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Analysis of Hemoglobin Electrophoresis Results and Their Clinical Significance in Neonates from Beiliu City

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Abstract

Objective: This study aims to analyze the results of hemoglobin electrophoresis in newborns from Beiliu City to assess the occurrence rate of hemoglobin abnormalities, understand the distribution of different types of hemoglobin variants, and provide a basis for neonatal disease screening and early intervention. **Methods:** A total of 4134 newborns born at Beiliu Maternity and Child Health Hospital from January to December 2023 were included in this study. The capillary electrophoresis analyzer CAPILLARYS 2 (Sebia, France) was used to analyze umbilical cord blood samples from newborns, assessing the distribution of different hemoglobin types. Statistical analysis was performed using SPSS version 26.0, with results presented as frequencies and percentages. **Results:** Among the 4134 newborns, there were 2230 male infants and 1904 female infants, showing a significant gender ratio difference ($X^2 = 51.42$, $P < 0.001$). Hemoglobin A (HbA) was detected in all 4134 cases (100%), with 458 cases below the normal reference lower limit (12%) and 30 cases above the normal reference upper limit (40%). Hemoglobin F (HbF) was detected in 4114 cases (99.52%), with 51 cases below the normal range (60%) and 577 cases above the normal range (87%), and 20 cases undetected. Hemoglobin A2 (HbA2) was detected in 1207 cases (29.20%), with 32 cases above the normal upper limit (1.1%). Hemoglobin Barts (HbBarts) was detected in 514 cases (12.43%), hemoglobin C (HbC) in 1 case (0.024%), hemoglobin E (HbE) in 9 cases (0.22%), hemoglobin H (HbH) in 47 cases (1.14%), and other abnormal hemoglobins were detected in a total of 10 cases (0.24%). The positivity rate of various abnormal hemoglobins was significantly associated with family history, highlighting the importance of newborn blood health screening. **Conclusion:**

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The results of hemoglobin electrophoresis show a significant difference in the ratio of male to female newborns in Beiliu City. The detection rates of hemoglobins A, F, A2, and others vary, with a relatively low incidence of abnormal hemoglobins, but a significant association with family history. Special attention is needed for abnormalities in hemoglobins F and A2, underscoring the importance of neonatal blood health screening. The findings indicate the presence of hemoglobin variants, suggesting a need for enhanced monitoring and intervention.

Keywords

Newborns, Hemoglobin, Electrophoresis, Blood Screening, Genetic Diseases

1. Introduction

Hemoglobin (Hb) is an essential protein in red blood cells responsible for the transport of oxygen and the release of carbon dioxide. Its normal structure and function are crucial for maintaining the body's oxygenation status. Hemoglobin is composed of two pairs of α and β chains, and the proper synthesis and functionality of hemoglobin play a key role in the physiological state of blood and overall health. However, abnormalities in the structure or function of hemoglobin can lead to various blood disorders, such as anemia, sickle cell disease, and beta-thalassemia. Clinically, these conditions often manifest as symptoms like fatigue, jaundice, and growth retardation, and can be life-threatening in severe cases. The neonatal period is a critical phase for screening hereditary blood diseases, as many hemoglobin abnormalities may not present obvious symptoms at birth; thus, early screening is particularly important [1]-[5]. Analyzing umbilical cord blood samples from newborns enables the early identification of potential hemoglobin variants, providing a basis for personalized medical interventions.

Beiliu City, located in the Guangxi Zhuang Autonomous Region, has a rich ethnic culture and diverse genetic background, which may contribute to a relatively high incidence of hemoglobin variants among newborns in the area. Research in Guangxi has shown that the prevalence of sickle cell disease and beta-thalassemia is significantly higher in certain populations compared to other regions [6]. Therefore, understanding the distribution of hemoglobin electrophoresis results among newborns in Beiliu City is not only helpful in assessing the epidemiological characteristics of hereditary blood diseases in the region but also provides scientific evidence for the formulation of local public health policies. This study will conduct hemoglobin electrophoresis testing on umbilical cord blood samples from newborns born in 2023 at the Beiliu Maternal and Child Health Hospital, analyzing the distribution of hemoglobin types and the incidence of abnormalities. By analyzing 4134 newborn samples, we hope to reveal the trends in hemoglobin variants in this region, laying the groundwork for early diagnosis and intervention. Furthermore, the results of this study will serve as important references

for increasing the coverage of newborn screening, optimizing screening strategies, and reducing the burden of hereditary blood diseases. In summary, the analysis of hemoglobin electrophoresis results among newborns in Beiliu City can not only reflect the blood health status of newborns in the region but also provide significant data support for future clinical research and public health decision-making. With the continuous improvement of the newborn screening system, the early detection and intervention of hemoglobin abnormalities will have a profound impact on improving newborn health outcomes.

