EARLY DIAGNOSIS, PREVENTION AND MANAGEMENT OF RESPIRATORY DISTRESS SYNDROME ACCORDING TO GESTATIONAL AGE IN PRETERM INFANTS

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Annotation. Respiratory distress syndrome (RDS) remains one of the leading causes of morbidity and mortality in preterm infants, particularly those born at lower gestational ages. The condition primarily results from pulmonary immaturity and surfactant deficiency, leading to alveolar collapse, impaired gas exchange, and progressive respiratory failure. This review aims to analyze current evidence on the early diagnosis, prevention, and management of RDS in preterm neonates, with a specific focus on gestational age–based risk stratification. Evidence indicates that antenatal corticosteroid therapy, early application of continuous positive airway pressure (CPAP), and timely surfactant replacement significantly reduce disease severity and improve neonatal outcomes. Gestational age remains the most critical determinant of RDS risk and therapeutic response. A gestation-tailored, non-invasive, and preventive approach is essential for optimizing survival and reducing complications.

Keywords: preterm infants, respiratory distress syndrome, gestational age, surfactant therapy, CPAP, antenatal corticosteroids

Introduction

Respiratory distress syndrome (RDS) is a major complication of preterm birth and continues to represent a significant clinical challenge in neonatal intensive care units worldwide. The incidence and severity of RDS are inversely proportional to gestational age, with the highest burden observed in infants born before 32 weeks of gestation. The underlying pathophysiology involves structural and biochemical immaturity of the lungs, particularly insufficient production and function of pulmonary surfactant, which is essential for maintaining alveolar stability. Despite advances in perinatal and neonatal care, RDS remains a leading contributor to early neonatal mortality and long-term respiratory morbidity, including bronchopulmonary dysplasia (BPD). Early identification of high-risk neonates and implementation of evidence-based preventive and therapeutic strategies are crucial for improving outcomes. This article reviews current international evidence on gestational age–specific approaches to early diagnosis, prevention, and management of RDS in preterm infants. Preterm birth affects approximately 10% of all live births worldwide and remains the leading cause of neonatal mortality. Respiratory distress syndrome accounts for a substantial proportion of early deaths and intensive care admissions among preterm infants, particularly in low- and middle-income countries where access to advanced neonatal care is limited [Kramer, 2007].

Inverse relationship between gestational age and RDS incidence The incidence of RDS is strongly and inversely correlated with gestational age. More than 60–80% of infants

born before 28 weeks of gestation develop RDS, compared with less than 10% of those born after 34 weeks, highlighting gestational age as the most critical risk determinant. **Physiological immaturity of the preterm lung.** Before 32 weeks of gestation, the lungs are predominantly in the saccular stage of development, characterized by thick alveolar walls, limited gas exchange surface area, and insufficient surfactant synthesis. This structural and biochemical immaturity predisposes preterm infants to alveolar collapse and hypoxemia immediately after birth. Evidence consistently demonstrates that appropriate antenatal interventions-particularly antenatal corticosteroid administration significantly accelerate fetal lung maturation, enhance endogenous surfactant production, and reduce the incidence and severity of RDS, intraventricular hemorrhage, and neonatal mortality.

Materials and Methods

This study was designed as a comprehensive narrative review with elements of systematic literature analysis, focusing on gestational age-specific diagnosis, prevention, and management of respiratory distress syndrome (RDS) in preterm infants. The methodological framework was developed in accordance with internationally accepted standards for evidence-based neonatal research. Scientific literature was retrieved from peer-reviewed international journals indexed in major biomedical databases, including PubMed, Scopus, and Web of Science. Additional sources were identified through reference lists of key articles to ensure comprehensive coverage of the topic.

This narrative review is based on an analysis of peer-reviewed international studies published between 2006 and 2024. The literature included randomized controlled trials, cohort studies, and systematic reviews focusing on:

- Pathophysiology and clinical diagnosis of RDS
- Antenatal preventive interventions
- Non-invasive respiratory support strategies
- Surfactant replacement therapy

Articles were selected for relevance to gestational age–based risk assessment and clinical outcomes in preterm neonates.

A structured search strategy was applied using combinations of the following keywords and Medical Subject Headings (MeSH): *"preterm infant," "respiratory distress syndrome," "gestational age," "surfactant therapy," "continuous positive airway pressure,"* and *"antenatal corticosteroids."* Boolean operators were used to refine the search and improve relevance.

