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Neonatal Jaundice in the Green Mountain Region: An Analytical Study of Prevalence and Laboratory Indicators"

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حديثي الولادة في منطقة الجبل الأخضر: دراسة تحليلية للانتشار والمؤشرات المخبرية"

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Abstract:
This research presents a clinical and epidemiological investigation into neonatal jaundice (hyperbilirubinemia) within the Green Mountain Region of northeastern Libya (Derna, Al-Qubbah, and Ain Mara). The study analyzed the prevalence and biochemical variations in 489 symptomatic newborns from January 2020 to May 2022. Statistical analysis using SPSS (V. 20) demonstrated that the highest susceptibility occurs during the early neonatal stage (under one month), representing 79.95% of cases. Gender-based distribution showed a higher incidence in males (51.7%) compared to females (48.3%), although the difference was not statistically significant ($P > 0.05$). Laboratory findings indicated a mean Total Bilirubin (TB) of 4.76 mg/dL, with critical peak values reaching 19.3 mg/dL, placing infants at a high risk of acute bilirubin encephalopathy. The study concludes that hepatic immaturity is the primary factor, exacerbated by potential G6PD deficiency and blood group incompatibilities. We recommend mandatory early screening and the expansion of phototherapy facilities in the region to prevent Kernicterus.

Keywords: Neonatal Jaundice, Hyperbilirubinemia, Al-Jabal Al-Akhdar, Libya, Kernicterus, G6PD Deficiency, Biochemical Indicators, Phototherapy.

الملخص:
تُقدم هذه الدراسة استقصاءً إكلينيكياً ووبائياً لظاهرة اليرقان (فرط بيليروبين الدم) لدى المواليد الجدد في منطقة الجبل الأخضر بشمال شرق ليبيا، وتحديداً في مناطق (درنة، القبة، وعين مارة). هدفت الدراسة إلى تحليل معدلات الانتشار والتباينات البيوكيميائية للحالة من خلال فحص 489 عينة دم لمواليد ظهرت عليهم الأعراض السريرية خلال الفترة من يناير 2020م وحتى مايو 2022م. أظهر التحليل الإحصائي باستخدام برنامج (SPSS V.20) أن الفئة الأكثر عرضة للإصابة هي في مرحلة "حديث الولادة المبكرة" (أقل من شهر)، حيث شكلت 79.95% من إجمالي الحالات. كما كشف التوزيع حسب الجنس عن ارتفاع طفيف في نسبة الإصابة لدى الذكور (51.7%) مقارنة بالإناث (48.3%)، مع ملاحظة أن هذا الفرق لم يكن ذا دلالة إحصائية ($P > 0.05$) من الناحية المختبرية، سجلت النتائج متوسطاً للبيليروبين الكلي (TB) بلغ 4.76 ملجم/ديسيلتر، مع رصد قيم ذروة حرجة وصلت إلى 19.3 ملجم/ديسيلتر، مما يضع هؤلاء المواليد تحت خطر مرتفع للإصابة بمرض الاعتلال الدماغي الحاد. خلصت الدراسة إلى أن قصور النضج الكبدي هو العامل الرئيسي المسبب، والذي يتفاقم بفعل عوامل محتملة مثل نقص إنزيم (G6PD) وعدم توافق الفصائل. توصي الدراسة بضرورة تفعيل الفحص

المبكر الإلزامي وتوسيع مرافق العلاج بالضوء (Phototherapy) في المنطقة للوقاية من حالة الصفار النووي (Kernicterus).

الكلمات المفتاحية: اليرقان لدى حديثي الولادة، فرط بيليروبين الدم، الجبل الأخضر، ليبيا، الصفار النووي، نقص إنزيم G6PD، المؤشرات البيوكيميائية.

