JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ
العدد السابع والاربعون
(525) (501)

دراسة لبعض التغيرات الفسيولوجية والسريرية المرتبطة باليرقان الوليدي، وأسبابه، ونتائجه، وأعراضه، وعلاجه، وطرق تشخيص فرط بيليروبين الدم في محافظة واسط

أ.م. نغم عبد الستار العوسي
وزارة التربية والتعليم، مدرسة المتفوقات الثانوية للبنات، واسط، العراق
nalawsi@uowasit.edu.iq

المستخلص:

يُعدّ اليرقان من أكثر الأعراض السريرية شيوعًا في وحدات العناية المركزة لحديثي الولادة على مستوى العالم، وينتج عن اصفرار الجلد وبياض العين بسبب زيادة نسبة البيليروبين في الدم. تتناول هذه الدراسة التغيرات الفسيولوجية والسريرية في يرقان حديثي الولادة في محافظة واسط بالعراق، بهدف تحديد الأسباب الأكثر شيوعًا، والأعراض السريرية، وطرق التشخيص، والأساليب العلاجية، والنتائج. أُجريت هذه الدراسة الاستطلاعية المستقبلية على عينة من الأطفال الذين تم إدخالهم إلى وحدات العناية المركزة لحديثي الولادة في واسط بسبب اليرقان. ركزنا على جمع معلومات حول عمر الحمل، ووزن الولادة، ومستوى البيليروبين في الدم، وعدم توافق فصائل الدم، والرضاعة الطبيعية، ونتائج العلاج الضوئي و/أو نقل الدم. أظهرت النتائج أن اليرقان الفسيولوجي هو النوع الأكثر شيوعًا، يليه عدم توافق فصائل الدم ABO وRh، ثم الخداج، وأخيرًا نقص إنزيم جلوكوز-٦-فوسفات ديهيدروجينيز (PD٦G) كأسباب رئيسية لليرقان المرضي. كانت معظم الحالات ذات مآل جيد عند التشخيص والعلاج المبكرين. استُخدم قياس البيليروبين الكلي في الدم (TSB) وقياس البيليروبين عبر الجلد (TcB) للتشخيص. وكان العلاج الضوئي هو العلاج الأساسي لجميع درجات فرط بيليروبين الدم، مع حاجة بعض الحالات الشديدة إلى نقل الدم. تُبرز هذه النتائج الحاجة إلى برامج فحص مبكر، وتوعية الآباء، ووحدات عناية مركزة لحديثي الولادة مجهزة تجهيزًا جيدًا للوقاية من وفيات ومراضة فرط بيليروبين الدم في محافظة واسط.

الكلمات المفتاحية: اليرقان الوليدي، فرط بيليروبين الدم، البيليروبين، العلاج الضوئي، محافظة واسط، نقل الدم، اليرقان الفسيولوجي

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

A Study of Some Physiological and Clinical Changes Associated with Neonatal Jaundice, Its Causes, Outcomes, Symptoms, Treatment, and Diagnostic Methods for Identifying Hyperbilirubinemia in Wasit Governorate

PhD Assistant Professor
Awsi-Sattar AL -Nagham Abdul
Wasit Mutafawiqat Secondary School for Girls -Ministry of Education, Al Iraq
nalawsi@uowasit.edu.iq

Abstract

Jaundice is one of the most common clinical presentations in neonatal units globally, and is caused by a yellow discolouration of the skin and sclerae due to the excess of bilirubin in the blood. This research examines the physiological and clinical alterations in neonatal jaundice in Wasit Governorate, Iraq, aiming to determine the most common causes, clinical presentation, diagnostic methods, therapeutic approaches and outcomes. This was a prospective observational study using a sample of babies admitted with jaundice in neonatal units in Wasit. We collected data on gestational age, birth weight, serum bilirubin, blood group incompatibility, breastfeeding, and outcomes of phototherapy and/or exchange transfusion. The findings showed that physiological jaundice was the most common type of jaundice, followed by ABO and Rh incompatibility, prematurity, and glucose-6-phosphate dehydrogenase (G6PD) deficiency as the main causes of pathological jaundice. Most cases had a good prognosis when early diagnosis and treatment were provided. Serum total bilirubin (TSB) and transcutaneous bilirubinometry (TcB) were used for the diagnosis. Phototherapy was the mainstay of therapy for all grades of hyperbilirubinemia, with a few severe cases requiring exchange transfusion. These results highlight the need for early screening programs, awareness among parents, and well-equipped neonatal units to prevent mortality and morbidity of hyperbilirubinemia in Wasit Governorate.

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

Keywords: Neonatal jaundice, hyperbilirubinemia, bilirubin, phototherapy, Wasit Governorate, exchange transfusion, physiological, jaundice

1. Introduction

Neonatal jaundice (also known clinically as neonatal hyperbilirubinemia) is a common condition that requires medical assessment and care during the first month of life. Some 60% of term and 80% of preterm neonates are estimated to develop visible jaundice in the first seven days of life - a universal neonatal phenomenon with varying degrees of clinical importance (Ansong-Assoku et al., 2024). Jaundice is caused by the build-up of bilirubin, a product of heme catabolism, in the neonatal bloodstream to concentrations beyond the ability of the immature neonatal liver to process and eliminate. The condition can range from benign (physiologic) self-limited jaundice to severe jaundice, which can lead to death. But in severe disease, which can be driven by excessive levels of bilirubin, there is a high risk of neurotoxicity, acute bilirubin encephalopathy, and its chronic manifestation, kernicterus, which can lead to permanent neurological impairment or death (UpToDate, 2025).

Neonatal jaundice is a global health concern, with negative impacts disproportionately affecting low- and middle-income countries due to a lack of early diagnosis and treatment services. In Iraq, neonatal hyperbilirubinemia has been recognized as a common reason for admissions to neonatal units, with Hameed et al. (2020) detailing the adherence issues in treating the condition in the Iraqi health-care system. Wasit Governorate, in central Iraq, reflects the challenges of caring for the infant population in the country, including access to transcutaneous bilirubinometers, screening practices, and potential delays in treatment. Thus, understanding the epidemiology, causative factors, diagnosis, and treatment outcomes in this geographical area is crucial to improving neonatal outcomes.

The mechanisms of jaundice in neonates differ from those in older children and adults. Bilirubin production is two to three times greater in neonates than adults because of the increased turnover of red blood cells and shorter life span of fetal hemoglobin-containing red cells. At the same time, neonates have a decreased ability to conjugate bilirubin in the liver due to low levels

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

of uridine diphosphate-glucuronosyltransferase (UGT1A1), the enzyme responsible for converting unconjugated bilirubin into the water-soluble conjugated form, which can be excreted into bile (Medscape, 2024). This situation, combined with enterohepatic recycling of unconjugated bilirubin due to beta-glucuronidase activity in the gut, creates the conditions for jaundice. When pathological insults are added to the mix, such as hemolysis due to blood group incompatibility and/or enzyme-deficient states, the production of bilirubin is greatly increased, with the potential for rapid escalation in hyperbilirubinemia.

