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Requirement respiratory support in preterm neonates

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Abstract

Introduction: Preterm birth leads to a number of life-threatening complications, especially respiratory issues. The use of positive airway pressure in babies with respiratory failure has been associated with significant reductions in respiratory failure, morbidity, and death. Positive pressure ventilation can be delivered either by conventional invasive ventilation or by non-invasive methods like CPAP or Duo PAP. Invasive ventilation causes barotrauma and volutrauma which can be avoided using non-invasive ventilation.To prevent dis advantages of the invasive ventilation, CPAP can be used as a first line of treatment in cases of moderate to severe distress.

Objective: to study the requirement of respiratory support in early preterm neonates

Materials and Methods: A retrospective cross-sectional study was carried out in the Neonatal Intensive Care Unit of a tertiary healthcare Centre.

Positive pressure ventilation was given using CPAP, Duo PAP, or conventional invasive ventilation and administration of surfactant depending upon the chest x-ray and level of respiratory distress scored by Silverman-Anderson scoring. All neonates at or below 34 weeks of gestation with signs and symptoms of respiratory distress. Neonates above 34 weeks of gestation and neonates having congenital heart diseases.

Results: 92 cases of preterm neonates were studied over a period of 6 months of which 73 cases required positive pressure ventilation. Out of the 73 cases, 47 cases had received antenatal steroids of which 39 cases had received 2 doses of antenatal steroids and the rest received a single dose of antenatal steroids. Out of these 73 cases, 66 cases were managed by CPAP or Duo PAP and 7 cases required conventional invasive ventilation. Out of the 73 cases 38 cases required surfactant ad ministration. Positive pressure ventilation using CPAP was found to be adequate for cases with moderate to severe respiratory distress when the cause of respiratory distress was specific to a respiratory cause. In cases of poor respiratory drive and cardiovascular instability or patients who required resuscitation needed conventional invasive ventilation.

Keywords: neonate, respiratory distress, preterm, positive pressure ventilation

Introduction

Preterm birth leads to several life-threatening complications, especially respiratory issues. The use of positive airway pressure in babies with respiratory failure has been associated with significant reductions in respiratory failure, morbidity, and death. Positive pressure ventilation can be delivered by conventional invasive ventilation or non-invasive methods like CPAP or Duo PAP.

Invasive ventilation causes barotrauma and volutrauma which can be avoided using non-invasive ventilation. Short-term complications of invasive mechanical ventilation include air leak syndromes, pulmonary hemorrhage, lung atelectasis, airway in flammation, subglottic stenosis, and ventilation -associated pneumonia. The long-term complication is broncho pulmonary dysplasia which is a significant cause of morbidity in preterm infants. To prevent disadvantages of the invasive ventilation, CPAP can be used as a first line of treatment in cases of moderate to severe distress.

Neonates are usually classified according to their gestational age. The outcome of the neonates varies with the gestational age.

Neonates born before 37 weeks of gestation are preterm neonates. Preterm neonates are further sub grouped as; Extremely preterm - <28 weeks of GA, Early preterm <34 weeks of GA, and late preterm born between 34 0/7 and 36 6/7 weeks of gestation.

Preterm births are associated with numerous respiratory problems which include respiratory depression after birth mainly due to hypoxic-ischemic perinatal conditions, respirtory distress syndrome due to surfactant deficiency, apnoeic episodes due to immature Mechani SMS for controlling the breathing and chronic lung disease of prematurity.

Respiratory distress syndrome due to surfactant deficiency in early preterm neonates still remains one of the major cause of morbidity and mortality.

Respiratory distress syndrome (RDS), formerly known as hyaline membrane disease (HMD), describes a disease typical of preterm infants that is caused by generalized atelectasis of alveoli due to insufficient pulmonary surfactant.

Pulmonary surfactant is a complex mixture of phospholipids, neutral lipids, and surfactant-specific proteins that is synthesized, packaged, and secreted from alveolar type II cells of the lung. In the alveoli, the surfactant disrupts the surface tension generated at the air–liquid interface.