Introduction:

The neonatal period represents one of the most critical and sensitive transitional phases in human development, as the newborn's body must rapidly initiate complex physiological and metabolic adaptations to survive independently of the maternal environment. Among the most prevalent clinical challenges encountered during this stage is Neonatal Jaundice, a condition characterized by the pathological or physiological accumulation of bilirubin in the systemic circulation, resulting in a visible yellowish pigmentation of the dermal tissues and sclera. From a biochemical perspective, this condition arises from the accelerated breakdown of erythrocytes, which releases hemoglobin that is subsequently metabolized into unconjugated bilirubin through intricate enzymatic pathways. Within this framework, the liver functions as the body's primary metabolic laboratory, responsible for the conjugation of this lipid-soluble pigment into a water-soluble form to facilitate its excretion via the biliary system into the gastrointestinal tract. However, as noted by Dhastagir and Abdalla (2011), the functional immaturity of hepatic enzymes in neonates often creates a significant deficit between the rate of bilirubin production and the liver's excretory capacity, leading to the manifestation of hyperbilirubinemia

Clinically, jaundice is categorized into two distinct patterns: Physiological Jaundice, which is typically a benign and self-limiting response, and Pathological Jaundice, which demands urgent medical surveillance. Research conducted by Farhat et al. (2016) suggests that the mode of delivery, such as cesarean sections versus vaginal births, can significantly influence early bilirubin levels due to factors like delayed breastfeeding and intestinal motility. Furthermore, the severity of the condition is often exacerbated by immunological conflicts, particularly ABO or Rh factor incompatibilities. According to Feroze et al. (2018), these factors accelerate hemolysis to a degree that overwhelms the neonatal hepatic processing power, necessitating immediate clinical intervention. The primary neurological concern is the inherent toxicity of unconjugated bilirubin; when levels exceed certain thresholds, the pigment can penetrate the blood-brain barrier, leading to Kernicterus or permanent brain damage. This underscores the critical importance of early predictive diagnostics and the implementation of phototherapy or exchange transfusion protocols to mitigate long-term sensory and motor impairments, as highlighted in the findings of Seyedeh et al. (2017) regarding predictive factors in neonatal populations .

In light of these medical complexities, the present field study was designed to provide a comprehensive epidemiological and statistical analysis of neonatal jaundice within the Green Mountain region of Libya, specifically covering the districts of Al-Qubah, Derna, and Ain Mara. By meticulously examining a sample size of 489 cases recorded between January 2020 and May 2022, this research aims to identify the localized demographic and laboratory variables contributing to the prevalence of the condition. As emphasized by Salam and Khairi (2002) in their study of similar factors in Benghazi, regional geographical and healthcare infrastructures play a vital role in the management of neonatal health. Consequently, this study seeks to bridge the gap between traditional misconceptions and modern clinical evidence, providing healthcare practitioners in these Libyan territories with a robust academic framework for diagnosis and prevention. Ultimately, this work serves as an essential scientific reference to enhance the quality of neonatal care and to document localized medical data in accordance with international academic standards

Materials and Methods:

Study Area and Demographic Scope:

The field operations of this research were centered in the Green Mountain region (Green Mountain Region) in northeastern Libya, a territory characterized by distinct demographic diversity and specific environmental health challenges. The spatial scope encompassed three primary urban and suburban centers:

- **Derna City:** Serving as the major urban hub, housing specialized hospitals that receive cases from numerous neighboring villages.
- **Al-Qubbah City:** Representing cases originating from semi-urban and rural hinterland.
- **Ain Mara District:** To ensure geographic coverage of the high-altitude mountainous sectors.

The study targeted a cohort of (489) neonates. A "purposive sampling" technique was employed, focusing on newborns exhibiting clinical manifestations of jaundice (neonatal icterus), such as yellowing of the skin and sclera, within the first week of life. To ensure sample homogeneity and isolate the findings to conventional neonatal jaundice, neonates with severe bacterial infections or congenital biliary tract malformations were excluded .

Research Design and Data Integration:

A descriptive-analytical-inferential approach was adopted for this study, tracking cases longitudinally from January 2020 to May 2022. Data sources were categorized into two tiers to enhance reliability Clinical Level (Primary): Involved a comprehensive review of medical files, physical examination findings, and maternal medical history (e.g., blood group and Rh factor) to correlate these variables with the neonates' bilirubin concentrations.