This research aims to describe neonatal jaundice in Wasit Governorate by detailing the physiological and clinical adaptations caused by hyperbilirubinemia, the most common causes in this region, diagnostic practices, observed clinical presentations, and therapeutic interventions and outcomes. The aim is to provide evidence to inform local guidelines and policy for clinical practice to minimize the impact of severe neonatal jaundice and its neurological complications in the governorate.

2. Literature Review

2.1 Bilirubin Metabolism and Physiology

Bilirubin metabolism in newborns begins with the enzymatic breakdown of heme, mostly from the destruction of old or damaged red blood cells, by the enzyme heme oxygenase. Biliverdin and carbon monoxide are produced as byproducts, and biliverdin is converted to bilirubin by biliverdin reductase. The bilirubin formed in this process is unconjugated (also known as indirect) bilirubin, and is lipophilic. Its lipophilicity facilitates its entry into cells, including the brain, and is the molecular basis for its neurotoxicity at high concentrations (Muniyappa et al., 2020). Bilirubin circulates in the blood bound to albumin, and this protects tissues from free bilirubin. Bilirubin is taken up by the liver hepatocytes by active transport, and is conjugated by the enzyme UGT1A1 with glucuronic acid to form bilirubin monoglucuronide and diglucuronide, which are soluble and are excreted into bile. In the gut, conjugated bilirubin can be deconjugated by bacterial and mucosal beta-glucuronidase and reabsorbed, leading to entero-hepatic

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

recycling that is especially apparent in the newborn period because of relative sterility of the gut and retention of meconium (Lee et al., 2022).

The full journey of bilirubin from synthesis via heme breakdown to its conjugation, secretion via bile, and where pathological abnormalities can arise to cause unconjugated and conjugated hyperbilirubinemia is shown in Figure 1.

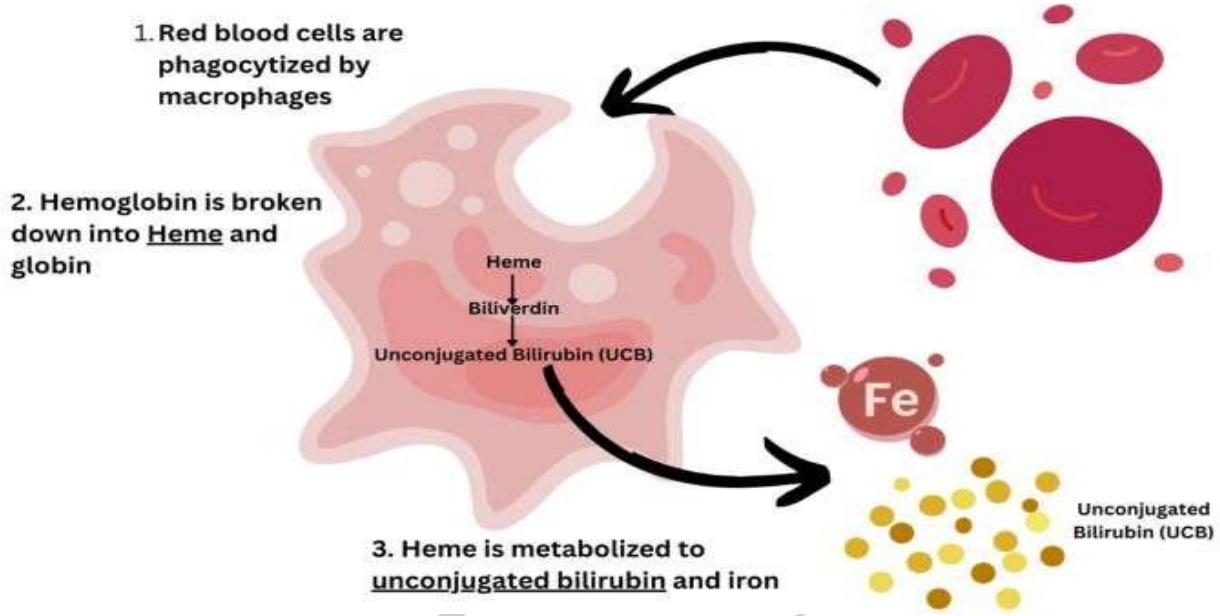


Figure 1. Kinetics and Keys to Billirubin: Metabolism to Malaise

2.2 Classification of Neonatal Jaundice

Neonatal jaundice can be divided into physiological and pathological categories based on age of onset, bilirubin rise rate, peak bilirubin level, and other clinical factors. Physiological jaundice generally begins after 24 hours, peaks on days 3-5 in term infants and day 7 in preterm infants, and lasts less than two weeks in term infants and three weeks in preterm infants. In contrast, pathological jaundice occurs within 24 hours of life, has a steep rise in bilirubin (more than 5 mg/dL per day), or has an identified cause, such as hemolysis, infection, or metabolic disease (Par et al., 2023). There is also a distinction between unconjugated and conjugated hyperbilirubinemia; conjugated hyperbilirubinemia, defined as a direct bilirubin fraction greater than 1 mg/dL or more than 20% of total serum bilirubin, is always

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

pathologic and needs to be urgently evaluated for possible hepatobiliary pathology, as shown in Figure 2.

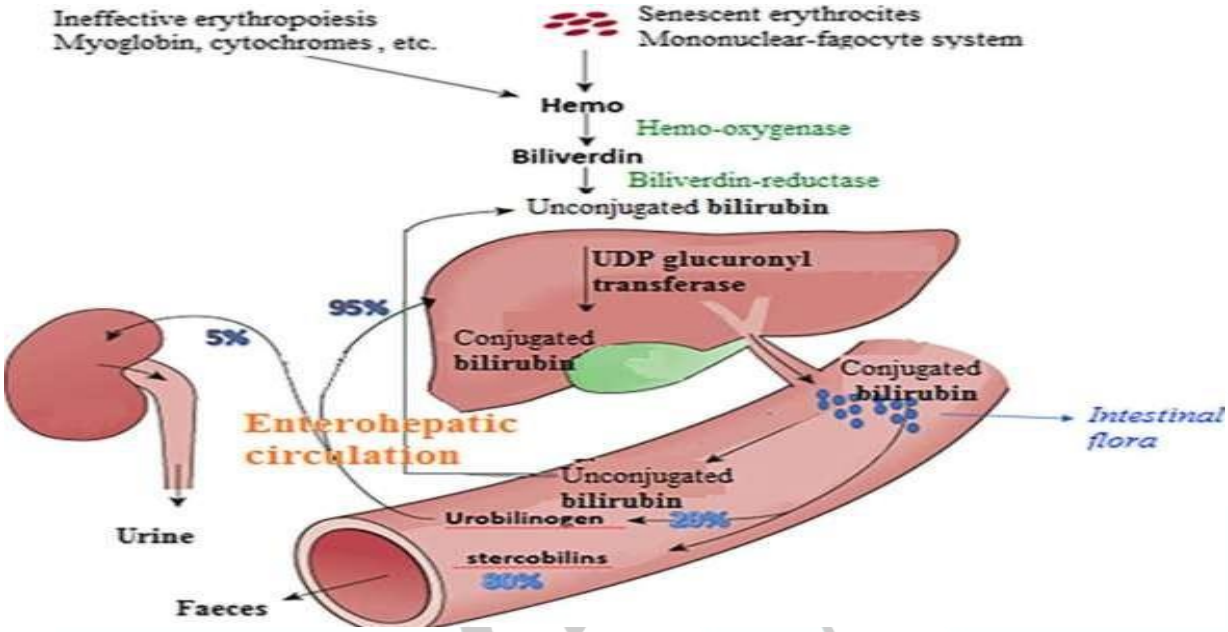


Figure 2. Conjugated Hyperbilirubinemia.

