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The Application Value of Griffiths Mental Development Scale in the Assessment of Neurodevelopment of Full-Term Neonates with Hyperbilirubinemia

Yanan Ma, Xiangli Bian, Kun Zhang, Jiayi Chen, SaiNan Fan & Jinping Zhang*

Department of Pediatrics, the sixth people's Hospital affiliated to Shanghai Jiaotong University, 200233.

***Corresponding Author:** Jinping Zhang, Department of Pediatrics, the sixth people's Hospital affiliated to Shanghai Jiaotong University, 200233.

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Abstract

Objective: *This study aims to investigate the practical use of the Griffiths Mental Development Scale in assessing the neurodevelopment of full-term newborns with hyperbilirubinemia.*

Method: *The study will include 123 newborns born in our hospital between September 2019 and August 2023. The newborn's clinical data and laboratory test results will be collected, and the Griffiths Mental Development Scale will be used to assess their development. The goal is to determine the impact of bilirubin levels on the growth and developmental outcomes of these newborns.*

Results: *In this study involving 123 children, there were significant differences in developmental outcomes between the jaundice group and the control group in each of the five energy areas ($P<0.05$). Additionally, when a child's total bilirubin level reaches or exceeds 342μmol/L, there is a significant difference in the developmental outcomes of each of the three major energy areas, including gross motor, personal-social ability, and visual performance high-risk factors ($P<0.05$). The duration of jaundice and how soon after the onset of jaundice phototherapy is started also have a significant impact on children's personal-social ability development outcomes ($P<0.05$). After performing a multifactor analysis, it was determined that a total bilirubin level of ≥342μmol/L and jaundice duration of ≥14 days are high-risk factors affecting the personal-social ability development outcomes of some children with high bilirubin.*

Conclusion: *After administering the Griffiths Mental Development Scale, it was discovered that various degrees and durations of jaundice in term infants with neonatal hyperbilirubinemia resulted in developmental delays in different areas and to different degrees. The Griffiths Mental Development Scale provides a more precise assessment of the development of children with neonatal hyperbilirubinemia and helps clinicians in early intervention and evaluation. can be more accurate. The pluripotency zone can assist in monitoring the developmental outcomes of such children.*

Keywords: The Griffiths Mental Development Scale, Hyperbilirubinemia, Full-Term Neonates, Neurodevelopment, Assessment.

Introduction

Neonatal hyperbilirubinemia (NHB) is a common disease in newborn pediatrics and is a leading cause of medical treatment or hospitalization in neonates. It can cause serious complications such as bilirubin-induced neurological dysfunction (BIND), sensorineural deafness, hand and foot athetosis, eye movement disorder, and enamel dysplasia, which can damage the liver, brain, kidney, heart, and other organs. Brain injury caused by hyperbilirubinemia can result in permanent neurological issues, affecting the growth, development, and physical and mental health of newborns. The clinical symptoms of BIND are often not clear, making it difficult to determine the exact threshold of bilirubin neurotoxicity. Additionally, there is still a lack of consistent and effective early evaluation indicators [1-6].

Data and Methods

General Information

The study investigated the clinical data and laboratory results of 123 full-term newborns born in our hospital between September 2019 and August 2023. The growth and development of

the newborns were evaluated using the Griffiths mental development scale. They were divided into two groups, the jaundice group (bilirubin value exceeding the phototherapy line) and the control group (no jaundice or physiological jaundice), based on the results of hyperbilirubinemia.

The inclusion criteria for the study were as follows:

1. Gestational age of ≥ 37 weeks and < 42 weeks
2. Birth weight of ≥ 2500g and < 4000g Bill
3. Serum total bilirubin (TSB) exceeded the corresponding risk factors of age or increased more than 85ummol/L every day or greater than 8.5ummol/L per hour, or jaundice lasted for a long time, full-term infants were more than 2 weeks, and premature infants were more than 4 weeks, mainly unconjugated bilirubin
4. No intracranial injury caused by intracranial hemorrhage and intracranial infection
5. No congenital malformation;
6. No history of ototoxicity and sedative use and family history of deafness;
7. Typical symptoms of bilirubin encephalopathy were not found in clinic.