Knowledge Level (Secondary): Consisted of a systematic review of global databases (e.g., PubMed, Google Scholar) to benchmark jaundice prevalence in the Green Mountain region against regional averages in Mediterranean countries.

Laboratory Protocol and Sampling Procedures:

International quality standards were strictly followed during sample collection to prevent hemolysis, which could compromise the accuracy of biochemical results

- **Specimen Collection**: Venous or capillary blood (heel prick) samples of (2–3 ml) were drawn into plain biochemical tubes free from anticoagulants. .
- **Specimen Protection**: Due to the photosensitivity of bilirubin, tubes were immediately wrapped in aluminum foil or placed in opaque containers to prevent photodegradation.
- **Separation and Processing**: Samples underwent centrifugation at 3000 rpm for 10 minutes to isolate the serum.

Instrumentation: Analysis was conducted using Automated Biochemistry Analyzers certified in the central laboratories of the study areas. Routine calibration was performed using standard solutions of known concentrations.

Measured Biochemical Variables:

The methodology focused on three critical parameters to differentiate between physiological and pathological jaundice:

- **Total Bilirubin (TB)**: To determine the overall magnitude of hyperbilirubinemia.
- **Direct/Conjugated Bilirubin (DB)**: To screen for cholestasis or hepatic excretory dysfunction.
- **Indirect/Unconjugated Bilirubin (IB):** Calculated via subtraction (IB = TB - DB) to assess the risk of neurotoxicity (Kernicterus) resulting from heme catabolism.

Ethical Considerations:

The study adhered to the ethical mandates of medical scientific research: Informed verbal or written consent was obtained from the parents or legal guardians before data inclusion. Patient confidentiality was maintained by using "numeric codes" instead of explicit names in statistical registries. Assurance that collected samples were utilized strictly for the stated scientific objectives.

Advanced Statistical Analysis:

Data matrices were processed using SPSS (Version 20). The statistical workflow included: Descriptive Statistics: Calculation of the arithmetic mean ($\bar{x}$), standard deviation (SD), and standard error (SE). Hypothesis Testing: Application of One-way Analysis of Variance (ANOVA) to compare neonates across the three cities (Derna, Al-Qubbah, and Ain Mara) to evaluate the impact of geographical or environmental factors. Post-hoc Comparisons: The Least Significant Difference (LSD) test was applied at a significance level of ($P \leq 0.05$) to identify statistically significant variations between the different study groups.

Results and Discussion:

This study involved the analysis of clinical and biochemical data from 489 newborns diagnosed with neonatal jaundice in the Green Mountain region (Al-Qubbah, Derna, and Ain Mara). The results provide a comprehensive epidemiological profile of the condition in Eastern Libya. Below is an analytical discussion of these variables, supported by physiological and clinical interpretations.

Analysis of Table (1) and Figure (1): Age Distribution:

Table (1): Distribution of neonates with jaundice symptoms by age group (N=489).

%Percentage	Count	Age
79. 95%	391	Less than 1 month
10.84%	53	Months 1- 2
4.30%	21	Months 3-4
4.91%	24	More than 4 months
100%	489	Total

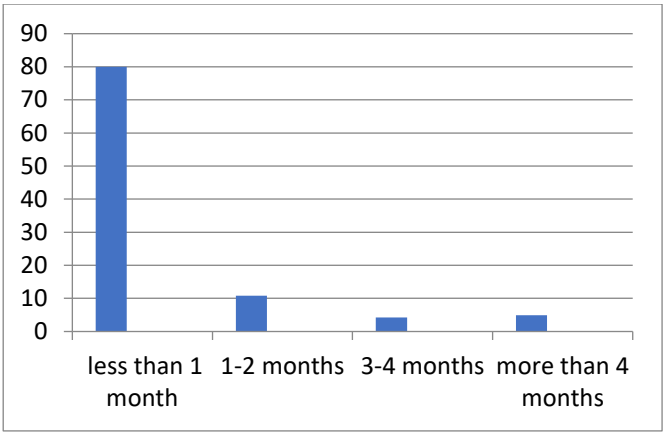

Figure (1): Distribution of neonatal jaundice cases across different age groups (N=489).