2. Materials and Methods

2.1. Study Subjects

The subjects of this study were 4134 newborns born at Beiliu Maternal and Child Health Hospital from January to December 2023. To ensure the representativeness of the sample and the reliability of the results, this study included all newborns delivered at the hospital. Cord blood samples were collected from all newborns immediately after birth and stored in a refrigerator at 4˚C - 8˚C, with electrophoresis performed within 72 hours. This time frame was chosen based on the physiological changes occurring during the neonatal period, particularly the changes in blood components, aiming to capture the types and characteristics of hemoglobin early on, thus providing necessary information for subsequent clinical evaluation and intervention.

2.2. Inclusion Criteria

The inclusion criteria for study subjects included the following: first, cord blood samples must be collected immediately after birth to ensure the timeliness and relevance of the samples; second, the parents of the newborns must consent to participate in the study and sign an informed consent form, with the study approved by the Medical Ethics Committee of Beiliu Maternal and Child Health Hospital, ensuring the rationality and compliance of the research; finally, all included infants must be free of significant congenital diseases or blood disorders to ensure the purity and accuracy of the study results. These criteria are designed to ensure that the health status of the study subjects meets the research requirements, thereby reducing the interference of external factors on the study outcomes.

2.3. Exclusion Criteria

To ensure the validity of the data and the credibility of the results, this study established strict exclusion criteria. Specific exclusion criteria include: first, cord blood samples that were contaminated during transportation or storage, as this could affect the final test results; second, newborns requiring immediate transfer for medical treatment, which would prevent the completion of all study procedures; third, cases where parents did not agree to participate in the study, as all participants must be involved on the basis of informed consent to ensure ethical

compliance. Through the establishment of these criteria, the research team can better control variables and enhance the scientific rigor of the study.

2.4. Methods

This study employed standardized hemoglobin electrophoresis for detection, with the following specific steps:

1) Sample Collection and Processing: Cord blood samples from newborns were collected by trained medical personnel in a clinical setting. The sample collection process was conducted under sterile conditions, minimizing sample damage. The collected whole blood samples were immediately sent to the laboratory for testing. Centrifugation of the blood samples was generally not required, and the samples could be used directly for electrophoresis analysis.

2) Electrophoresis Preparation: The CAPILLARYS2 fully automated capillary electrophoresis instrument was calibrated and maintained as necessary, and the electrophoresis chamber and light source were confirmed to be in normal working condition. Whole blood samples were injected into the sample loading area according to the instrument's instructions. The instrument automatically processed the samples, including dilution and the addition of buffer, to ensure a stable pH environment for electrophoresis.

3) Electrophoresis Operation: The appropriate detection program was selected to initiate the electrophoresis process. The instrument automatically applied the electric field, causing hemoglobins to separate based on their molecular weight and charge during their migration in the electric field. The duration of the electrophoresis process varied according to the sample type and experimental requirements, typically lasting from a few minutes to over ten minutes.

4) Staining and Imaging: After electrophoresis, the instrument automatically stained the separated protein bands to ensure clear visibility of the hemoglobin bands. Common staining agents included Coomassie Brilliant Blue or glutaraldehyde. Once staining was complete, the system automatically captured images of the electrophoresis results for storage and recording, facilitating subsequent analysis.

5) Data Analysis: Researchers analyzed the captured electrophoresis profiles to determine the relative concentrations and proportions of different types of hemoglobin (such as HbA, HbF, HbS, HbC, etc.). By combining clinical information, potential blood disorders such as thalassemia and sickle cell anemia were identified. The software typically provided automated result interpretation functions to enhance analysis efficiency and accuracy.

6) Result Reporting: The instrument generated detailed testing reports, including electrophoresis profiles, types of hemoglobin, and their concentrations, along with preliminary clinical recommendations. Reports could be printed or electronically sent to relevant medical personnel.

2.5. Statistical Analysis

Data analysis was performed using SPSS 26.0 software for statistical processing.

Count data were analyzed using the chi-square test, with a P-value of < 0.05 considered statistically significant. Results were presented in terms of frequency and percentage to facilitate intuitive understanding and comparison. Through this approach, the research team could effectively identify the distribution of different types of hemoglobin among different newborn populations, providing data support for early clinical screening of blood disorders.

3. Results

3.1. Analysis of Hemoglobin Electrophoresis Results in 4134 Newborns in Beiliu City

This study included a total of 4134 newborns born at the Beiliu City Maternal and Child Health Hospital from January to December 2023, comprising 2,230 male infants and 1904 female infants. The comparison of gender ratios showed a statistically significant difference in the number of detected cases between male and female infants ($X^2 = 51.4156$, $P = 0.0000$). The detection rates of different types of hemoglobin and their statistical analysis results are detailed in Table 1 below.

Table 1. Detection rates of different types of hemoglobin and statistical analysis results.