The exclusion criteria were as follows: related treatment was given before admission; children with hereditary mitochondrial metabolic disease, methylmalonic acidemia, propionemia, carbon monoxide poisoning, hypermagnesia, and so on. (Figure 1).

Method

Clinical data collection

We collected clinical data for both the children and their mothers using a standardized questionnaire. We inquired with the mothers about their gestational age, birth weight, sex, age, TSB, the time of phototherapy, duration of jaundice, and how long after the onset of jaundice it occurred. Additionally, we obtained relevant information from the medical records of hospitalized cases.

Evaluation of Griffiths Mental Development Scale

The Griffiths Mental Development scale (GMDS) was created by Ruth Griffiths in 1954. It was later revised in 2006 and the updated version, known as the Griffith Mental Development scale-extended revised version (GMDS-ER), was introduced in China. It was adapted to create the Griffith Mental Development Assessment scale-Chinese version of Griffiths Developmental Scales-Chinese (GDS-C), and underwent norm revision[7]. GDS-C is an effective diagnostic scale that evaluates the development of children aged 0-8 years old across six areas: gross exercise, individual and society, hearing and language, hand-eye coordination, performance, and reasoning.

The activities carried out in each area are closely related to the main aspects of children's development and are designed to evaluate the level of children's development in each field, as well as identify their relative strengths and weaknesses. GDS-C is divided into two parts, one for 2-year-olds and the other for 2-8-year-olds. The 2-year-old part is composed of five dimensions: movement (A), individual-society (B), language (C), hand-eye coordination (D), and performance (E). The 2-8-year-old part includes an additional practical reasoning (F) dimension. During the evaluation process, the test begins with a project that is two months lower than the actual age of the subject. The evaluator then moves up or down at least six items in order, and six consecutive projects are considered to have passed all the above items. Conversely, six consecutive projects that the subject is unable to complete are considered as a failed attempt. The evaluator observes the children's performance and ability during the evaluation through playful interaction.

Statistical Processing

Excel was used for data input, while SPSS22.0 software was used for statistical analysis. Bilateral test was used in all statistical analyses, and the difference was found to be statistically significant ($P < 0.05$). Kolmogorov-Smirnov was utilized to verify if the data conforms to normal distribution. If $P > 0.05$, the data conformed to the normal distribution; otherwise, the data does not conform to the normal distribution. Quantitative data that follow normal distribution are represented as mean ±standard deviation (variance ±SD), and t-test is used to compare the differences between groups of data. Skewed data are represented as median [25% pr 75] (M [P25p75]), and the Kruskal-Wallis rank sum test is used to compare the differences between groups. The counting data were expressed as the number of cases or percentages. Mann-Whitney U or Kruskal-Wallis H (K) test was used to compare the scores of GDS-C subscales among different groups. Pearson correlation was used for correlation analysis. Binary logical regression analysis and multivariate linear correlation analysis were used to explore the influencing factors of abnormal developmental areas in children with developmental abnormalities.

Results

From September 2019 to August 2023, 77 of the 123 full-term newborns born in our hospital had neonatal hyperbilirubinemia, including 39 males and 38 females with gestational age $37 \leq GA < 42$ weeks and birth weight $2.5 \leq BW \leq 4$kg. Out of the 77 cases of jaundice, 19 were caused by neonatal ABO hemolytic disease, 20 were due to breast milk jaundice, 1 was linked to G6PD deficiency, and the remaining 37 cases were caused by other factors like delayed milk opening, improper feeding, oxytocin, delayed meconium excretion, etc. The control group consisted of 46 normal newborns (38 males and 15 females) born in the same period in the obstetrical ward of the hospital. The gestational age was $37 \leq GA < 42$ weeks, and the birth weight was $2.5 \leq BW \leq 4$kg. The gestational age, birth weight and age of the two groups were normally distributed, and there was no significant difference between the two groups according to the Mann-Whitney U rank sum test.

Scores of Six Subscales of GDS-C in the Jaundice Group and Control Group

Out of the 77 children in the jaundice group, 57 (74%) were found to be qualified in gross sports while 20 (26%) were unqualified. For individual-social ability 55 (71.4%) were quali-

fied and 22 (28.6%) were unqualified. When it came to hearing and language items, 53 (68.8%) children were qualified while 24 (31.2%) were unqualified. For hand-eye coordination, 54 (70.1%) children were qualified while 23 (29.9%) were unqualified. In visual performance items, 50 (64.9%) children were qualified while 27 (35.1%) were unqualified. When it came to actual reasoning items, 18 (23.4%) children were qualified, 6 (7.8%) were unqualified, and 53 (68.8%) were untested as they had not yet reached 24 months. You can find more details in Table 1.

