Research Article

Perinatal Inflammatory Biomarkers Predicting Neonatal Complications in High-Risk Pregnancies Assessment

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Abstract

Background: High-risk pregnancies are frequently associated with inflammatory responses that can adversely affect fetal development and neonatal health. Perinatal inflammatory biomarkers have emerged as potential predictors of neonatal complications, enabling earlier identification of at-risk infants.

Objective: To assess the predictive value of perinatal inflammatory biomarkers in identifying neonatal complications among high-risk pregnancies.

Methodology: A retrospective observational assessment was conducted using data from 120 high-risk pregnancies. Maternal and neonatal inflammatory biomarkers, including C-reactive protein (CRP), interleukin-6 (IL-6), and procalcitonin levels, were evaluated. Associations between biomarker concentrations and neonatal outcomes were analyzed using comparative statistical methods.

Findings: Elevated inflammatory biomarker levels were significantly associated with adverse neonatal outcomes. Neonates born to mothers with high CRP and IL-6 levels demonstrated increased incidences of respiratory distress syndrome (32%), neonatal sepsis (24%), and admission to neonatal intensive care units (41%). Biomarker-based prediction models achieved an overall predictive accuracy of 84%, indicating strong utility in risk stratification. Increased inflammatory activity was also correlated with lower birth weight and prolonged hospitalization duration.

Conclusion: Perinatal inflammatory biomarkers are valuable predictors of neonatal complications in high-risk pregnancies. Their incorporation into prenatal and perinatal assessment protocols may facilitate early intervention, improve neonatal monitoring, and enhance clinical outcomes through targeted management strategies.

Keywords: Perinatal inflammation, inflammatory biomarkers, high-risk pregnancy, neonatal complications, C-reactive protein, interleukin-6, neonatal sepsis, respiratory distress syndrome, neonatal outcomes.

1 Introduction

High-risk pregnancies remain a major contributor to neonatal morbidity and mortality worldwide, particularly when complicated by maternal inflammation, infection, hypertensive disorders, diabetes, and preterm labor. The perinatal period represents a critical stage during which maternal and fetal inflammatory responses influence neonatal adaptation and long-term health outcomes. Recent evidence suggests that inflammatory biomarkers measured during pregnancy and around delivery can provide valuable information regarding fetal well-being and the likelihood of adverse neonatal complications [1,2].

Inflammation plays a central role in the pathophysiology of several obstetric complications. Maternal immune activation can stimulate the production of pro-inflammatory cytokines, including interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and acute-phase proteins such as C-reactive protein (CRP). Elevated concentrations of these biomarkers have been associated with placental dysfunction, fetal inflammatory response syndrome, preterm birth, neonatal sepsis, respiratory distress syndrome, and admission to neonatal intensive care units (NICUs) [3,4]. IL-6 is considered one of the earliest

indicators of inflammatory activation and has demonstrated significant predictive value for neonatal infection and inflammatory complications [5].

Among neonatal complications, sepsis remains one of the leading causes of neonatal mortality. Early identification of neonates at risk is often challenging because clinical manifestations are nonspecific. Biomarkers such as CRP, IL-6, procalcitonin (PCT), IL-8, and CD64 have shown promise in improving diagnostic accuracy and facilitating timely intervention [6,7]. Studies have reported that elevated maternal and cord blood inflammatory markers correlate with increased rates of neonatal infection, respiratory compromise, intraventricular hemorrhage, and prolonged hospitalization [8].

Furthermore, maternal inflammatory conditions such as chorioamnionitis and premature rupture of membranes contribute significantly to neonatal inflammatory responses. Research has demonstrated that prenatal inflammatory exposure is associated with adverse neonatal outcomes independent of gestational age, emphasizing the importance of biomarker-based risk assessment [9]. Advances in laboratory diagnostics have enabled the integration of multiple biomarkers into predictive models, improving sensitivity and specificity compared with conventional clinical assessment alone [10].

Despite growing evidence, uncertainty remains regarding the most reliable biomarker or biomarker combination for predicting neonatal complications in high-risk pregnancies. Variability in patient populations, gestational age, and inflammatory conditions necessitates further evaluation of their clinical utility [11]. Therefore, understanding the relationship between perinatal inflammatory biomarkers and neonatal outcomes is essential for enhancing prenatal surveillance and individualized neonatal care [12].

