/admission) and on days 1, 3, 5, and 7 post-treatment initiation to compare intergroup

differences. (4) Changes in body weight, body length, and head circumference were measured at admission (pre-nursing) and at discharge (post-nursing). (5) Treatment-related adverse events (e.g., infections, feeding intolerance) during the treatment were recorded. (6) Family satisfaction was evaluated at discharge using the Newcastle Satisfaction with Nursing Scale (NSNS).[12] Responses were stratified as very satisfied (≥95 points), satisfied (76–94 points), or dissatisfied (19–75 points); "very satisfied" and "satisfied" ratings were combined for satisfaction analysis.

Statistical methods

Statistical analysis was carried out by using GraphPad Prism 8.3 software (GraphPad Software, San Diego, CA, USA). Categorical variables, recorded as [n(%)], were comparatively analyzed using chi-square ($\chi2$) tests. For continuous variables, Shapiro-wilk testing was first utilized for distribution assessment; data following a normal distribution ($\bar{\chi}$±s) were analyzed by independent sample t tests and paired t tests, while Mann-Whitney U tests and Willcoxon tests were used to compare non-normally distributed data [M (P25,P75)]. P<0.05 is the statistical significance level for all analyses.

Ethical considerations

This study obtained approval from the Ethics Committee of Lixin County People's Hospital, and all guardians of the study subjects signed an informed consent form. The research team adhered to strict ethical guidelines throughout the study, ensuring participant information confidentiality and minimizing potential risks. All outcome assessors (e.g., those who measure growth indicators and analyze TBIL data) were unaware of the group assignments.

Results

Clinical recovery metrics

Hospitalization duration did not differ between the two groups (P>0.05). However, the research group had shorter time to jaundice resolution (P=0.028) than the control group, whereas daily stool frequency and milk intake were higher (P=0.002, 0.012) (Table 1).

Comparison of TBIL changes

The dynamic monitoring results of TBIL showed no notable inter-group differences before treatment (P>0.05). After one day of treatment, TBIL levels decreased (P<0.001) but remained comparable between groups. At 3, 5, and 7 days, TBIL levels declined in both groups, with the research group showing significantly lower levels (P<0.001) (Table 2).

Comparison of developmental outcomes

Prior to nursing intervention, no significant between-group differences were observed in body weight, length, or head circumference among the children (P>0.05). Post-nursing, both the research and control groups exhibited statistically significant increases in these growth metrics (P<0.05). While no significant difference in head circumference remained between groups after intervention (P>0.05), the research group demonstrated significantly greater improvements in body weight and length (P<0.05) (Figure 1).

Safety profile comparison

During the nursing period, complications including feeding intolerance, hypoglycemia, and anemia were reported in both groups. No significant difference was found in the overall complication incidence rate between groups (P=0.069). However, subgroup analysis revealed a significantly lower incidence of feeding intolerance in the research group compared to the control group (P=0.031) (Table 3).

Nursing satisfaction comparison

Results from the NSNS questionnaire administered to caregivers showed that the research group achieved a total nursing satisfaction rate of 90.00%, versus 74.00% in the control group. The inter-group comparison revealed a statistically higher satisfaction rate in the research group (P=0.037) (Table 4).

Table 1: Clinical recovery metrics in both groups of children

Groups (n=50)	Time to jaundice resolution (d)	Daily stool frequency	Daily milk intake (mL)	Hospitalization time (d)
Control	5.42±1.05	2.56±0.76	536.16±13.52	5.72±1.14
Research	4.96±1.01	3.14±1.07	542.81±12.26	5.44±1.07
t	2.232	3.126	2.576	1.263
P	0.028	0.002	0.012	0.210

Table 2: TBIL changes in the two groups of children

Groups (n=50)	Before treatment	After treatment				F	P
		1d	3d	5d	7d		
Control	286.57±6.45	259.84±6.91^{a}	242.33±8.54^{ab}	211.26±10.94^{abc}	107.55±15.77^{abd}	2265.372	<0.001
Research	285.37±8.59	257.25±8.58^{a}	224.97±12.67^{ab}	183.16±12.03^{abc}	80.37±15.83^{abcd}	2274.186	<0.001
t	0.793	1.660	8.031	12.224	8.602		
P	0.430	0.100	<0.001	<0.001	<0.001		