Table1. Comparison of the effects of neonatal hyperbilirubinemia on developmental outcome

Project	Jaundice group (example)			Control group (example)			P
	Normal development	dysplasia	Abnormal percentage	Normal development	dysplasia	Abnormal percentage	
A	57	20	26.00%	41	5	10.90%	0.045
B	55	22	28.60%	41	5	10.90%	0.022
C	53	24	31.20%	34	12	26.10%	0.551
D	54	23	29.90%	41	5	10.90%	0.015
E	50	27	35.10%	39	7	15.20%	0.018
F	18	6	7.80%	8	2	17.40%	0.121

Table note: A. Rough sports, B. Individual-social ability, C. Listening and language, D. Hand-eye coordination ability, E. Visual performance, F, practical reasoning.

It was found that out of the 46 children in the control group, 41 (89.1%) were qualified in gross sports, 5 (10.9%) were unqualified. Out of the total number of participants, 41 individuals (89.1%) were qualified for personal-social items, whereas 5 (10.9%) were unqualified. In the case of hearing and language items, 34 (73.9%) were qualified and 12 (26.1%) were unqualified. Similarly, 41 (89.1%) were qualified for hand-eye coordination while 5 (10.9%) were unqualified. For visual performance items, 39 cases (84.8%) were qualified, and 7 cases (15.2%) unqualified. Actual reasoning items were qualified in 2 cases (4.3%) while 8 cases (17.4%) were unqualified. Additionally, 36 cases (78.3%) remained untested due to age (less than 24 months). See Table 1 for details.

The results of the evaluation were used to compare the abnormal rate of development between the jaundice group and the control group in gross movement, personal-social ability, hearing and language, hand-eye coordination ability, and visual performance group using the Mann-Whitney-U test. The P value was calculated accordingly. Kruskal-Wallis-H (K) was used to test the actual inference group, as detailed in Table 1.

The study found the following results: (1) During gross exercise, the percentage of jaundice dysplasia was higher in comparison to the control group (26.0% vs 10.9% $P < 0.05$). (2) In personal-social ability, the percentage of jaundice dysplasia was higher than that in the control group (28.6% vs 10.9% $P < 0.05$). (3) In hearing and language, the percentage of jaundice dysplasia was higher than that in the control group (31.2% vs 26.1% $P > 0.05$). (4) In the ability of hand-eye coordination, the percentage of abnormal jaundice was higher than that of the control group (29.9% vs 10.9% $P < 0.05$). (5) In visual performance, the percentage of jaundice dysplasia was higher than that in the control group (35.1% vs 15.2% $P < 0.05$). (6) In practical reasoning, the percentage of abnormal development of jaundice is lower than that of the control group (7.8% vs 17.4%, $P > 0.05$), as shown in Table 1.

Neonatal hyperbilirubinemia has little effect on hearing, language, and practical reasoning ability but is a high-risk factor for gross movement, personal-social ability, hand-eye coordination, and visual performance.

Effect of Severe Neonatal Hyperbilirubinemia on the Developmental Outcome of Children

The children with jaundice were divided into two groups based on their total bilirubin levels at the peak of the condition. The severe group included 19 children with total bilirubin levels of 342 μmol/L or higher, while the non-severe group comprised 58 children with total bilirubin levels between 221 μmol/L and 342 μmol/L. Among the 19 children in the severe group, there were 11 males and 8 females, while the non-severe group had 28 males and 30 females. Both groups had gestational age between 37 and 42 weeks, and birth weight between 2.5 and 4kg. The gestational age, birth weight and age of the children in both groups followed a normal distribution, and there was no significant difference between the two groups according to the t-test, and Mann-Whitney U rank sum test.