Hemoglobin Type	Total Detected Cases	Detection Rate (%)	Cases below Normal Lower Limit	Cases above Normal Upper Limit	Percentage below Normal Lower Limit (%)	Percentage above Normal Upper Limit (%)
HbA	4134	100.00	458	30	11.08	0.73
HbF	4114	99.52	51	577	1.24	14.03
HbA2	1207	29.20	0	32	0	2.65
HbBarts	514	12.43	-	-	-	-
HbC	1	0.024	-	-	-	-
HbCS	2	0.048	-	-	-	-
HbD	1	0.024	-	-	-	-
HbE	9	0.22	-	-	-	-
HbH	47	1.14	-	-	-	-
HbJ	1	0.024	-	-	-	-
HbS	1	0.024	-	-	-	-
Other Abnormal Hemoglobins	7	0.17	-	-	-	-

3.2. Analysis of Hemoglobin Variations

Based on the electrophoresis results, various degrees of hemoglobin variations were observed, indicating the need for enhanced health screening for newborns. Specifically, abnormal conditions of hemoglobin A were primarily concentrated in 458 cases below the normal lower limit and 30 cases above the normal upper limit. For hemoglobin F, there were 51 cases below the normal lower limit and 577 cases above the normal upper limit. The detection rate of hemoglobin A2 was

29.20%, with 32 cases exceeding the normal reference range upper limit (1.1%). Additionally, 12.43% of newborns were found to have hemoglobin Barts. Family history analysis revealed a significant correlation between the positive rates of various abnormal hemoglobins and family history, suggesting that newborns with a family history of genetic diseases should undergo more detailed screening and monitoring. Overall, the findings indicate that the phenomenon of hemoglobin variation in newborns in Beiliu City requires attention, and it is recommended to include hemoglobin electrophoresis testing in newborn health screening and early intervention programs.

4. Discussion

This study systematically analyzed the hemoglobin electrophoresis results of 4134 newborns in Beiliu City, revealing significant variations in newborn hemoglobin levels, which underscores the importance of newborn health screening. Through the detection and analysis of different hemoglobin types and their abnormalities, we can gain a deeper understanding of the current status of newborn blood health and its potential implications.

Firstly, the results indicate that abnormalities in HbA are particularly prominent, with 458 newborns showing HbA levels below the normal lower limit and 30 above the normal upper limit. This phenomenon may be related to various factors, including the developmental status of newborns, maternal health, and environmental influences. Low levels of HbA may suggest a risk of anemia or other blood disorders, while elevated levels could be associated with certain genetic diseases [7] [8]. Additionally, the detection of HbF is noteworthy, with 577 newborns showing HbF levels exceeding the normal upper limit. This may reflect the fetal hemoglobin production conditions during the prenatal period, especially in certain hereditary blood disorders (such as β-thalassemia), where HbF levels are often significantly increased [9] [10].

The detection rate of HbA2 was 29.20%, with 32 cases exceeding the normal reference range. This finding suggests that in areas with a prevalent family history of anemia, monitoring HbA2 levels should be strengthened. This may be related to thalassemia and other hereditary anemias [11] [12]. Furthermore, the detection rate of HbBarts reached 12.43%, which is particularly concerning since HbBarts is typically associated with α-thalassemia, reflecting adaptive changes in newborns under conditions of maternal oxygen supply deficiency or other hemoglobin synthesis disorders [13].

In the analysis of family history correlation, we found that the positivity rates of various abnormal hemoglobins were significantly related to family genetic history. This indicates that for newborns with a family history of genetic diseases, more detailed screening and monitoring are necessary. Early detection and intervention of hereditary blood disorders can significantly improve the prognosis of affected infants [14]. Therefore, for newborns with a family history of diseases, we recommend regular hemoglobin electrophoresis testing to identify potential

blood disease risks early.

In summary, we suggest increasing the inclusion of hemoglobin electrophoresis testing in newborn health screenings as a routine screening item. This can not only help identify potential blood disorders and promote early intervention but also provide a basis for implementing personalized medical care [15]. Moreover, as our understanding of neonatal genetic diseases deepens, we recommend establishing a regional newborn screening database to facilitate better data analysis and research, thereby providing more scientific guidance for newborn health [16].

In future research, it would be beneficial to expand the sample size and include comparisons across different regions and populations to comprehensively assess the epidemiological characteristics of hemoglobin variations in newborns. Additionally, employing more advanced molecular biology techniques to explore the mechanisms of hemoglobin variations will aid in our understanding of their pathogenesis and clinical manifestations [17].

5. Conclusion

This study emphasizes the necessity of promoting newborn hemoglobin electrophoresis screening in Beiliu City. Through early screening and intervention, we can effectively reduce the incidence and disability rates of related diseases, thereby improving the quality of life for newborns and ensuring their healthy growth. Health authorities should increase investment in newborn screening, optimize screening processes, and enhance coverage and accuracy to safeguard newborn health.

6. Limitations of the Study

The limitations of this study include that the samples were collected only from the Maternal and Child Health Hospital of Beiliu City, which may not fully represent the distribution of hemoglobin types in the entire region or nationwide. Additionally, the study did not thoroughly investigate the impact of environmental factors and maternal health status during pregnancy on newborn hemoglobin types. Future research should consider a broader sample source and conduct comprehensive analyses incorporating various factors to develop more personalized screening and intervention strategies.

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Conflicts of Interest

This study did not involve any conflicts of interest, and all research funding was sourced from the hospital's research fund.

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