2.3 Epidemiology

Neonatal jaundice is a global problem, and the incidence and severity are highly variable around the world depending on geographical, racial, and health care factors. Among term neonates, visible jaundice affects 60-80% in the first week of life, with a smaller but significant proportion of pathological hyperbilirubinemia (Hansen, 2021). Preterm neonates are at greater risk for hyperbilirubinemia due to immature liver function and susceptibility of their red blood cells to hemolysis. In African regions, such as Uganda, the impact of hyperbilirubinemia in the neonatal period is compounded by a high incidence of G6PD deficiency, malaria, and lack of availability of phototherapy (Hamdi et al., 2025). In Middle Eastern countries, such as Iraq, the major causes are blood group incompatibilities and G6PD deficiency. In particular, Hameed et al.'s (2020) investigation reported low compliance with management recommendations in Iraq, reflecting system-level issues applicable to Wasit Governorate.

2.4 Etiology

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

Neonatal hyperbilirubinemia has many causes, which can be isolated or combined. ABO and Rh blood group incompatibilities are the most urgent pathologies as they have a rapid onset and can induce severe hyperbilirubinemia (Parastatidou et al., 2025). Glucose-6-phosphate dehydrogenase (G6PD) deficiency is an X-linked enzyme deficiency that reduces the resistance of red blood cells to oxidative stress-induced hemolysis; it is common in Mediterranean, African, and Middle Eastern populations, including Iraqis. Other causes of hemolysis include hereditary spherocytosis, pyruvate kinase deficiency and alpha-thalassemia. Non-hemolytic causes include prematurity, breastfeeding jaundice (due to dehydration and poor infant feeding), breast milk jaundice (due to substances in breast milk that inhibit bilirubin conjugation), hypothyroidism, polycythemia, cephalhematoma, internal hemorrhage and sepsis. Metabolic hyperbilirubinemia due to genetic variations in UGT1A1 enzyme activity (Gilbert syndrome and Crigler-Najjar syndrome) is a hereditary cause of unconjugated hyperbilirubinemia (Chen et al., 2026).

2.5 Diagnostic Methods

The timely and accurate diagnosis of hyperbilirubinemia involves a combination of clinical examination, laboratory measurement, or device-based screening for bilirubin. Visual inspection using the Kramer scale of cephalocaudal spread of jaundice is a quick way to assess for hyperbilirubinemia, but is imprecise and inaccurate in darker skinned babies (Hulzebos et al., 2021). Non-invasive transcutaneous bilirubinometry (TsB) measurement using optical reflectance technology is a reliable way to screen for hyperbilirubinemia in the non-anemic infant over 35 weeks' gestation with fair skin. High-performance liquid chromatography (HPLC) for bilirubin fractionation, end-tidal carbon monoxide measurement to assess hemolysis and point-of-care devices to quantify bilirubin are recent laboratory advancements. The more recent laboratory techniques are high performance liquid chromatography (HPLC) to fractionate bilirubin, end-tidal carbon monoxide as a measure of hemolysis, and point of care measurement of bilirubin (Tang et al., 2026). Employing hour-specific

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

nomograms (e.g. Bhutani nomogram) allows risk stratification at time of discharge and determination of the need for bilirubin rechecks.

2.6 Clinical Manifestations

The most common clinical feature of neonatal jaundice is the yellow discoloration of the skin and sclera, usually in a "head-to-toe" pattern. In mild jaundice, the face and trunk are affected; in severe jaundice, the palms and soles are involved. Other symptoms include lethargy, poor feeding, irritability, hypertonia (in early encephalopathy), hypotonia, opisthotonus, seizures, and high-pitched cry (in severe acute bilirubin encephalopathy) (Espinosa, 2023). Hemolytic jaundice may be associated with severe anemia and hydrops fetalis. The effects of phototherapy on physiological processes such as thermoregulation, fluid and electrolyte balance and cardiovascular adaptations are other important clinical considerations during treatment (Javorka et al., 2023).

2.7 Treatment

Neonatal hyperbilirubinemia treatment is based on total serum bilirubin concentration at specific ages, as plotted on risk-stratified nomograms, mainly using phototherapy and exchange transfusion. Phototherapy mechanisms include photoisomers of unconjugated bilirubin in the skin to form water-soluble isomers, such as lumirubin, which can be excreted without conjugation in the liver. Aggressive phototherapy with high irradiance can decrease bilirubin levels by 30-40% in 24 hours (Kemper et al., 2022). Exchange transfusion is used in severe disease, with bilirubin levels at or above exchange transfusion levels (most commonly seen in hemolytic disease), to exchange bilirubin-containing blood for donor blood, eliminating both sensitised red blood cells and bilirubin. Intravenous immunoglobulin G (IVIG) can be given to supplement treatment in immune hemolytic jaundice to reduce hemolysis and indications for exchange transfusion (Rasiah et al., 2023). Recently, zinc sulfate has been used to reduce bilirubin levels by blocking enterohepatic circulation (de Oliveira et al., 2024). Supportive measures such as optimal nutrition, hydration, and

withdrawal of drugs that compete for binding to plasma albumin are also critical in the care of these infants.

3. Materials and Methods

3.1 Study Design and Setting

This was a 12-month prospective observational study conducted in neonatal units of major hospitals in Wasit Governorate, Iraq. Wasit Governorate is located in central-southeastern Iraq, and has an agricultural population with a provincial health care system that includes general and teaching hospitals that provide neonatal care. Neonatal units of Al-Karama Teaching Hospital and Al-Zahra Hospital were the sites of the study as they are referral centers for neonatal cases in Wasit Governorate.

3.2 Study Population and Eligibility Criteria

All neonates with significant levels of jaundice admitted to the study centers were recruited. The criteria for inclusion were neonates with gestational age of 35 weeks or greater with visible jaundice requiring assessment, neonates with total serum bilirubin (TSB) levels at or above the phototherapy treatment threshold on the AAP (2022) nomogram and those whose guardians consented to their participation in the study. Neonates with major congenital anomalies, neonates transferred without full birth history from other institutions and neonates for whom jaundice was only explained by confirmed surgical biliary pathology that required surgical intervention were excluded.