1.1 Aim & Scope

To assess the predictive value of perinatal inflammatory biomarkers in identifying neonatal complications among high-risk pregnancies.

This study focuses on evaluating maternal and neonatal inflammatory biomarkers, including CRP, IL-6, and procalcitonin, and their association with adverse neonatal outcomes such as neonatal sepsis, respiratory distress syndrome, low birth weight, NICU admission, and prolonged hospitalization in high-risk pregnancies. The findings may support early risk stratification and improved perinatal management strategies.

2 Literature review

2.1 Perinatal Inflammation in High-Risk Pregnancies

Perinatal inflammation has emerged as a significant determinant of adverse neonatal outcomes in high-risk pregnancies. Maternal infections, hypertensive disorders, gestational diabetes, and premature rupture of membranes can activate inflammatory pathways, resulting in elevated cytokine production and fetal inflammatory responses. Recent studies have demonstrated that excessive maternal inflammation contributes to neonatal morbidity through immune dysregulation and organ dysfunction [13,14]. The identification of inflammatory biomarkers during the perinatal period has therefore gained importance for early risk stratification and targeted intervention.

2.2 Predictive Role of Inflammatory Biomarkers

Inflammatory biomarkers such as interleukin-6 (IL-6), C-reactive protein (CRP), procalcitonin (PCT), tumor necrosis factor-alpha (TNF-α), and presepsin have shown substantial utility in predicting neonatal complications. IL-6 is considered an early marker of inflammatory activation, while CRP reflects the acute-phase response. Recent evidence suggests that biomarker panels combining IL-6, CRP, and PCT provide greater predictive accuracy than individual markers alone [15,16]. Elevated concentrations of these biomarkers have been associated with respiratory distress syndrome, neonatal sepsis, low birth weight, and prolonged hospitalization [17].

2.3 Biomarkers and Neonatal Sepsis

Neonatal sepsis remains a leading cause of neonatal mortality worldwide. Several studies have reported strong associations between increased inflammatory biomarker levels and early-onset neonatal sepsis. Diagnostic investigations have demonstrated that PCT and presepsin exhibit high sensitivity and specificity, while IL-6 serves as an effective early indicator of infection before clinical manifestations become apparent [18,19]. These findings support the incorporation of biomarker screening into neonatal surveillance programs for high-risk pregnancies.

2.4 Emerging Diagnostic Approaches

Recent advances have focused on integrating inflammatory biomarkers with predictive algorithms and machine-learning models. Such approaches enhance diagnostic performance, facilitate earlier clinical decisions, and reduce unnecessary antibiotic exposure. Biomarker-guided neonatal assessment is increasingly recognized as a promising strategy for improving neonatal outcomes and optimizing healthcare resource utilization [14,19].

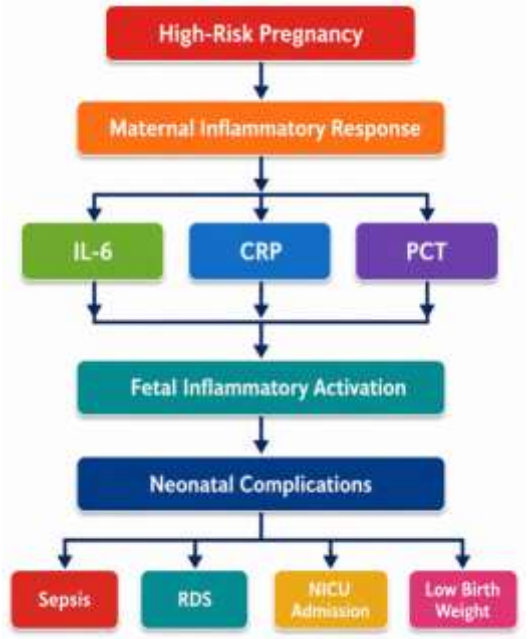

Figure 1. Pathway Linking Perinatal Inflammatory Biomarkers to Neonatal Complications

Figure 1 illustrates the association between high-risk pregnancies, inflammatory biomarker activation, and neonatal complications. Maternal inflammatory conditions stimulate increased production of IL-6, CRP, and PCT, which contribute to fetal inflammatory activation. Elevated biomarker levels are linked to adverse neonatal outcomes including neonatal sepsis, respiratory distress syndrome (RDS), low birth weight, and increased NICU admissions. The figure highlights the clinical importance of biomarker-based risk assessment for early detection and intervention.