Note: *vs.* before treatment, $^{a}P<0.05$, *vs.* 1 day after treatment, $^{b}P<0.05$, *vs.* 3 day after treatment, $^{c}P<0.05$, *vs.* 5 day after treatment, $^{d}P<0.05$

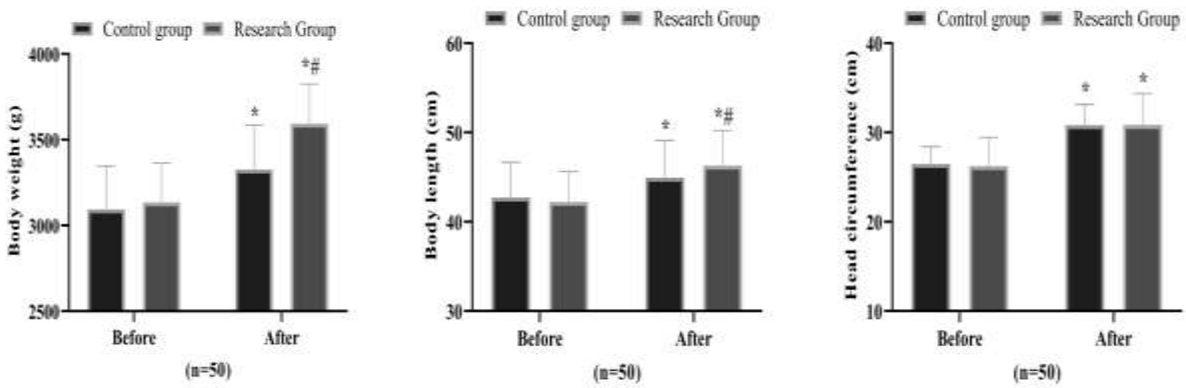

Figure 1: Changes in growth of children in the two groups before and after nursing. The figure shows the weight, body length and head circumference of the two groups of children before and after nursing. Note: *vs.* before treatment, $^{*}P<0.05$, *vs.* Control group, $^{\#}P<0.05$

Table 3: Adverse reactions in the two groups of children

Groups (n=50)	Feeding intolerance	Hypoglycemia	Anemia	Delay in development	Ataxia	Rash	Total
Control	8 (16.00%)	5 (10.00%)	6 (12.00%)	3 (6.00%)	0 (0.0%)	4 (8.00%)	52.00%
Research	1 (2.00%)	3 (6.00%)	5 (10.00%)	2 (4.00%)	1 (2.00%)	5 (10.00%)	34.00%
Statistics	-	-	$\chi^2=0.102$	-	-	-	$\chi^2=3.305$
P	0.031	0.715	0.749	>0.999	>0.999	>0.999	0.069

Note: Fisher's exact test was used for subgroup comparisons (e.g., feeding intolerance) due to small expected frequencies in some cells.

Table 4: Satisfaction of family members of children in both groups

Groups (n=50)	Very satisfied	Satisfied	Dissatisfied	Satisfaction (very satisfied+satisfied)
Control	16 (32.00%)	21 (42.00%)	13 (26.00%)	74.00%
Research	25 (50.00%)	20 (40.00%)	5 (10.00%)	90.00%
χ^2				4.336
P				0.037

Discussion

This study employed a prospective randomized controlled design to evaluate the multifaceted benefits of bundle nursing interventions for NHB. The findings not only demonstrated the model's efficacy in rapidly lowering serum TBIL levels but also suggested its potential to safeguard early infant development, offering valuable evidence for clinical nursing practices.