The alveoli and respiratory bronchioles are lined by a liquid layer over the surface of the lung epithelium. The surface tension exerted by this lung liquid is sufficient to

promote atelectasis in the distal lung and oppose re-expansion of atelectatic airspaces. The polar head groups of surfactant phospholipids

interposed between water molecules break the hydrogen bonding that mediates the surface tension. Therefore, an inadequate or dysfunctional surfactant in infants with RDS leads to an inappropriately high alveolar surface tension, resulting in difficulties in recruiting atelectatic alveoli and in progressive atelectasis of recruited airspaces.

An absent or insufficient surfactant due to develop mental immaturity of alveolar type II cells (rarely due to mutations of surfactant-related genes), or inactivation of the surfactant due to inflammation (pneumonia), chemical modification (meconium), or lung injury, results in high surface tension and atelectasis. Preterm infants are particularly prone to RDS because alveolar type II cells do not develop until early in the third trimester, and their number and capacity to produce a surfactant increase throughout the third trimester.

Lower gestational age is the most important predictor of surfactant deficiency. Clinical features of RDS are usually seen in preterm infants <34 weeks of gestation.

Signs of respiratory distress mainly include chest retractions, grunting, nasal flaring, hypoxia and tachypnoea.

The severity of RDS can be analysed using Silverman Anderson scoring system. A score of >5 is suggestive of increased work of breathing and has a higher need for respiratory support to improve functional residual capacity.

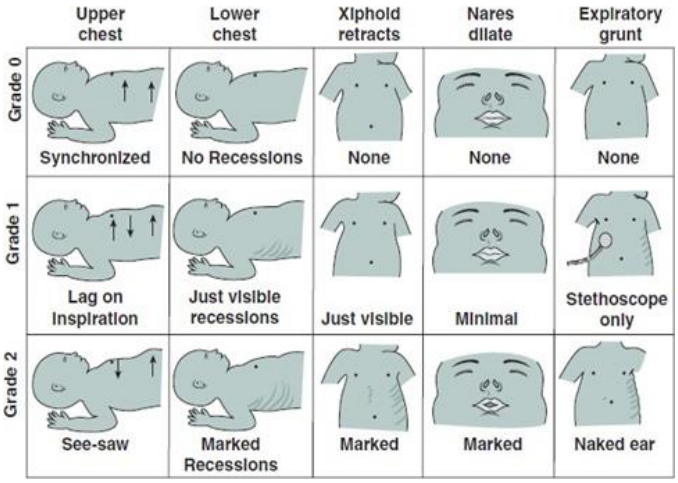

Figure 1: Silverman Anderson scoring

Radio logical Findings in RDS are due to atelectasis of alveoli (homogenous white lung) “black” bronchi that do not collapse (air bronchograms: black bronchi stand out on the white background) Low volume lungs are seen before initial ting CPAP or any other form of ventilation.

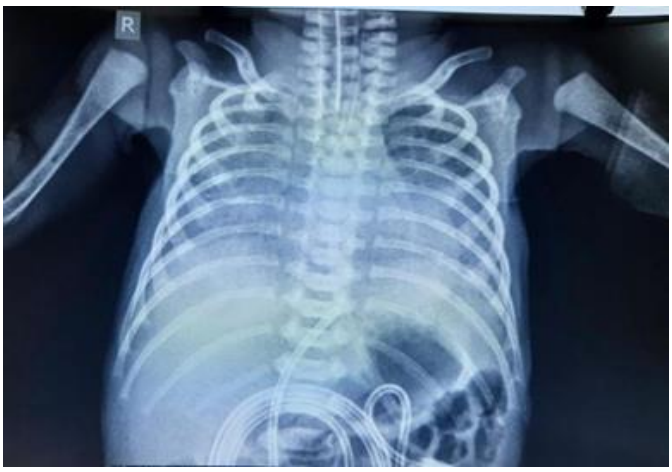

Figure 2: Chest radiograph showing RDS

Findings on ultrasonography of lung are consolidation with air bronchogram, irregular and thickened pleural line, compact B-lines from the base to the apex, A-line disappearance on the transthoracic view, and diffuse retro - diaphragmatic hyper – echogenicity replacing the normal diaphragm echo complex on the transabdominal view are the main findings on the lung ultrasound.