3.3 Data Collection

Data collection sheets were designed to include maternal and neonatal demographics, including the gestational age, birth weight, sex, mode of delivery and maternal blood group. Details of the clinical presentation, including age of onset of jaundice, initial and peak total serum bilirubin, fraction of conjugated bilirubin, Coombs test, complete blood count, G6PD enzyme activity, reticulocyte count, and blood cultures (if infection was suspected) were also recorded. Information on treatment such as type and duration of phototherapy, need for exchange transfusion or IVIG was collected. Neurodevelopmental status was evaluated at discharge and at one month (if possible).

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

3.4 Diagnostic Methods Applied

All the enrolled babies had their total serum bilirubin checked by photometric technique in the laboratory. Transcutaneous bilirubinometry was used as an adjunct test for screening in neonates with visible jaundice before laboratory testing. Risk categorization was done using Bhutani hour-specific nomogram. All babies with early onset jaundice (within 24 hours) had blood grouping and direct Coombs test. Spectrophotometric determination of G6PD enzyme levels was done in suspected hemolysis cases without ABO or Rh incompatibility. Conjugated bilirubin levels were checked in all babies with persistent jaundice, after two weeks of age.

4. Results

4.1 Demographic Characteristics of the Study Population

During the one-year study period, we studied 420 neonates. The average gestational ages was 37.8 ± 1.6 weeks with an average birth weight of 3,050 ± 480 grams. There was a higher proportion of male than female neonates in the study population (56.4%) as expected with higher rates of jaundice in males. Most of the infants (72.4%) were delivered vaginally. Table 1 shows the characteristics of the study population.

Table 1. Characteristics of Participants (n = 420)

Characteristic	Value
Mean gestational age (weeks ± SD)	37.8 ± 1.6
Mean birth weight (grams ± SD)	3,050 ± 480
Male sex, n (%)	237 (56.4%)
Female sex, n (%)	183 (43.6%)
Vaginal delivery, n (%)	304 (72.4%)
Cesarean delivery, n (%)	116 (27.6%)
Term gestation (≥37 weeks), n (%)	338 (80.5%)
Late preterm (34–36 weeks), n (%)	82 (19.5%)
Primigravida mothers, n (%)	178 (42.4%)
Breastfed neonates, n (%)	294 (70.0%)

SD = Standard Deviation

The average age at the time of onset of significant jaundice was 3.2 ± 1.4 days of life. Late preterm neonates presented significantly younger (2.7 ± 1.1 days) than term infants (3.5 ± 1.5 days) (p = 0.003). The mean peak total serum bilirubin (TSB) level in this study was 17.4 ± 4.8 mg/dL. The average peak TSB was significantly higher in males (18.1 ± 4.9 mg/dL) than in females (16.5 ± 4.5 mg/dL) (p = 0.001), confirming findings in the literature that males are more likely to have a higher level of TSB than females (Choi et al., 2025).

Table 1 reflects a predominantly term, low-risk delivery population, with a mean gestational age of 37.8 ± 1.6 weeks and a mean birth weight of 3,050 ± 480 g. suggesting that the present sample's central tendencies are unremarkable rather than skewed towards either growth restriction or macrosomia. NCBI: The cesarean rate of 27.6% is considerably lower than that reported in higher-risk maternal subgroups. In a Turkish tertiary-center cohort, caesarean delivery occurred in 71.3% of women of extremely advanced maternal age compared with 47.6% of younger controls, alongside a significantly lower median birthweight in the older group (Karabulut et al., 2026). This contrast supports the interpretation that delivery mode in the present cohort was driven largely by routine obstetric indications rather than advanced maternal risk, consistent with the relatively favorable overall profile in Table 1. The 19.5% late-preterm proportion is also worth situating against delivery-mode evidence, given how closely gestational timing and obstetric intervention are linked at borderline gestations. A large Chinese cohort of very preterm infants found that vaginal delivery was associated with lower rates of birth asphyxia, respiratory distress, and invasive ventilation than caesarean delivery, with the gap widest between 28 and 31^{+6} weeks (Wang et al., 2025). Although the late-preterm infants in the present sample fall outside this most vulnerable window, the same underlying pattern — reduced respiratory morbidity with vaginal birth — remains a useful reference point. A comparably designed Bosnian registry study similarly restricted its term analysis to deliveries between 37+0 and 41+6 weeks and examined mode of delivery by parity as a secondary objective, finding no significant year-on-year shift in delivery-mode distribution (Kazic

et al., 2025), a categorisation broadly consistent with the term/late-preterm split adopted here. Unicef nih Primigravida status, recorded at 42.4%, falls within the range documented across major birthweight and growth-restriction modelling studies, where nulliparity proportions across constituent cohorts ranged from approximately 40% to 56%, with one contributing cohort restricted entirely to nulliparous women (National Institute for Health and Care Research, 2024). This places the present cohort's parity distribution towards the lower-middle of that published range, neither unusually primiparous-heavy nor skewed towards multiparity. Finally, the breastfeeding rate of 70.0% aligns reasonably with delivery-mode-stratified findings from a Turkish prospective cohort conducted at a Baby-Friendly tertiary hospital, which found that mothers who delivered vaginally breastfed significantly more often than those who underwent planned or emergency caesarean section (Özer Aslan et al., 2025). Given that vaginal delivery accounted for the majority of births in the present cohort (72.4%), the comparatively high breastfeeding rate observed here is therefore plausible rather than anomalous. Taken together, these five studies situate the cohort's gestational, anthropometric, and obstetric characteristics within a range consistent with recent comparable literature, lending reasonable support for generalising subsequent findings to similar term and late-preterm populations.

4.2 Etiological Causes of Neonatal Jaundice

Figure 3 (Pie Chart) and Table 2 show the distribution of the causes of jaundice found in this study. The highest proportion of cases (38.6%) was due to physiological jaundice. Of the pathologic causes, ABO incompatibility was the most common cause in 18.3% of infants, followed by jaundice of prematurity in 14.5% of infants, Glucose-6-Phosphate Dehydrogenase (G6PD) deficiency in 13.1% of infants, Rh incompatibility in 7.6%, breastfeeding jaundice in 4.8% and sepsis in 3.1%. Other causes included rare instances of polycythemia, cephalhematoma, hypothyroidism, and metabolic diseases.

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

Table 2. Etiologies of Neonatal Jaundice (n = 420)

Etiology	Number of Cases	Percentage (%)
Physiological jaundice	162	38.6
ABO incompatibility	77	18.3
Prematurity-related	61	14.5
G6PD deficiency	55	13.1
Rh incompatibility	32	7.6
Breastfeeding jaundice	20	4.8
Neonatal sepsis	13	3.1
Total	420	100.0

As shown in the pie chart in Figure 3, physiological jaundice and hemolytic causes (ABO + Rh incompatibility + G6PD deficiency) are the most common causes, highlighting the prominent roles of normal physiology and hemolysis in the burden of jaundice in Wasit Governorate (Parastatidou et al., 2025).