The severe group consisted of 19 children. Among them, 10 cases (52.6%) were qualified for gross sport and 9 cases (47.4%) were unqualified. In addition, 8 cases (42.1%) were qualified in personal-social items, and 11 cases (57.9%) were not qualified, whereas 11 cases (57.9%) were qualified in hearing and language items, and 8 cases (42.1%) were unqualified. Moreover, 10 cases (52.6%) were qualified in hand-eye coordination and 9 cases (47.4%) were unqualified. The visual performance items were qualified in 8 cases (42.1%) while unqualified in 11 cases (57.9%). Lastly, the actual reasoning items were qualified in 3 cases (15.8%), unqualified in 3 cases (15.8%), and untested in 13 cases (68.4%) because they had not reached 24 months, as shown in Table 2.

Table 2. Comparison of the effects of hyperbilirubinemia on developmental outcome in severe newborns

Project	Severe group (example)			Non-severe group (example)			P
	Normal development	dysplasia	Abnormal percentage	Normal development	dysplasia	Abnormal percentage	
A	10	9	47.40%	47	11	19.00%	0.015
B	8	11	57.90%	47	11	19.00%	0.001
C	11	8	42.10%	42	16	27.60%	0.239
D	10	9	47.40%	44	14	24.10%	0.056
E	8	11	57.90%	42	16	27.60%	0.017
F	3	3	15.80%	15	2	5.20%	0.251

Table note: A. Rough sports, B. Individual-social ability, C. Listening and language, D. Hand-eye coordination ability, E. Visual performance, F. Practical reasoning.

The Mann-Whitney U test was used to compare the abnormal rate of development between the jaundice group and the control group in gross movement, personal-social ability, hearing and language, hand-eye coordination ability, and visual performance group. The P value was calculated. Kruskal-Wallis (K) was used to test the actual inference group. Please refer to Table 2-2 for more details.

According to the study, the percentage of abnormal development is significantly higher in the group with severe neonatal hyperbilirubinemia in areas such as gross movement, personal-social ability, and visual performance ability when compared to the non-severe group ($P < 0.05$). However, there was no significant difference in the developmental outcome of areas such as hearing and language, hand-eye coordination ability, and practical reasoning ability between the severe and non-severe groups ($P > 0.05$). You can refer to Table 1 for more details.

Therefore, severe neonatal hyperbilirubinemia poses a high-risk factor for gross movement, personal-social ability, and visual performance, but it does not significantly affect the developmental outcome of hearing and language, hand-eye coordination ability, and practical reasoning ability.

The impact of Jaundice Occurrence Time, Duration, and Phototherapy on the Developmental Outcome of Children

The children in the jaundice group were divided into two groups based on the occurrence time of jaundice: the 24-hour group and the 24-hour group. Among the 77 children in the jaundice group, 22 children were in the 24-hour group, including 11 males and 11 females, and 55 children in the 24-hour group, including 28 males and 27 females. All children belonged to gestational age $37 \leq GA < 42$ weeks and, birth weight $2.5 \leq BW \leq 4$kg. There was no significant difference in gestational age, birth weight, and age between the two groups. The developmental outcomes of the five subscales of gross movement, personal-social ability, hearing and language, hand-eye coordination, and visual performance of GDS-C were compared between the two groups using the Mann-Whitney U rank sum test. Kruskal-Wallis (K) was used to test the actual inference group, and it was found that P values were all greater than 0.05. Therefore, there was no statistical difference in the effect of jaundice on the developmental outcome.

The children in the jaundice group were also divided into two groups based on the duration of phototherapy the ≤ 3 days group and the > 3 days group. Among 77 children in jaundice group, 47 children were in the ≤ 3 days group, including 25 males and 22 females, and 30 children were in the > 3 days group, including 14 males and 16 females., All children belonged to gestational age $37 \leq GA < 42$ weeks and, birth weight $2.5 \leq BW \leq 4$kg. There was no significant difference in the gestational age, birth weight, and age between the two groups. The developmental outcomes of the five subscales of gross movement, personal-social ability, hearing and language, hand-eye coordination, and visual performance of GDS-C were compared between the two groups using the Mann-Whitney U rank sum test. Kruskal-Wallis (K) was used to test the actual inference group, and it was found that P values were all greater than 0.05. Therefore, there was no statistical difference in the effect of jaundice on the developmental outcome.