The results indicated that infants receiving bundle nursing exhibited significantly faster meconium passage and jaundice resolution compared to the control group (P<0.05), alongside increased daily stool frequency and milk intake. These outcomes align with the principles of neonatal enterohepatic circulation: early optimal feeding enhances intestinal motility, accelerating TBIL elimination via meconium,[13] while abdominal massage reduces TBIL reabsorption by supporting intestinal mucosal development.[14] Notably, the research group's higher daily milk intake (P<0.05) corroborates the growth-promoting effects of "on-demand feeding" reported by Xianlin W *et al*.,[15] underscoring the centrality of nutritional strategies in jaundice management. Regarding TBIL metabolism, the research group exhibited a progressive decline in TBIL levels at days 3, 5, and 7 of treatment, with values significantly lower than those in the control group. This highlights the effectiveness of the bundle nursing dynamic monitoring system in precisely regulating TBIL metabolism.

Notably, severe hyperbilirubinemia was absent in the research group but occurred in 12 cases in the control group, suggesting that bundle nursing may modify disease progression through timely and intensive early interventions. Additionally, the research group demonstrated greater improvements in body weight and length compared to the control group after nursing (P<0.05), supporting the findings of Shu X *et al*.'s large-scale study. Their research indicated that neonatal weight loss exceeding 8% during jaundice is linearly associated with an elevated risk of developmental retardation.[16] This effect may be attributed to probiotic supplementation (Saccharomyces boulardii), as evidence specific to this strain suggests it helps regulate the intestinal immune microenvironment and improve gut barrier function, potentially indirectly promoting nutrient absorption.[17] However, no significant difference in head circumference growth was observed (P>0.05), this lack of difference might be explained by the relatively short duration of the intervention (hospitalization period), as head circumference growth is typically less sensitive to short-term nutritional interventions compared to weight and length, and may be more strongly influenced by genetic factors and prenatal conditions. Long-term follow-up studies are necessary to assess potential neurocognitive outcomes. Concerning safety, while the overall complication rates did not differ significantly between groups (P>0.05), the research group demonstrated a notably lower incidence of feeding intolerance (P<0.05). This improvement can be linked to the implementation of a closed-loop "feeding-monitoring-adjustment" approach in bundle nursing. By utilizing electronic scale measurements to precisely regulate nutritional intake, the risk of gastrointestinal overload due to excessive feeding was effectively minimized.[18] Finally, nursing satisfaction in the research group reached 94%, significantly surpassing that of the control group (P<0.05). This enhancement can be attributed to enhanced Communication: Regular updates on the infant's condition and emergency protocol simulations fostered greater parental involvement. This approach aligns with the family-oriented care principles outlined in the WHO

Guidelines for Essential Newborn Care in the Early Period.[19]

Based on the findings of this investigation, we propose the implementation of a comprehensive care protocol incorporating "dynamic monitoring-feeding intervention-family engagement" into standard NHB management protocols in tertiary care facilities.

Furthermore, we suggest the development of an Internet of Things-enabled TBIL monitoring system to facilitate real-time correlation analysis between transcutaneous and serum bilirubin measurements. The study also highlights the importance of post-discharge community support services. Establishing a telemedicine follow-up platform with AI-powered clinical decision support could optimize both service efficiency and resource utilization while ensuring continuity of care.

Firstly, the modest sample size (n=100) may restrict the generalizability of the findings, underscoring the need for future multi-center investigations with larger cohorts. Secondly, the relatively brief follow-up period precluded the assessment of long-term neurodevelopmental outcomes, which warrants further longitudinal evaluation. Additionally, the study did not differentiate between etiologies of NHB (e.g., hemolytic vs. infectious), potentially obscuring subtype-specific responses to the bundle nursing intervention. Lastly, the abbreviated nursing staff training period (2 weeks) could have influenced intervention adherence, suggesting the importance of implementing standardized quality control protocols in future studies.

To sum up, this research has demonstrated notable improvements in symptom control, TBIL metabolism management, neurodevelopmental protection, and family care capacity through an evidence-based integrated bundle nursing approach.

The innovation lies in the synergistic integration of dynamic monitoring, optimized feeding protocols with precise quantification, and active family engagement within a standardized care bundle. These outcomes contribute substantially to advancing neonatal jaundice care models, shifting the paradigm from mere disease treatment to holistic developmental protection, while establishing an operational model for family-integrated neonatal care.

Conflicts of interest

The authors report no conflict of interest.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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