Prevention of RDS is done by the administration of antenatal steroids. The target population for this is

pregnant women at 24 to 34 weeks of gestation with preterm labour or planned delivery.

A complete course of ANS is considered to be either betamethasone at 12 mg intramuscular (IM) q24h × 2 doses OR dexamethasone 6 mg IM q12h × 4 doses, course completed at least 24 hours before the delivery.

In the management of RDS major goal is to establish and maintain FRC at the earliest either by using IMV or CPAP. The most important role of pulmonary surfactant in the alveoli and distal respiratory bronchioles is to maintain a low surface tension that permits the alveoli to remain patent at low pressures.

CPAP or continuous positive airway pressure was first used clinically in preterm infants in 1971. (1)

Constant PEEP (Positive end-expiratory pressure) is delivered by N-CPAP (Nasal CPAP) devices to neonatal lung via different interfaces. PEEP prevents the collapsing of alveoli in the lungs and maintains the functional residual capacity and facilitates gas exchange. (2)

Mechanism of Action of CPAP is as follows

- continuous distending pressure level to maintain functional residual capacity (FRC)
- reduction of airway collapse by decreased airway resistance
- splinting of the pharyngeal airway to avoid obstruction
- keeping surfactant on alveolar surface and reduction of alveolar edema
- reduced work of breathing
- improvement in ventilation-perfusion ratio and decreased intrapulmonary shunting. (1)

Main components of CPAP are

1. Pressure generator
2. Compressed air, compressed oxygen and a blender.
3. Humidifier.
4. Patient interface – nasal prongs or nasal mask.

Figure 3: Nasal mask, patient interface for CPAP

Complications associated with CPAP use are

- Over distension of lungs
- Air leaks
- Nasal septum trauma
- Failure of CPAP

Second goal of management of RDS includes restoration of pulmonary surfactant. There is an advantage to early surfactant treatment of infants at the onset of RDS signs as compared to waiting to establish a diagnosis of RDS. For infants on optimal CPAP, if the FiO2 is >0.30, the surfactant may be administered by the In Sur E (Intubate - Surfactant administration - Extubate) method.

The baby is extubated to CPAP within 15 minutes of surfactant delivery. Newer minimal invasive methods of surfactant delivery are now being used. Natural surfactants are better than synthetic surfactants. Available surfactants include a variety of animal-derived products and protein-free synthetic surfactants. Synthetic surfactants modified by the surfactant proteins B and C are also available, and overcome the major difference from animal-derived surfactants.

Babies with poor respiratory efforts, recurrent apnea or severe RDS (High FiO2 requirement, high CO2 despite optimal CPAP and surfactant), and cardio respiratory failure should be identified early and supported with intermittent invasive mandatory ventilation.

Short-term complications of invasive mechanical ventilation include air leak syndromes, pulmonary hem or rhage, lung atelectasis, airway inflammation, sub glottic stenosis, and ventilation - associated pneu monia. The long-term complication is broncho pulmonary dysplasia which is a significant cause of morbidity in preterminfants.

Materials and methods

A retrospective cross-sectional study was carried out in the Neonatal Intensive Care Unit of a tertiary healthcare Centre. Positive pressure ventilation was given using CPAP, Duo PAP, or conventional invasive ventilation and administration of surfactant depending upon the chest x-ray and level of respiratory distress scored by Silverman-Anderson scoring. All neonates at or below 34 weeks of gestation with signs and symptoms of respiratory distress.

Neonates above 34 weeks of gestation and neonates having congenital heart diseases.

Results

Chart 1: Requirement of positive pressure ventilation in preterm neonates at and before 34 weeks of gestation.