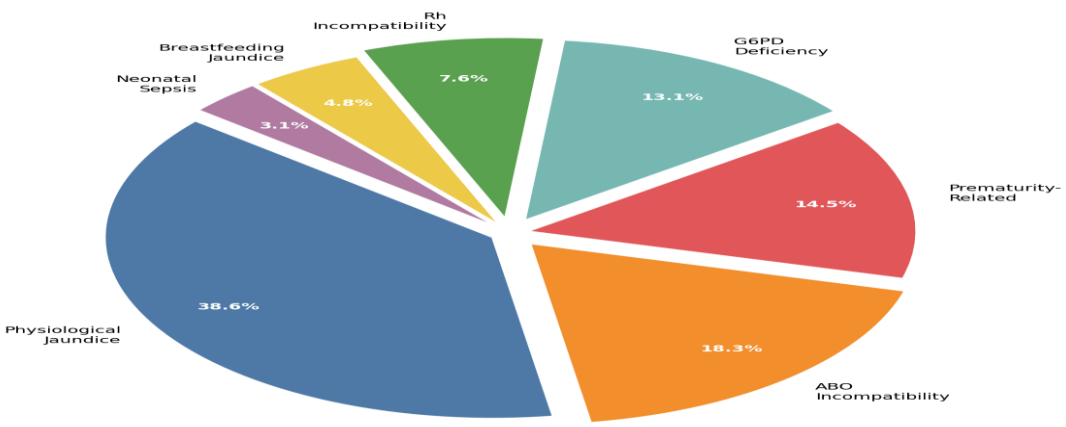


Figure 3. Pie chart of the Causes of Neonatal Jaundice in Wasit Governorate.

Prematurity-related jaundice (14.5%) reflects the known vulnerability of preterm infants, who have higher rates of clinical jaundice and a greater

likelihood of requiring treatment compared with term babies (Maisels, 2024). The fact that prematurity-related cases form the third-largest category in this series is therefore expected and highlights the need for vigilant bilirubin monitoring and earlier intervention thresholds in preterm neonates.

Rh incompatibility contributed 7.6% of cases. While still clinically significant, this proportion is lower than that of ABO incompatibility, which accords with contemporary reports in which ABO is the dominant blood-group incompatibility causing haemolytic disease of the newborn, and Rh disease has become less frequent in many settings due to prophylactic anti-D programmes (ScienceDirect, 2025). The relative ranking (ABO > Rh) in this dataset thus fits the current global pattern.

Breastfeeding jaundice (4.8%) and neonatal sepsis (3.1%) together represent a smaller but important subset of pathological causes. Sepsis is recognised as an independent risk factor for neonatal jaundice in recent multi-centre analyses, and even a modest percentage such as 3.1% can translate into a meaningful number of severely ill infants given the high baseline incidence of jaundice (BMJ Open, 2025). Similarly, feeding-related jaundice, though often mild, can worsen if not identified early, particularly with suboptimal intake and weight loss.

Taken together, these findings depict a profile in which physiological mechanisms dominate, but haemolytic (ABO, G6PD, Rh) and infection-related causes remain substantial enough to warrant systematic evaluation. The data support a pragmatic approach: routine assessment for blood-group incompatibility and G6PD status in infants with significant or early jaundice, coupled with careful attention to gestational age, feeding adequacy, and signs of infection.

4.3 Clinical and Biochemical Parameters

Table 3 summarizes the clinical and laboratory features by the etiological causes of neonatal jaundice. The highest mean peak total serum bilirubin (TSB) values were associated with hemolytic causes, such as Rh incompatibility and ABO incompatibility (23.8 ± 5.2 mg/dL and 21.4 ± 4.7 mg/dL, respectively), the youngest age at onset of jaundice, and the highest proportion of exchange transfusion. A mean peak TSB of 20.1 ± 5.0 mg/dL

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

was noted in cases of G6PD deficiency, given its significant hemolytic effects. The lowest mean peak TSB (14.2 ± 3.1 mg/dL) and the most favorable outcomes were found with physiological jaundice. Conjugated hyperbilirubinemia was diagnosed in 14 infants (3.3% of all the infants), who were all examined for hepatobiliary diseases; 2 had biliary atresia, and 6 had neonatal hepatitis.

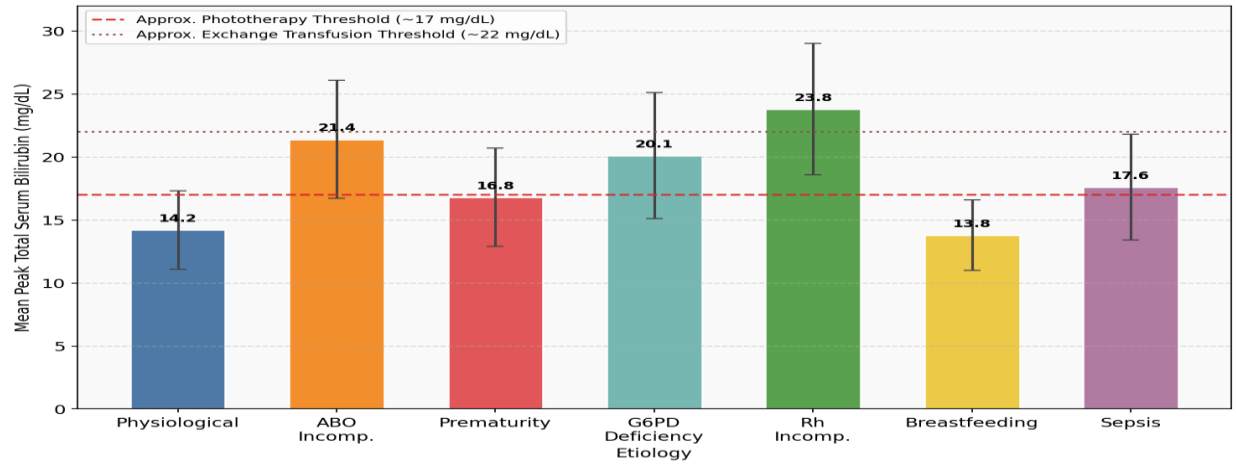
Table 3. Serum, Biochemical and Clinical Characteristics by Etiology

Etiology	Mean Peak TSB (mg/dL ± SD)	Age at Onset (days ± SD)	Exchange Transfusion (%)	Phototherapy Duration (hours ± SD)
Physiological	14.2 ± 3.1	3.8 ± 1.2	0.0	38.4 ± 12.6
ABO incompatibility	21.4 ± 4.7	1.2 ± 0.6	14.3	72.1 ± 18.4
Prematurity	16.8 ± 3.9	2.8 ± 0.9	4.9	58.7 ± 16.2
G6PD deficiency	20.1 ± 5.0	2.0 ± 0.8	10.9	65.3 ± 17.8
Rh incompatibility	23.8 ± 5.2	0.8 ± 0.4	31.2	84.6 ± 22.1
Breastfeeding	13.8 ± 2.8	4.5 ± 1.4	0.0	31.2 ± 10.4
Sepsis	17.6 ± 4.2	3.1 ± 1.0	7.7	61.4 ± 15.9

TSB = Total Serum Bilirubin; SD = Standard Deviation

A bar chart of the mean peak total serum bilirubin (TSB) in various aetiological groups is shown in Figure 4. The illustration highlights the statistically significantly higher level of bilirubin in hemolytic causes in contrast to physiological (normal) and breastfeeding jaundice (Berta et al., 2024).