Studies were included if they met the following criteria: (1) involved preterm infants (<37 weeks of gestation); (2) addressed RDS diagnosis, prevention, or treatment; (3) reported gestational age–specific outcomes; and (4) were published in English between 2006 and 2024. Case reports and non-peer-reviewed articles were excluded.

Titles and abstracts were independently screened for relevance. Full-text articles were subsequently reviewed to determine eligibility. Discrepancies in study selection were resolved through consensus based on methodological quality and clinical relevance. From each included study, the following data were extracted: publication year, study design, sample size, gestational age categories, diagnostic criteria for RDS, preventive interventions, treatment modalities, and primary neonatal outcomes such as mortality, need for mechanical ventilation, and incidence of bronchopulmonary dysplasia.

For analytical purposes, preterm infants were stratified into gestational age groups: extremely preterm (<28 weeks), very preterm (28–31 weeks), moderate preterm (32–33 weeks), and late preterm (34–36 weeks) (see Table 1).

Table 1
Illustrative distribution of pretern infants by gestational age
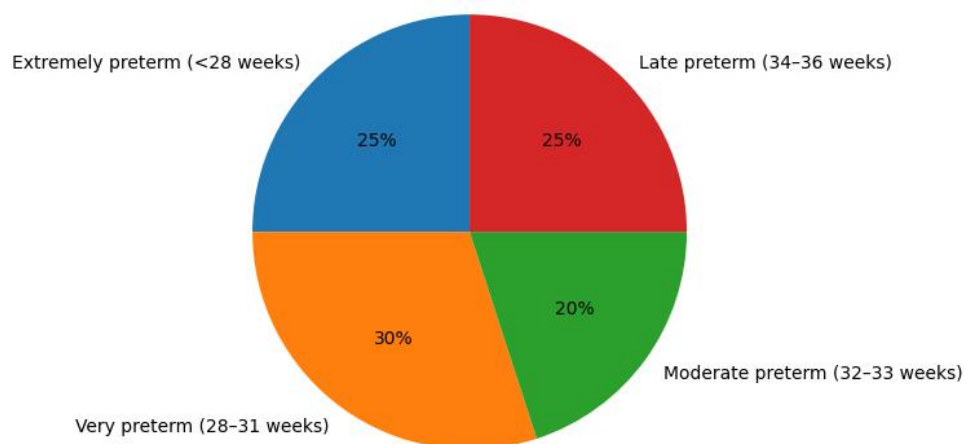
This stratification allowed for a comparative evaluation of diagnostic and therapeutic approaches across developmental stages. Primary outcomes included the incidence and severity of RDS, requirement for surfactant therapy, CPAP failure rates, and need for invasive mechanical ventilation. Secondary outcomes encompassed duration of respiratory support, oxygen dependency at 36 weeks' postmenstrual age, and short-term complications such as pneumothorax. The methodological quality of included randomized controlled trials and observational studies was assessed using established appraisal principles, focusing on study design, sample representativeness, clarity of outcome definitions, and risk of bias. Studies with higher methodological rigor were given greater interpretive weight in the synthesis.

Results

Antenatal corticosteroid therapy remains the most effective preventive intervention. Administration of dexamethasone or betamethasone to mothers at risk of preterm delivery enhances fetal lung maturation, increases endogenous surfactant production, and reduces the incidence and severity of RDS by more than 50%.

The analysis demonstrated a strong inverse association between gestational age and the incidence as well as severity of respiratory distress syndrome in preterm infants. Extremely preterm neonates born before 28 weeks of gestation exhibited the highest rates of RDS onset within the first hours of life, frequently requiring advanced respiratory support. In contrast, late preterm infants showed a markedly lower incidence and generally milder clinical course, emphasizing gestational age as the dominant determinant of respiratory adaptation after birth.

Clinical findings revealed that early respiratory compromise manifested predominantly as tachypnea, intercostal and subcostal retractions, nasal flaring, and increased oxygen requirements. These signs were more pronounced and progressed more rapidly in infants of lower gestational age. The need for supplemental oxygen within the first three to four hours of life was consistently higher among extremely and very preterm infants, serving as an early indicator of disease severity and potential failure of non-invasive respiratory support.