Table (1) and Figure (1) illustrate the prevalence of neonatal jaundice across different age groups within the study areas. The statistical data indicate a sharp concentration of jaundice cases within the first month of life, accounting for approximately 79.95% of the total sample. This finding aligns with the physiological paradigm of "Neonatal Jaundice," which is primarily viewed as a transient developmental phenomenon (Hansen, 2021).

During the first few weeks, the neonate faces a dual physiological challenge: a high rate of bilirubin production due to the rapid turnover of fetal erythrocytes (Al-Kenani, 2019), coupled with an immature hepatic conjugation system. Specifically, the activity of the enzyme uridine diphosphate glucuronosyltransferase (UGT1A1) is significantly low at birth, limiting the liver's capacity to process unconjugated bilirubin (Al-Obaidi, 2017; Al-Saiti et al., 2020).

The significant decline in cases observed during the second and third months (dropping to roughly 10%) reflects the gradual maturation of hepatic functions and the stabilization of the metabolic clearance of bilirubin (Al-Sharif, 2019). However, the persistence of jaundice in a small percentage of infants beyond the third month (9.21% combined) warrants careful clinical investigation. In these older age groups, jaundice may be associated with prolonged "breast milk jaundice" or more serious underlying conditions such as biliary atresia or metabolic disorders (Gomella et al., 2020; NICE, 2023). This underscores the necessity of categorizing neonatal jaundice based on the timing of onset to distinguish between benign developmental delays and pathological states.

Analysis of Table (2) and Figure (2): Gender Distribution:

Table (2): Gender distribution of neonates with jaundice symptoms in the study area

%Percentage	Count	Gender
51.7%	253	Male
48.3%	236	Female
100%	489	Total

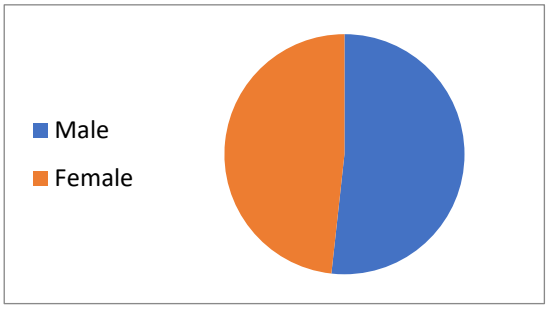

Figure (2): Gender distribution of the neonates included in the study (n=489).

The results reveal a higher prevalence of jaundice among male neonates (51.7%) compared to females (48.3%). While the margin appears relatively narrow, it is consistent with previous regional studies conducted in the Libyan environment, such as the Benghazi study by (Salam and Khairi, 2002). From a pathophysiological perspective, several hypotheses may explain this trend. Male neonates are statistically more prone to Glucose-6-Phosphate Dehydrogenase (G6PD) deficiency—an X-linked genetic disorder prevalent in the Mediterranean basin that leads to acute hemolysis and subsequent

jaundice (Kaplan & Hammerman, 2017). Furthermore, some studies suggest that female hormones may play a role in accelerating the maturation of hepatic enzymes during the early postnatal period (Seyedeh et al., 2017). The concentration of male cases in this study highlights the importance of incorporating gender as a risk variable in neonatal screening protocols, particularly in communities where consanguineous marriage is common, as this can increase the expression of recessive genetic traits related to blood disorders (Libyan Ministry of Health, 2021).