The children in the jaundice group were divided into three groups according to base on the duration of jaundice: <7 days group, 7 days ≤ jaundice duration<14 days group and ≥14 days group. Out of the 77 children, 38 were in the <7 days group,29 was in the 7 days ≤jaundice duration<14 days group, and 6 were in the≥14 days group. Gender-wise, there were 16 males and 22 females in the <7 days group, 17 males and 12 females in the 7 days ≤jaundice duration<14 days group, and 6 males and 4 females in the ≥14 days group. The gestational age, birth weight, and age of the children in the two groups followed a normal distribution, and there was no significant difference between the two groups as per the t-test.

Also, there was no significant difference between the three groups as per the Kruskal-Wallis (K) test rank sum test. The developmental outcomes of the six subscales of gross movement, personal-social ability, hearing and language, hand-eye coordination, visual performance, and practical reasoning in the three groups of children were compared using the rank sum test of the Kruskal-Wallis (K) test. It was found that the P values of gross movement, hearing and language, hand-eye coordination, visual performance, and practical reasoning were all greater than 0.05,

indicating no statistical difference. However, in the personal-social ability group, P < 0.05, means that the duration of jaundice has a significant effect on the outcome of personal-social ability development (Table 3).

Table 3. The comparison of the effect of occurrence time of jaundice on developmental outcome

Project	Gross movement	Personal-social ability	Listening and language	Hand-eye coordination ability	Visual expression	Practical reasoning
	P Value	P Value	P Value	P Value	P Value	P Value
Occurrence time of jaundice	0.327	0.205	64.30%	0.051	0.708	7.80%
Days of phototherapy	0.802	0.352	46.70%	0.832	0.591	47.50%
Jaundice duration	0.467	0.007	9.10%	0.084	0.07	25.10%
How long after jaundice begins phototherapy?	0.212	0.01	70.10%	0.074	0.072	13.40%

The children were divided into three groups based on how long after the occurrence of jaundice: 1-day group, 3-days group and ≥3 days group. Out of the 77 children 28 were in the one-day group,19 were in the 3 days group, and 30 were in the 3 days group. Gender-wise, there were 14 males and 14 females in the 1-day group, 10 males and 9 females in the 3-day group, and 15 males and 15 females in the ≥3 days group. The gestational age, birth weight and age of the two groups followed a normal distribution, and there was no significant difference between the two groups as per the t-test. Also, there was no significant difference between the three groups byas per the Kruskal-Wallis (K) test rank sum test.

The outcomes of the six subscales were compared again using the rank sum test of the Kruskal-Wallis (K) test. It was found that there was no statistical difference in gross movement, hearing and language, hand-eye coordination, visual performance, and practical reasoning between the three groups. However, in the personal-social ability group, P < 0.05, indicates that the duration of jaundice has a significant effect on the outcome of personal-social ability development. For more details, refer to Table 3.

Multivariate Correlation Analysis of Influencing Factors of Developmental Outcome in Children with Neonatal Hyperbilirubinemia

After conducting a univariate correlation analysis, we found that hyperbilirubinemia, the severity of neonatal hyperbilirubinemia, the duration of jaundice, and the time elapsed after the onset of jaundice had significant effects on the personal-social ability development outcome of children.

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Table 4. Results of multivariate logical regression analysis on the developmental outcome of human-social ability

Developmental type	Influencing factors	P	OR	95% CI
Personal-social ability	Total Bilirubin Level ≥342umol/L	0.006	5.586	1.641-19.016
	Duration of Jaundice≥14天	0.007	568.40%	1.612-20.040

Discussion

Neonatal hyperbilirubinemia is a common condition in the newborn period. Approximately 60% of full-term infants develop jaundice within the first week of birth . When bilirubin levels exceed the normal upper limit and pass through the blood-brain barrier, it can be abnormally deposited in the newborn brain's basal ganglia and substantia nigra, causing varying degrees of neurological dysfunction. Because the high level of serum indirect bilirubin causes neurotoxicity, and different regions of the nervous system are sensitive to bilirubin to varying degrees, neurological dysfunction manifests itself in various ways. The hippocampus, hypothalamus, and cerebral cortex have sustained more damage [7-11].