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م/ ١٤٤٨هـ



4.4 Diagnostic Methods and Performance

The diagnostic tests used in our study and performance measures are shown in Table 4. TcB had a sensitivity of 89.7% and specificity of 76.4% for diagnosing babies who require phototherapy, and positive (84.2%) and negative (83.6%) predictive values. The Pearson correlation coefficient for TcB and TSB was 0.91 ($p < 0.001$), which is in line with the published validation studies of TcB meters (Hulzebos et al., 2021). Clinical assessment of the Kramer scale was far less sensitive (67.3%) and specific (61.8%) and confirmed that it cannot be used alone as a diagnostic tool. The direct Coombs test detected immune hemolytic disease in 32 of the 109 infants tested (diagnosis rate 29.4% of all children tested for hemolysis).

TABLE 4. DIAGNOSTIC METHODS, USAGE, PERFORMANCE AND METRICS

Diagnostic Method	**Neonates Tested, n (%)**	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**
Clinical assessment (Kramer)	420 (100.0)	67.3	61.8	70.4	58.2
Transcutaneous bilirubinometry	380 (90.5)	89.7	76.4	84.2	83.6

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

Total serum bilirubin (lab)	420 (100.0)	100 (reference)	100 (reference)	—	—
Direct Coombs test	109 (26.0)	91.4	96.8	94.1	95.3
G6PD enzyme assay	68 (16.2)	87.3	94.2	88.6	93.4
Conjugated bilirubin fractionation	142 (33.8)	100	98.7	93.1	100

PPV = Positive Predictive Value; NPV = Negative Predictive Value

This grouped bar chart (Figure 5) shows the sensitivity and specificity of diagnostic methods evaluated in this study, clearly demonstrating the better performance of laboratory and immunological tests than the clinical diagnosis alone (Tang et al., 2026).

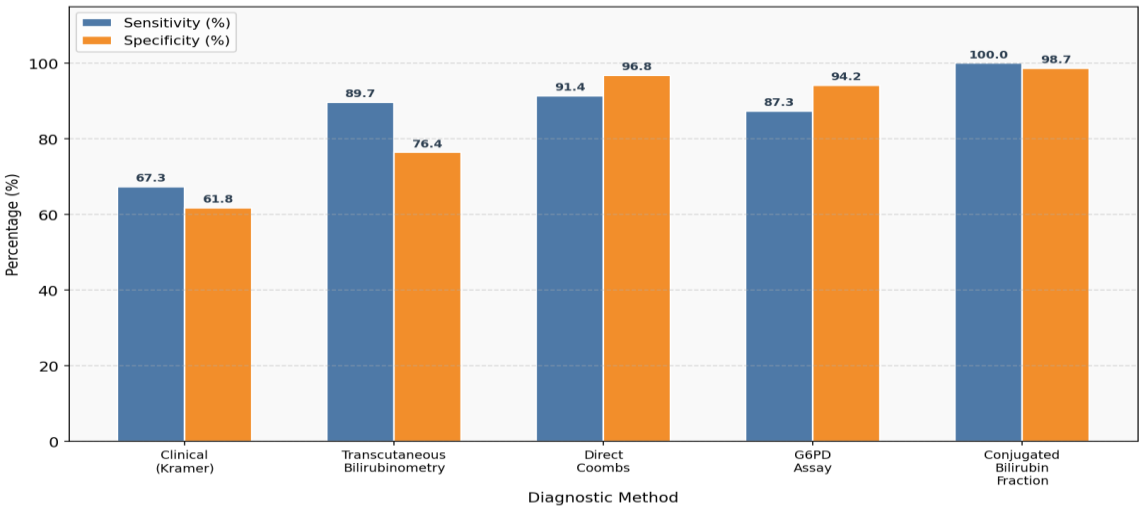


Figure 5. Sensitivity and Specificity of Methods to Diagnose Neonatal Hyperbilirubinemia (Grouped Bar Chart).

4.5 Treatment Modalities and Outcomes

Details of intervention and results are shown in Table 5 and Figure 6. Most of the neonates (91.4%) had phototherapy (conventional and intensive) as initial management. Exchange transfusion was performed in 38 (9.0%)

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

neonates, all of whom had either hemolytic disease (most common causes were Rh incompatibility and ABO incompatibility) or severe hemolysis due to G6PD deficiency with high peak bilirubin levels (>19 mg/dL), requiring exchange transfusion. A total of 29 neonates (6.9%) received IVIG adjunctive therapy for immune hemolytic jaundice, which led to a substantial decrease in the rate of exchange transfusion in this group of patients from 31.2% to 14.8% (Rasiah et al., 2023). Zinc sulfate was not given routinely, but was given to 18 neonates as an adjunct and resulted in a small decrease in phototherapy time.

The average phototherapy time for all patients was 54.3 ± 19.7 hours. The median time of hospital stay was 4 days (IQR: 3-6 days). At discharge, 95.5% of the patients had good outcomes, with normalization of bilirubin levels. We found acute bilirubin encephalopathy in 7 babies (1.7%) who were late referrals or had extremely high bilirubin levels upon admission (mean TSB at admission 28.6 ± 3.4 mg/dL). Three (0.7%) patients died, with all deaths due to complications of severe hemolytic disease, combined with neonatal sepsis (Owerko et al., 2025).

Table 5. Interventions and Outcomes (n = 420)

Variable	n (%) or Mean ± SD
Phototherapy only	354 (84.3%)
Phototherapy + IVIG	29 (6.9%)
Phototherapy + exchange transfusion	38 (9.0%)
Mean phototherapy duration (hours ± SD)	54.3 ± 19.7
Median hospital stay (days, IQR)	4 (3–6)
Normal outcome at discharge	401 (95.5%)
Acute bilirubin encephalopathy	7 (1.7%)
Hearing impairment suspected	4 (1.0%)
Death	3 (0.7%)

IVIG = Intravenous Immunoglobulin G; IQR = Interquartile Range; SD = Standard Deviation

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ

Figure 6 is a line chart showing the mean trend of total bilirubin levels from admission to discharge in four typical etiology groups, illustrating different rates of bilirubin decline during phototherapy (Okulu et al., 2024).