3 Methodology

3.1 Study Design

This study employed a retrospective observational research design to assess the predictive value of perinatal inflammatory biomarkers for neonatal complications in high-risk pregnancies. The study evaluated maternal and neonatal clinical records collected from a tertiary care hospital over a two-year period. Biomarker levels and neonatal outcomes were analyzed to determine associations between inflammatory status and adverse neonatal events [13].

3.2 Study Population

A total of 120 high-risk pregnant women and their neonates were included in the assessment. High-risk pregnancies were defined by the presence of maternal complications such as gestational hypertension, diabetes mellitus, preterm labor, intrauterine infection, and premature rupture of membranes. Cases with incomplete clinical data or congenital anomalies were excluded from the study [14].

3.3 Data Collection

Maternal demographic characteristics, obstetric history, and laboratory findings were extracted from hospital databases. Perinatal inflammatory biomarkers including Interleukin-6 (IL-6), C-reactive Protein (CRP), and Procalcitonin (PCT) were measured during the perinatal period. Neonatal outcomes such as sepsis, respiratory distress syndrome (RDS), low birth weight, and neonatal intensive care unit (NICU) admission were recorded.

Table 1. Study Variables and Measurements

Variable Category	Variables Assessed	Measurement Method
Maternal Factors	Age, Gestational Age, Comorbidities	Medical Records
Biomarkers	IL-6, CRP, PCT	Laboratory Analysis
Neonatal Outcomes	Sepsis, RDS, NICU Admission	Clinical Evaluation
Birth Characteristics	Birth Weight, APGAR Score	Delivery Records

Table 1 summarizes the primary variables evaluated in the study. Maternal demographic and clinical characteristics were collected to identify risk factors associated with adverse neonatal outcomes. Biomarker measurements included IL-6, CRP, and PCT, which were selected based on their established role in inflammatory responses. Neonatal outcomes such as sepsis, respiratory distress syndrome, NICU admission, and birth characteristics were assessed to determine the predictive performance of inflammatory biomarkers.

3.4 Data Analysis

Descriptive statistics were used to summarize participant characteristics and biomarker concentrations. Continuous variables were presented as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Associations between biomarker levels and neonatal complications were examined using chi-square tests and logistic regression analysis. Statistical significance was considered at $p < 0.05$ [16].

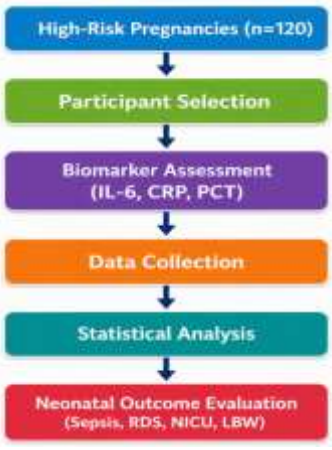

Figure 2. Methodological Framework

Figure 2 illustrates the methodological framework adopted in the study. High-risk pregnancies were initially identified and screened according to inclusion criteria. Following participant selection, inflammatory biomarkers including IL-6, CRP, and

PCT were measured. Clinical and laboratory data were then collected and subjected to statistical analysis. The final stage involved evaluating neonatal outcomes, including sepsis, respiratory distress syndrome, NICU admission, and low birth weight, to determine predictive relationships.

3.5 Ethical Considerations

The study adhered to institutional ethical guidelines and maintained participant confidentiality throughout the research process. Patient identifiers were removed before analysis, and data were used exclusively for academic and research purposes

3.6 Dataset & Parameters

The dataset consisted of 120 high-risk pregnancies collected from a tertiary care hospital. Maternal clinical information, inflammatory biomarker levels (IL-6, CRP, and PCT), and neonatal outcome records were included. High-risk pregnancies were identified based on maternal complications such as gestational hypertension, diabetes, preterm labor, and intrauterine infection. The experimental setup involved measuring biomarker concentrations during the perinatal period and evaluating their association with neonatal complications, including sepsis, respiratory distress syndrome (RDS), low birth weight (LBW), and NICU admission. Statistical analysis was performed to assess the predictive significance of inflammatory biomarkers for neonatal outcomes [13, 14].