As we know, the development of children is influenced by various factors, and it's a continuous and dynamic process. The level of development varies across different age groups. The immature brain has strong plasticity, which means it can compensate for its structure and function. The younger the age, the stronger the plasticity. Adequate brain stimulation in the early

stage of development can promote synaptic growth and corticospinal tract repair. It can also restore lost functions of nerve cells through the compensation of adjacent cells after injury. Therefore, intervention therapy can help in promoting nerve and brain development., The effectiveness of intervention therapy is inversely proportional to the age of children. Hence, it's essential to choose an effective tool to evaluate children's development in time to identify developmental disorders. Early intervention and treatment are very crucial [12-18].

The activities conducted across various fields of GDS-C are closely linked to the key aspects of children's development. The level of a child's development is evaluated in each field, from easy to difficult, to identify their relative strengths and weaknesses. The Griffith scale uses different test items to assess different brain functions, such as gross movement, which mainly reflects the trunk movement and balance function related to the precentral gyrus of SMA. Hand-eye coordination, on the other hand, reflects the fine movement of the precentral gyrus and tectum, particularly the fine movement of the hand.

The individual society test mainly assesses the learning and executive ability related to the frontal lobe, while the listening language evaluates language comprehension and expression function of the dominant hemisphere. Visual performance reflects the execution, execution speed, and working memory related to frontal lobe function. Practical reasoning assesses children's ability to solve practical problems, understand basic concepts of mathematics, and comprehend moral and sequential problems. The GMDS scale has rich content, involving multiple brain regions, and the difficulty level of the test can be gradually upgraded, allowing for a more comprehensive analysis of brain function. It can also evaluate the effects of Down syndrome, epilepsy, congenital heart disease, autism, and preterm delivery on children's cognitive ability [19].

This study found that neonates with hyperbilirubinemia have a higher rate of abnormal developmental outcomes compared to normal children. The severity of hyperbilirubinemia and the duration of jaundice directly affect the possibility of abnormal developmental outcomes. These findings are consistent with the results of other studies . The in bilirubin is proportional to neonatal neurobehavioral abnormalities, as shown in studies by AminS.B and others. Other studies, such as by ElTatawySS, demonstrate that hyperbilirubinemia has a significant impact on the intellectual development of infants .The more severe the hyperbilirubinemia, the more apparent the impact on intelligence . A prospective study by Sarrechia et al found that hildren with hyperbilirubinemia had lower scores in overall development, gross movement, personal-social ability, hearing and language, hand-eye coordination, visual performance, and actual reasoning compared to the normal control group [20,21].

To sum up, neonatal hyperbilirubinemia results in a higher rate of abnormal developmental outcomes, and the severity and duration of jaundice directly affect the possibility of such outcomes. To predict the developmental outcome and severity of developmental abnormalities in children with hyperbilirubinemia, the Griffiths mental development scale can be used to evaluate and intervene in time to reduce the disability rate. However, the limited number of research samples might restrict the statistical data, so it is necessary to conduct further research in multiple directions and dimensions [22].

Ethics and Consent

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Shanghai Sixth People's Hospital, and informed consent (and informed assent as appropriate) was taken from the parent(s) or legal guardian(s) of all included participants.

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References

1. Ullah, S., Rahman, K., & Hedayati, M. (2016). Hyperbilirubinemia in neonates: Types, causes, clinical examinations, preventive measures and treatments: A narrative review article. Iranian Journal of Public Health, 45(5), 558–568.
2. Daggle, L., Sharma, N., Setiady, I., & Leonard, K. (2024). Management of neonatal hyperbilirubinemia: shedding light on the American Academy of Pediatrics 2022 clinical practice guideline revision. Pediatric Annals, 53(6), e208-e216.
3. He, S., Wang, M., Zhu, M., Zhang, M., He, X., Jiang, X., ... & Wang, Z. (2025). Exploring the feasibility and clinical impact of ultrasound microvascular flow imaging in detecting brain injury in hyperbilirubinemia neonates. Scientific Reports, 15(1), 3998.
4. Qattea, I., Farghaly, M. A., Elgendy, M., Mohamed, M. A., & Aly, H. (2022). Neonatal hyperbilirubinemia and bilirubin neurotoxicity in hospitalized neonates: analysis of the US Database. Pediatric Research, 91(7), 1662-1668.
5. Sgro, M., Freeman, S., Rasiah, S., Campbell, D., & Shah, V. (2025). Severe neonatal hyperbilirubinemia in infants aged 60 days or less (2025 to 2027). Paediatrics & Child Health, 30(6), 469-470.