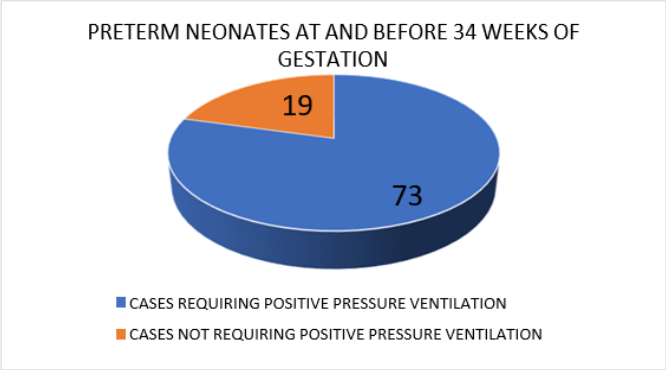

Chart 1: 92 cases of preterm neonates were studied over a period of 6 months of which 73 cases required positive pressure ventilation.

Chart 2: Antenatal doses of steroids

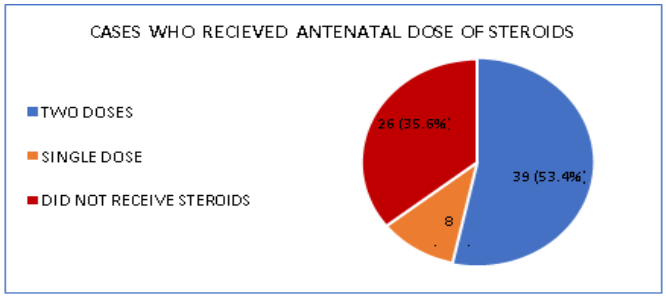

Chart 2 Out of the 73 cases, 47 cases had received antenatal steroids of which 39 (53.4%) cases had received 2 doses of antenatal steroids and the rest received a single dose of antenatal steroids.

Chart 3: Management by ventilation

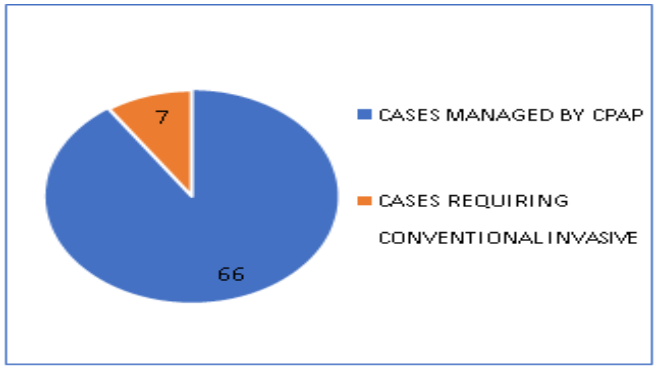

Chart 3 Out of these 73 cases, 66 cases were managed by CPAP or Duo PAP and 7 cases required conventional invasive ventilation.

Chart 4: Management by surfactant

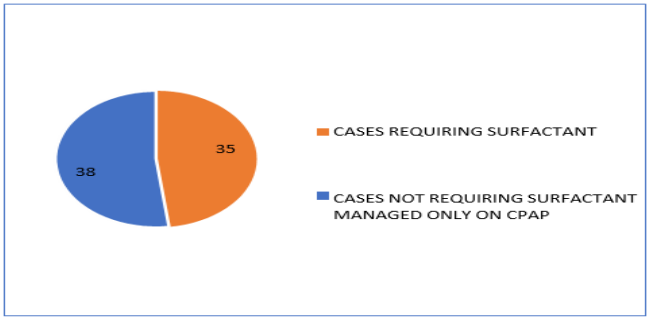

Chart 4 Out of the 73 cases 35 cases required surfactant administration.