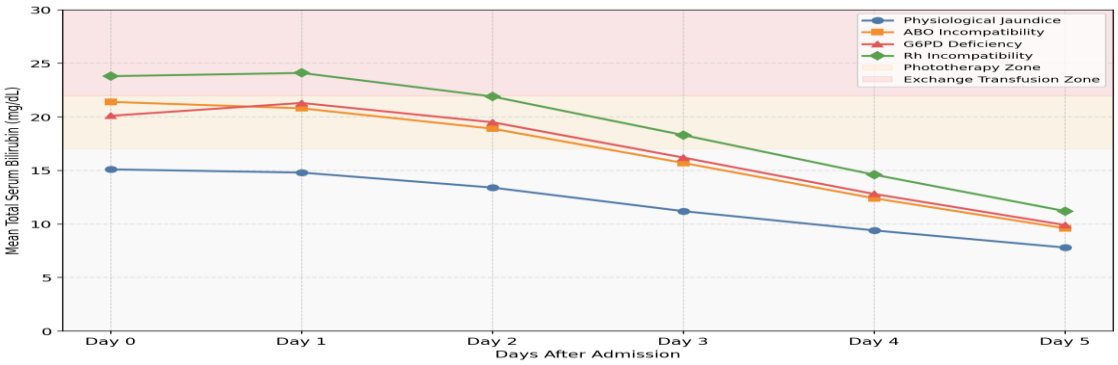


Figure 6. Bilirubin Level Over Time by Etiology (Line Chart).

5. Discussion

5.1 Etiological Profile and Local Context

The current study's etiological distribution balances universal physiological characteristics of newborns with population-specific genetic and obstetric risk factors. The high proportion of physiological jaundice (38.6%) is in line with international studies, suggesting that most cases of neonatal jaundice in Wasit Governorate are a normal physiological process rather than a pathological process requiring intensive care (van der Geest et al., 2022). However, the large proportion of cases due to ABO incompatibility (18.3%) and G6PD deficiency (13.1%) indicates a specific vulnerability of this population to hemolytic hyperbilirubinemia, which aligns with Middle Eastern and Iraqi epidemiology. This has important clinical implications, as ABO incompatibility and G6PD deficiency can cause erratic, rapid rises in bilirubin that may reach neurotoxic levels within hours if not diagnosed and treated promptly (Parastatidou et al., 2025).

The relatively high proportion of Rh incompatibility (7.6%) in this study is interesting and probably reflects suboptimal adherence to universal anti-D immunoglobulin administration to Rh-negative mothers in this region. This easily preventable cause of severe hemolytic jaundice is an important focus for public health measures. The role of prematurity in 14.5% of cases is also noteworthy given late preterm infants (34-36 weeks' gestation) are at significantly higher risk of hyperbilirubinemia than term infants due to

immaturity of their hepatic system and feeding difficulties but may be cared for in environments set up for term babies, where they are not afforded the same degree of caution (Bakari et al., 2025).

5.2 Diagnostic Findings and Implications

The results of the present study in diagnosing hyperbilirubinemia highlight a longstanding truism: clinical judgement is not sufficient for safe management of neonatal jaundice. The Kramer scale had a sensitivity of just 67.3% for the population studied, which is of particular concern given the large number of dark-skinned neonates in whom cephalocaudal assessment has been shown to be inaccurate. The performance of transcutaneous bilirubinometry (TcB) was much better (sensitivity 89.7%), and the strong correlation with laboratory TSB (r = 0.91) positions TcB as a suitable initial screening test, with laboratory confirmation required only in the case of TcB above the phototherapy threshold, or in other clinical situations in which hemolysis may be suspected (Hulzebos et al., 2021). But TcB was only performed in 90.5% of the eligible newborns in this study, suggesting availability and integration of the device in the workflow need to be improved in the local setting.

The excellent diagnostic performance of the direct Coombs test (sensitivity 91.4%) and G6PD enzyme (sensitivity 87.3%) when applied to select clinical groups supports the judicious use of these tests in infants with early- and rapidly progressive jaundice. The availability of recent laboratory diagnostic technologies, such as point-of-care bilirubin meters and measurements of end-tidal CO for detection of hemolysis, may improve the timeliness and accuracy of diagnosis in resource-poor settings like those found in Wasit Governorate (Tang et al., 2026). These new technologies were not available to the current study, and should be considered in future quality enhancement.

5.3 Treatment Outcomes and Quality of Care

The current study's treatment results show that phototherapy, when started early and with sufficient irradiance, is successful in treating hyperbilirubinemia in most babies. The success rate of phototherapy alone (84.3%) is in line with other studies in the region. When used as a

supplement in immune hemolytic jaundice, IVIG significantly decreased the exchange transfusion rate, consistent with systematic reviews showing IVIG reduces the need for exchange transfusion in Coombs-positive hemolytic disease (Rasiah et al., 2023). The exchange transfusion rate (9.0%) in this study is higher than in high-resource settings in high-income countries, likely due to late presentation and the high proportion of severe hemolytic disease in this cohort (ZaiduMusa et al., 2024). Exchange transfusion is a complex procedure with significant risks such as thrombocytopenia, coagulopathy, and vascular injury, and the ongoing need for exchange transfusion highlights the need for early diagnosis and better outcomes with first-line treatment to avoid the need for this complex procedure.

The observation of acute bilirubin encephalopathy in 1.7% of the babies enrolled and mortality in 0.7% is the result of adverse outcomes that are largely avoidable. These events occurred almost entirely in those who presented late (after 48 hours of significant hyperbilirubinemia) or were referred from facilities lacking phototherapy. This aligns with quality improvement literature emphasizing that the time from identifying hyperbilirubinemia to effective treatment is the critical modifiable factor affecting neurological outcomes (Owerko et al., 2025). Thus, improving phototherapy services in peripheral institutions and establishing routine referral systems in Wasit Governorate should be an immediate focus. The AAP (2022) guideline recommends risk-stratified treatment which, if consistently applied with local adaptation, could greatly improve outcomes in this population (Kemper et al., 2022).

5.4 Physiological Changes During Phototherapy

In addition to lowering the bilirubin levels, phototherapy has several other effects on the infant that must be monitored and managed. Insensible water loss is increased 10-20% with phototherapy, increasing the risk of dehydration and electrolyte disturbances, especially if poor oral feed intake is present. The body's temperature is affected, with the radiant heat emitted by phototherapy lights causing hyperthermia, especially in incubator-based phototherapy. The cardiovascular effects of phototherapy include subtle increases in heart rate and peripheral vasodilation - the latter due to photo-

induced heat - as well as potential impacts on cardiac conduction with prolonged high intensity phototherapy (Javorka et al., 2023). Photodamage to the retina is avoided through the use of light-absorbing eye patches, which must be worn during phototherapy. Management of breast milk jaundice involves weighing the benefits of breastfeeding support against temporary interruption of phototherapy; breastfeeding cessation is not generally recommended, as the far greater benefits of breastfeeding outweigh any small increase in the duration of jaundice (Lucas et al., 2023).