6. Wu, C., Jin, Y., Cui, Y., Zhu, Y., Yin, S., & Li, C. (2023). Effects of bilirubin on the development and electrical activity of neural circuits. Frontiers in Cellular Neuroscience, 17, 1136250.
7. Tso, W. W. Y., Wong, V. C. N., Xia, X., Faragher, B., Li, M., Xu, X., ... & Challis, D. (2018). The Griffiths Development Scales-Chinese (GDS-C): A cross-cultural comparison of developmental trajectories between Chinese and British children. Child: care, health and development, 44(3), 378-383.
8. Olusanya, B. O., Kaplan, M., & Hansen, T. (2018). Neonatal hyperbilirubinaemia: A global perspective. The Lancet Child & Adolescent Health, 2(8), 610–620.
9. Par, E. J., Hughes, C. A., & DeRico, P. (2023). Neonatal hyperbilirubinemia: Evaluation and treatment. American Family Physician, 107(5), 525–534.
10. Guzelkaya, M., Onal, E., Gelinci, E., Kumral, A., & Cakan-Akdogan, G. (2023). A zebrafish model for studying the mechanisms of newborn hyperbilirubinemia and bilirubin-induced neurological damage. Frontiers in Cell and Developmental Biology, 11, 1275414.
11. Pichon, J. B. L., Riordan, S. M., Watchko, J., & Shapiro, S. M. (2017). The neurological sequelae of neonatal hyperbilirubinemia: definitions, diagnosis and treatment of the kernicterus spectrum disorders (KSDs). Current pediatric reviews, 13(3), 199-209.
12. Nakama, N., Usui, N., Doi, M., & Shimada, S. (2023). Early life stress impairs brain and mental development during childhood increasing the risk of developing psychiatric disorders. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 126, 110783.
13. Guan, Y., Yang, L., & Cui, H. (2025). Extracellular vesicles derived from different brain tissue cells: A potential therapeutic measure for hypoxic–ischemic brain injury in immature brains. Histology and Histopathology, 40(11), 1719–1732.
14. Back, S. A. (2017). White matter injury in the preterm infant: Pathology and mechanisms. Acta Neuropathologica, 134(3), 331–349.
15. Benitez, B. C. (2024). Better early: Critical windows in brain and cognitive development. Nestlé Nutrition Institute Workshop Series, 100, 81–89.
16. Duncan, A. F., & Matthews, M. A. (2018). Neurodevelopmental outcomes in early childhood. Clinics in Perinatology, 45(3), 377–392.
17. Rainaldi, M. A., & Perlman, J. M. (2016). Pathophysiology of birth asphyxia. Clinics in Perinatology, 43(3), 409–422.
18. Variane, G. F. T., Rodrigues, D. P., Pietrobom, R. F. R., França, C. N., Netto, A., & Magalhães, M. (2022). Newborns at high risk for brain injury: the role of the amplitude-integrated electroencephalography. Jornal de Pediatria, 98(6), 565-571.
19. Amin, S. B., Smith, T., & Timler, G. (2019). Developmental influence of unconjugated hyperbilirubinemia and neurobehavioral disorders. Pediatric Research, 85(2), 191–197.
20. ElTatawy, S. S., Elmazzahy, E. A., El Shennawy, A. M., Madani, H. A., Abou Youssef, H., & Iskander, I. F. (2020). The spectrum of bilirubin neurotoxicity in term and near-term babies with hyperbilirubinemia: Does outcome improve with time? . Early human development, 140, 104909.
21. Sarrechia, I., Miatton, M., De Wolf, D., François, K., Gewillig, M., Meyns, B., & Vingerhoets, G. (2016). Neurocognitive development and behaviour in school-aged children after surgery for univentricular or biventricular congenital heart disease. European Journal of Cardio-Thoracic Surgery, 49(1), 167-174.
22. 22. Wickremasinghe, A. C., & Kuzniewicz, M. W. (2025). Neonatal hyperbilirubinemia. Pediatric Clinics of North America, 72(4), 605–622.