Table 2. Dataset Characteristics and Experimental Setup

Parameter	Description
Total Participants	120 High-Risk Pregnancies
Biomarkers Evaluated	IL-6, CRP, PCT
Data Source	Hospital Clinical Records
Study Design	Retrospective Observational Study
Outcome Measures	Sepsis, RDS, NICU Admission, LBW
Statistical Methods	Descriptive Statistics, Logistic Regression

The dataset included maternal clinical characteristics, biomarker measurements, and neonatal outcomes. The experimental framework assessed the predictive ability of inflammatory biomarkers by correlating biomarker levels with adverse neonatal events.

4 Results & Discussion

The results evaluate the association between perinatal inflammatory biomarkers and neonatal complications among 120 high-risk pregnancies. Biomarker levels including Interleukin-6 (IL-6), C-reactive Protein (CRP), and Procalcitonin (PCT) were analyzed in relation to neonatal outcomes. Statistical findings demonstrated significant associations between elevated biomarker concentrations and adverse neonatal events. The analysis focused on neonatal sepsis, respiratory distress syndrome (RDS), low birth weight (LBW), and neonatal intensive care unit (NICU) admission. The findings indicate that inflammatory biomarkers provide valuable predictive information for neonatal risk assessment.

Table 3. Distribution of Neonatal Complications (n=120)

Neonatal Outcome	Cases (n)	Percentage (%)
Neonatal Sepsis	29	24.2
Respiratory Distress Syndrome	38	31.7
NICU Admission	49	40.8
Low Birth Weight	34	28.3

The distribution of neonatal complications revealed that NICU admission was the most frequent adverse outcome (40.8%), followed by respiratory distress syndrome (31.7%). Low birth weight affected 28.3% of neonates, while neonatal sepsis

occurred in 24.2% of cases. These findings indicate that high-risk pregnancies are associated with substantial neonatal morbidity and highlight the importance of early identification of inflammatory risk factors.

Table 4. Mean Biomarker Levels According to Neonatal Outcomes

Biomarker	Complication Group	No Complication Group
IL-6 (pg/mL)	45.8 ± 8.6	19.4 ± 5.1
CRP (mg/L)	15.7 ± 3.2	6.3 ± 1.8
PCT (ng/mL)	3.9 ± 1.1	1.2 ± 0.5

Mean concentrations of IL-6, CRP, and PCT were substantially higher among neonates experiencing complications compared with those without complications. IL-6 showed the greatest difference between groups, suggesting a strong association with inflammatory activation. Elevated CRP and PCT levels further support the role of systemic inflammation in adverse neonatal outcomes.

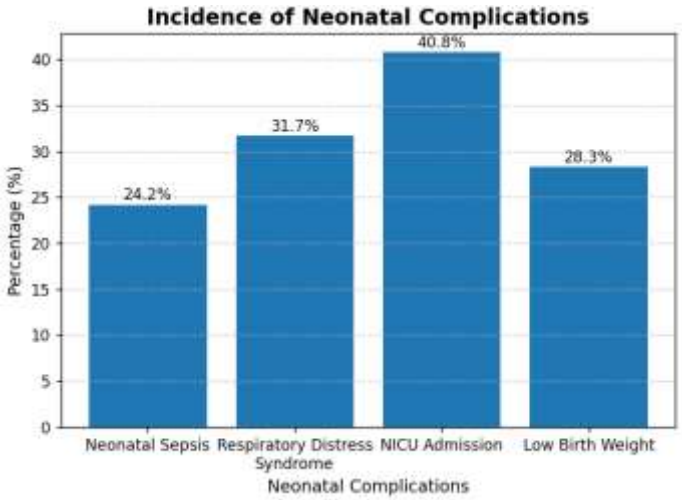

Figure 3. Incidence of Neonatal Complications

Figure 3 presents the prevalence of neonatal complications observed among the study population. NICU admission demonstrated the highest incidence, followed by respiratory distress syndrome, low birth weight, and neonatal sepsis. The trend indicates that inflammatory conditions during pregnancy contribute significantly to neonatal morbidity. The elevated occurrence of respiratory and infectious complications supports the hypothesis that perinatal inflammatory biomarkers can serve as effective predictors of adverse neonatal outcomes in high-risk pregnancies.