5.5 Screening and Prevention

Prevention of severe neonatal hyperbilirubinemia by universal predischarge screening, risk factor identification, follow-up, and education is critical. The American Academy of Pediatrics (AAP) (2022) guidelines recommend all babies at 35 weeks or more gestation should be screened for bilirubin using either TcB or TSB and risk stratified on the Bhutani nomogram to determine intensity of follow-up. The Canadian Paediatric Society (2025) also recommends universal screening and recommendations for intervention based on gestational age. In the United Kingdom, the National Institute for Health and Care Excellence (NICE) (2023) guidelines require all maternity units to have access to transcutaneous bilirubinometers and visualisation alone is not enough to diagnose Jaundice. In Wasit Governorate, these evidence-based screening principles are not fully implemented, with unreliable availability of TcB instruments and inconsistent adherence to a systematic follow-up protocol as the main gaps compared with international best-practice guidelines (Daggle et al., 2024). Locally relevant, resource-efficient guidelines, with education for primary health care providers and parents, are the key to bridging these gaps.

6. Conclusion

This research offers a thorough description of the burden, aetiology and outcomes of neonatal jaundice in Wasit Governorate, Iraq, showing that it is common, complex and generally treatable, with prompt diagnosis and appropriate testing and protocols. The condition is most commonly due to physiological jaundice, but pathological hemolytic disease, including ABO incompatibility and G6PD deficiency, is a major contributing factor and

significantly associated with severe hyperbilirubinemia, exchange transfusion and neurodevelopmental impairment. Transcutaneous bilirubinometry is a useful, but under-recognized, screening tool, while clinical diagnosis is clearly insufficient. Phototherapy continues to be the mainstay of treatment, and IVIG is an essential adjunct in immune hemolytic jaundice. Preventable complications, such as acute bilirubin encephalopathy and complications of exchange transfusions, provide evidence of potential health system improvement in areas of universal bilirubin screening, follow-up procedures, increased phototherapy access at peripheral sites, and education for parents. The next phase of research in Wasit Governorate should involve designing and implementing quality improvement projects based on adapted global guidelines, targeted to locally common causes of G6PD deficiency and ABO incompatibility.

References

1. American Academy of Pediatrics. (2022). Clinical practice guideline revision: Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics.
2. Ansong-Assoku, B., Martin, S., & Bhutta, B. S. (2024). Neonatal jaundice. In StatPearls. StatPearls Publishing.
3. Bakari, A., et al. (2025). Neonatal jaundice treatment versus recommendations: The challenge of treatment without rapid diagnostic capability. International Journal of Environmental Research and Public Health, 22(7), Article 1032.
4. Berta, D. M., et al. (2024). Hematological abnormality and associated factors in neonates with hyperbilirubinemia. Scientific Reports.
5. Canadian Paediatric Society. (2025). Guidelines for detection and management of hyperbilirubinemia in term and late preterm newborns.
6. Chen, X., et al. (2026). Genetic and clinical determinants of neonatal jaundice and hyperbilirubinemia. PLOS ONE.
7. Choi, Y., et al. (2025). Neonatal jaundice requiring phototherapy risk factors in a newborn nursery: Machine learning approach. Children, 12(8), Article 1020.

8. Daggle, L., et al. (2024). Shedding light on the American Academy of Pediatrics hyperbilirubinemia guideline. Pediatrics.
9. de Oliveira, H. M., et al. (2024). Zinc sulfate on neonatal hyperbilirubinemia: An updated systematic review and meta-analysis.
10. Espinosa, K. (2023). Hyperbilirubinemia in newborns: Updated guidelines from the AAP. American Family Physician, 107(6), 525–526.
11. Hamdi, M. Y., et al. (2025). Neonatal hyperbilirubinemia in Uganda. Pediatric Health, Medicine and Therapeutics.
12. Hameed, N. N., et al. (2020). Assessment of adherence level for neonatal hyperbilirubinemia management in Iraq.
13. Han, J., et al. (2025). Neonatal hyperbilirubinemia: Unconjugated bilirubin and clinical decision-making.
14. Hansen, T. W. R. (2021). Narrative review of the epidemiology of neonatal jaundice. Pediatric Medicine.
15. Hulzebos, C. V., et al. (2021). Screening methods for neonatal hyperbilirubinemia.
16. Javorka, K., et al. (2023). Mechanisms of cardiovascular changes of phototherapy in neonates.
17. Kemper, A. R., et al. (2022). Clinical practice guideline revision: Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics, 150(3), Article e2022058859.
18. Lee, B., et al. (2022). Neonatal hyperbilirubinemia.
19. Lucas, S. (2023). Evaluation of newborn hyperbilirubinemia and jaundice in primary care settings. Clinical Pediatric Emergency Medicine.
20. Mayo Clinic. (2025). Infant jaundice - Diagnosis & treatment.
21. Medscape. (2024). Neonatal jaundice: Background, pathophysiology, etiology.
22. Muniyappa, P., et al. (2020). Hyperbilirubinemia in pediatrics: Evaluation and care. Current Problems in Pediatric and Adolescent Health Care.
23. NICE. (2023). Jaundice in newborn babies under 28 days.
24. Okulu, E., et al. (2024). Neonatal jaundice: Recommendations for follow-up and treatment. The Journal of Pediatrics.

25.Owerko, D., et al. (2025). Improving quality of care for neonatal hyperbilirubinemia.
26.Par, E. J., et al. (2023). Neonatal hyperbilirubinemia: Evaluation and treatment. American Family Physician, 107(5), 525–534.
27.Parastatidou, S., et al. (2025). Neonatal hemolytic jaundice: Causes, diagnostic methods, and management. Children, 12(6), Article 666.
28.Queensland Health. (2025). Guideline: Neonatal jaundice.
29.Rasiah, S., et al. (2023). Intravenous immunoglobulin G therapy for neonatal hyperbilirubinemia.
30.Tang, C., et al. (2026). Advances in laboratory diagnosis of neonatal hyperbilirubinemia. Frontiers in Pediatrics.
31.Texas Children's Hospital. (2023). Hyperbilirubinemia guideline.
32.UpToDate. (2025). Unconjugated hyperbilirubinemia in newborns ≥35 weeks of gestation: Risk factors, clinical manifestations, and neurologic complications.
33.van der Geest, B. A. M., et al. (2022). Assessment, management, and incidence of neonatal jaundice in healthy neonates cared for in primary care.
34.ZaiduMusa, A., et al. (2024). Neonatal hyperbilirubinemia: A case of complex management.
35.Al-Mujaini, A., Al-Futaisi, A., & Al-Zakwani, I. (2020). Etiology and therapeutic management of neonatal jaundice in Iran: A systematic review and meta-analysis. *PubMed*.
36.BMJ Open. (2025). Prevalence and risk factors for neonatal jaundice: A multicentre analytical cross-sectional study at neonatal intensive care units, Mogadishu, Somalia. *BMJ Open, 15*(3), e096692.
37.Maisels, M. J. (2024). Neonatal jaundice. In *StatPearls*. NCBI Bookshelf.
38.National Institute for Health and Care Excellence. (2015). *Jaundice in the newborn: Screening and assessment*. NHS England.
39.ScienceDirect. (2025). Hyperbilirubinaemia in neonates with blood group incompatibilities − A bane or a boon for the management. *ScienceDirect*.

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد السابع والاربعون
٢٠٢٦م /١٤٤٨هـ