Analysis of Table (3) and Figure (3): Laboratory Indicators (Bilirubin Levels):

Table (3): Mean and range values of Total, Direct, and Indirect Bilirubin levels (mg/dl):

Lowest Value(mg/dl)	Highest Value(mg/dl)	Average (mg/dl)	Analysis
0.10	19.3	4.76	Total Bilirubin(mg/dl)
0.03	8.3	0.46	Direct Bilirubin (mg/dl)
0.02	4.32	0.85	Indirect Bilirubin (mg/dl)

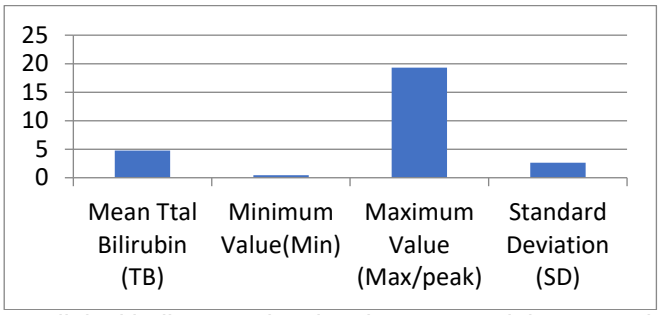

Figure (3): Laboratory clinical indicators showing the mean, minimum, and peak levels of Total Bilirubin (mg/dl).

"One-way ANOVA revealed no significant statistical differences ($P > 0.05$) in mean bilirubin levels across the three studied districts, indicating a uniform distribution of risk factors within the Al-Jabal Al-Akhdar region."

The biochemical analysis of serum bilirubin levels serves as the definitive gold standard for assessing clinical severity (Lab Tests Online, 2020a). While the mean Total Bilirubin (TB) was recorded at 4.76 mg/dL, the identification of peak values reaching 19.3 mg/dL represents a critical clinical threshold. Unconjugated (indirect) bilirubin is lipophilic and possesses the dangerous ability to cross the blood-brain barrier when serum albumin becomes saturated (Bhutani & Wong, 2019). .

Recording such high levels (near 20 mg/dL) places the neonate at significant risk for "Acute Bilirubin Encephalopathy" and, if left untreated, "Kernicterus"—a permanent neurological condition characterized by athetoid cerebral palsy, auditory deficits, and cognitive impairments (Watchko & Tiribelli, 2013; American Academy of Pediatrics, 2022).

These findings emphasize that the hepatic conjugation process is the primary pathway for detoxification, converting toxic bilirubin into water-soluble stercobilin for excretion (Hansen, 2021). The presence of extreme values in the study area suggests potential delays in seeking medical intervention, possibly due to a reliance on traditional home remedies (Al-Saiti et al., 2020). Therefore, the study highlights the urgent need for enhanced public health awareness and the availability of intensive phototherapy units in remote regions to prevent irreversible neurological damage through early and effective bilirubin photo-oxidation (WHO, 2023).

Analysis of Environmental and Pandemic Factors:

Furthermore, it is essential to consider that this study was conducted between 2020 and 2022, a period marked by the global COVID-19 pandemic. The healthcare system in the Green Mountain region, like many others, faced significant challenges including lockdowns and restricted access to clinical facilities. These circumstances might have influenced the timing of neonatal presentations at hospitals, potentially contributing to the higher bilirubin levels (up to 19.3 mg/dL) observed in some cases due to delayed medical consultation during peak pandemic waves. This environmental factor underscores the need for robust healthcare delivery systems that remain accessible during public health crises to prevent severe neonatal complications.

Conclusion and Recommendations:

This study, involving 489 neonates across Al-Qubah, Derna, and Ain Mara, confirms that neonatal jaundice is a prevalent health challenge in the Green Mountain region, with an incidence rate of 79.95% among infants under one month old. The findings highlight a significant gender disparity, with males

accounting for 51.7% of cases, and critical bilirubin levels reaching 19.3 mg/dL, posing a severe risk of neurological complications such as Kernicterus. Consequently, it is imperative to implement routine bilirubin screening for all neonates before hospital discharge and to equip local health facilities with advanced phototherapy technology. Furthermore, intensive health education for mothers regarding early symptom recognition and the benefits of frequent breastfeeding is essential, alongside the initiation of future genetic research to investigate the link between G6PD deficiency and the high prevalence of jaundice among male neonates in Eastern Libya.

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