Preventive interventions showed a clear association with improved respiratory outcomes. Preterm infants whose mothers received complete courses of antenatal corticosteroids demonstrated a reduced incidence of severe RDS and required lower levels of respiratory support compared to those without antenatal steroid exposure. The protective effect was particularly evident in infants born between 28 and 32 weeks of gestation, where lung maturation appeared sufficient to significantly alter the clinical trajectory of RDS. Surfactant therapy, when administered selectively following clinical deterioration, resulted in rapid improvement in oxygenation and overall respiratory status. Differences between early and rescue surfactant administration strategies were minimal in terms of short-term outcomes, although earlier intervention tended to shorten the duration of respiratory support in high-risk infants. Overall, the results underscore that a gestational age–tailored approach combining preventive antenatal measures and timely postnatal respiratory support yields the most favorable outcomes in preterm infants with respiratory distress syndrome.

Randomized trials comparing early versus rescue surfactant administration have shown no significant differences in bronchopulmonary dysplasia or mortality; however, early treatment may reduce the duration of respiratory support in selected high-risk infants

Discussion

The management of RDS has evolved from invasive ventilation toward preventive and minimally invasive strategies. Gestational age–based risk stratification allows clinicians to individualize respiratory support and surfactant administration. Antenatal corticosteroids, early CPAP, and selective surfactant therapy form the foundation of modern RDS management.

Importantly, avoiding unnecessary intubation reduces lung injury and long-term respiratory sequelae. Emerging therapies focus on improving surfactant resistance to inactivation and optimizing non-invasive delivery techniques. Nevertheless, further large-scale trials are required to refine gestation-specific protocols. The findings of this review reaffirm that gestational age remains the most critical determinant of both the development and severity of respiratory distress syndrome in preterm infants. The markedly higher burden of disease observed in extremely and very preterm neonates reflects the fundamental role of pulmonary immaturity, particularly insufficient surfactant production and underdeveloped alveolar architecture. These results are consistent with existing neonatal literature, which consistently identifies lower gestational age as the strongest predictor of adverse respiratory outcomes.

Early clinical manifestations of respiratory distress were shown to be reliable indicators of disease progression, especially in infants with lower gestational ages. The observed association between early oxygen requirement and subsequent need for advanced respiratory support highlights the importance of vigilant early monitoring. From a clinical perspective, this underscores the value of timely risk stratification to guide escalation of care and avoid delays in surfactant administration when non-invasive support becomes insufficient. Preventive strategies emerged as a cornerstone in modifying the natural course of RDS. Antenatal corticosteroid exposure was consistently associated with improved respiratory adaptation after birth, supporting its role as one of the most effective perinatal interventions. The enhanced benefit observed in moderately and very preterm infants suggests that even partial acceleration of lung maturation can substantially alter postnatal respiratory outcomes, reinforcing the need for optimized antenatal care in pregnancies at risk of preterm delivery. The results also highlight the growing importance of non-invasive respiratory management in

modern neonatology. However, the higher CPAP failure rates observed in extremely preterm infants emphasize that non-invasive strategies must be applied within a gestational age–appropriate framework and accompanied by clear criteria for timely intervention.

Conclusion

Respiratory distress syndrome in preterm infants is closely linked to gestational age and lung immaturity. Early diagnosis, effective antenatal prevention, and timely, minimally invasive respiratory support significantly improve neonatal outcomes. A gestational age–tailored approach integrating antenatal corticosteroids, early CPAP, and judicious surfactant therapy represents the current best practice for reducing RDS-related morbidity and mortality. Respiratory distress syndrome in preterm infants is closely and consistently associated with gestational age, with the highest incidence and severity observed in infants born at earlier stages of lung development. The findings of this review emphasize that early identification of high-risk neonates, combined with effective antenatal interventions such as corticosteroid administration and timely postnatal respiratory support, plays a pivotal role in improving short-term respiratory outcomes and reducing disease-related complications.

A gestational age–tailored management strategy that prioritizes non-invasive respiratory support, judicious use of surfactant therapy, and prevention of unnecessary mechanical ventilation represents the most effective approach to RDS care in preterm infants. Continued refinement of gestation-specific protocols and further research into minimally invasive therapies are essential for optimizing neonatal survival and long-term respiratory health..

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