Chart 5: Association of risk factors with respiratory distress

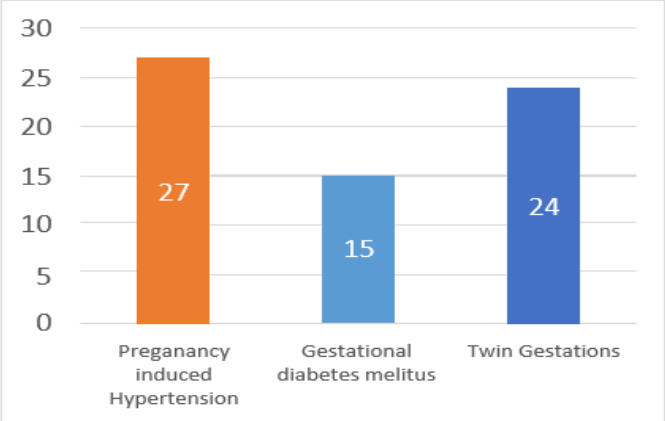

Chart 5 respiratory distress was associated with Pregnancy-induced hypertension in 90% of cases, Gestational diabetes mellitus in 50% of cases, and twin gestation in 60% of cases.

Chart 6: Mode of delivery

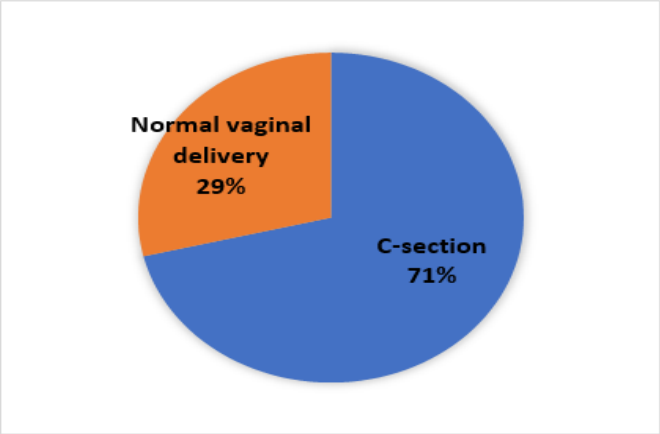

Chart 6: 71 % of cases were born by C-section and 29% of cases were born by normal vaginal delivery

Discussion

Cases of respiratory distress syndrome can be managed by using CPAP or Duo PAP and surfactant administration alone without the use of invasive mechanical ventilation.

Early initiation of CPAP or other forms of Non-Invasive Ventilation reduces the need for reintubation or invasive mechanical ventilation thus reducing the complications.

Our study showed similar results to the studies which have been discussed below.

Timothy et al. (2007) [3], conducted an analysis "Early surfactant administration with brief ventilation vs. selective surfactant and continued mechanical ventilation for preterm infants with or at risk for respiratory distress syndrome". The objective of the study was to compare two treatment strategies in preterm infants with or at risk for RDS: early surfactant administration with brief mechanical ventilation (less than one hour) followed by Extubation vs. later selective surfactant administration, continued mechanical ventilation, and Extubation from low respiratory support. Six randomized controlled clinical trials met selection criteria and were included in this review. In these studies of infants with signs and symptoms of RDS, intubation and early surfactant therapy followed by Extubation to nasal CPAP (NCPAP) compared with later selective surfactant administration was associated with a lower incidence of mechanical ventilation [typical RR 0.67, 95% CI 0.57, 0.79], air leak syndromes [typical RR 0.52, 95% CI 0.28, 0.96] and BPD [typical RR 0.51, 95% CI 0.26, 0.99]. A larger proportion of infants in the early surfactant group received surfactant than in the selective surfactant group [typical RR 1.62, 95% CI 1.41, 1.86]. The number of surfactant doses per patient was significantly greater among patients randomized to the early surfactant group [WMD 0.57 doses per patient, 95% CI 0.44, 0.69]. In stratified analysis by FIO2 at study entry, a lower threshold for treatment (FIO2 < 0.45) resulted in lower incidence of air leak [typical RR 0.46 and 95% CI 0.23, 0.93] and BPD [typical RR 0.43, 95% CI 0.20, 0.92]. A higher treatment threshold (FIO2 > 0.45) at study entry was associated with a higher incidence of patent ductus

arteriosus requiring treatment [typical RR 2.15, 95% CI 1.09, 4.13].