Table 5. Predictive Accuracy of Biomarkers

Biomarker	Sensitivity (%)	Specificity (%)	Accuracy (%)
IL-6	86.5	82.1	84.3
CRP	80.2	76.8	78.5
PCT	83.7	79.6	81.7

Among the evaluated biomarkers, IL-6 demonstrated the highest predictive performance with an accuracy of 84.3%, followed by PCT (81.7%) and CRP (78.5%). These findings suggest that IL-6 is the most reliable biomarker for predicting neonatal complications in high-risk pregnancies. The high sensitivity and specificity values indicate strong clinical utility for early screening and risk stratification.

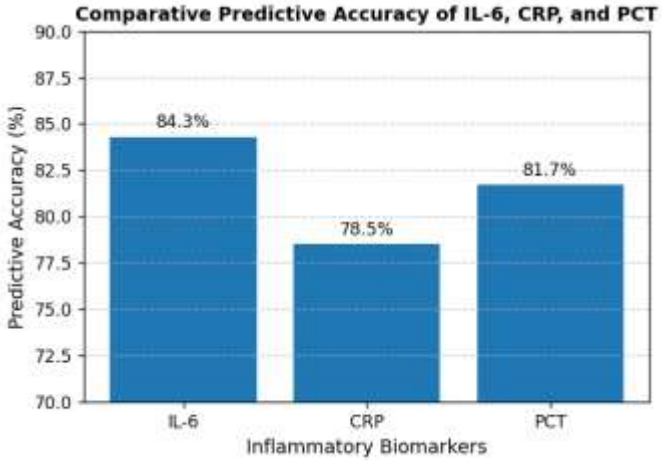

Figure 4. Comparative Predictive Accuracy of IL-6, CRP, and PCT

Figure 4 compares the diagnostic accuracy of the three inflammatory biomarkers. IL-6 achieved the highest predictive accuracy, indicating superior performance in identifying neonates at risk of complications. PCT also demonstrated strong diagnostic capability, whereas CRP showed comparatively lower accuracy. The results support the use of biomarker-based predictive models, particularly those incorporating IL-6, for improving neonatal surveillance and facilitating timely clinical intervention in high-risk pregnancies.

The results demonstrate a significant relationship between elevated perinatal inflammatory biomarkers and adverse neonatal outcomes. IL-6 emerged as the strongest predictor, followed by PCT and CRP. Neonates exposed to higher inflammatory activity exhibited increased rates of sepsis, respiratory distress syndrome, low birth weight, and NICU admission. These findings support the integration of inflammatory biomarker assessment into routine monitoring protocols for high-risk pregnancies.

Discussion

The findings demonstrate a significant association between elevated perinatal inflammatory biomarkers and adverse neonatal outcomes in high-risk pregnancies. Increased levels of IL-6, CRP, and PCT were strongly correlated with neonatal sepsis, respiratory distress syndrome, low birth weight, and NICU admission. Among the evaluated biomarkers, IL-6 exhibited the highest predictive accuracy, highlighting its potential as an early indicator of neonatal complications. These results are consistent with recent studies emphasizing the role of inflammatory responses in fetal and neonatal morbidity. Incorporating biomarker assessment into routine prenatal monitoring may facilitate early risk identification, timely intervention, and improved neonatal clinical outcomes.

5 Conclusion

This study highlights the importance of perinatal inflammatory biomarkers as valuable predictors of neonatal complications in high-risk pregnancies. Elevated levels of IL-6, CRP, and PCT were significantly associated with adverse neonatal outcomes, including neonatal sepsis, respiratory distress syndrome, low birth weight, and increased NICU admissions. Among the evaluated biomarkers, IL-6 demonstrated the highest predictive accuracy, indicating its potential utility as an early diagnostic indicator. The findings support the integration of biomarker-based assessment into routine prenatal and perinatal care to improve risk stratification and clinical decision-making. Early identification of vulnerable neonates can facilitate timely interventions, optimize neonatal management, and reduce morbidity. Future large-scale prospective studies are recommended to validate these findings and enhance predictive models for neonatal outcome assessment.

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