Kajsa Bohlin (4), from Department of Neonatology, Karolinska University Hospital and Karolinska Institute, Stockholm, Sweden wrote a review article "RDS – CPAP or surfactant or both" and concluded that early CPAP in very preterm infants is as safe as routine intubation in the delivery room. However, a strategy for surfactant administration should be part of a non-invasive ventilation approach for those infants at risk of developing significant RDS. Shivtej et al. (2019) (5), conducted a study "Effect of single dose and double dose antenatal corticosteroids on respiratory distress syndrome among preterm babies", they included 55 babies born to mothers who received single dose of antenatal corticosteroids and delivered at 12hrs before receiving 2nd dose antenatal corticosteroids and 55 babies born to mothers who received double dose of antenatal corticosteroids. Once baby is born, they compared for the requirement of surfactant. The conclusion was there was significant reduction in RDS in babies whose mother received complete course of antenatal corticosteroids.

Kulkarni et al. (2021) (6), conducted a study "A study of respiratory disorders in neonates in emergency caesarean section, elective caesarean section and normal vaginal delivery at term" with an objective to find out whether the mode of delivery is associated with the neonatal respiratory outcomes. It was an observational study, following three groups of pregnant women (30 in each group) were included a) normal vaginal delivery b) elective LSCS and c) emergency LSCS. Respiratory morbidity (Tachypnoea, chest retraction, grunting, and nasal flaring) and APGAR scores were compared between three groups. The results showed that Respiratory morbidity was higher in elective and emergency LSCS groups compared to normal vaginal delivery group. However, the differences were not statistically significant. APGAR scores at 1 and 5 minutes were similar in three groups. NICU admissions were higher in elective caesarean groups as compared to the other two groups. Afjeh et al. (2017) (7), conducted a prospective study "Evaluation of Initial Respiratory Support Strategies in VLBW Neonates with RDS". This prospective study was conducted over three years (March 21, 2011 to March 20, 2014). Each eligible VLBW baby with RDS diagnosis received a specific initial respiratory support, including room air, oxygen therapy, n. CPAP, NIPPV, Mechanical Ventilation ± use of surfactant, based on clinical evaluation; then, the next strategies were selected based on the disease progression. The results showed in total, 499 neonates were included in the study. The mean birth weight was 1,125 ± 254 g and the gestational age was 29.2 ± 2.5 weeks. The initial respiratory support included: Room Air = 43, O2 thrapy = 60, N. CPAP/NIPPV = 219, INSURE = 83 and MV ± SURF = 177. In terms of the need for IRS upgrading during hospitalization, neonates not on mechanical ventilation (64.5%) were divided into three groups. In 45.3% of cases, the IRS did not change (Never upgrading); in 24.5% of cases, the level of IRS increased but there was no need for e MV in the first three days of life (Specific); in 24.8% of cases, there was need for e MV within the first three days of life (Absolute) and during hospitalization (after the first three days of life) 5.3% of cases were in need of e MV (General). The reasons for upgrading the respiratory support were low gestational age, low birth weight, multiple pregnancy, maternal disease, low one-minute Apgar score, and need for surfactant therapy had

significant correlation, and multivariable analysis showed that low gestational age, low birth weight and maternal disease were risk factors independently correlated to IRS upgrading, CLD and death.

Conclusion

Early initiation of positive pressure ventilation using CPAP and surfactant administration was found to be adequate for cases with moderate to severe respiratory distress when the cause of respiratory distress was specific to a respiratory cause. In cases of poor respiratory drive and cardio vascular instability or patients who required resuscitation at birth needed conventional invasive ventilation.

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Abbreviations

RDS – respiratory distress syndrome

CPAP- Continuous positive airway pressure

IMV- Invasive mechanical ventilation

GA- Gestational age