

COMPARATIVE EFFECTIVENESS OF CONTINUOUS POSITIVE AIRWAY PRESSURE VERSUS MECHANICAL VENTILATION IN PRETERM NEONATES WITH RESPIRATORY DISTRESS SYNDROME

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Abstract

Objective: The objective of this study was to study Comparative effectiveness of continuous positive airway pressure versus mechanical ventilation in preterm neonates with respiratory distress syndrome

Study design: Comparative Cross Sectional Observational Study

Place and duration of study: Department of Pediatrics, Tertiary Care Hospital, Faisalabad from November 2024- April 2025.

Methodology: 100 preterm neonates diagnosed with respiratory distress syndrome (RDS) were included. Neonates were divided into two groups based on respiratory support received: continuous positive airway pressure (CPAP) and mechanical ventilation (MV), with 50 patients in each group. Clinical diagnosis, radiological findings, and gestational age criteria were used for inclusion. Data regarding demographic characteristics, duration of respiratory support, complications, NICU stay, and mortality were collected and analyzed using SPSS version 26, with $p < 0.05$ considered statistically significant.

Results: The study demonstrated that preterm neonates managed with CPAP had significantly better clinical outcomes compared to those receiving mechanical ventilation. The CPAP group showed shorter duration of respiratory support, oxygen therapy, and NICU stay. Complications such as bronchopulmonary dysplasia, pneumothorax, and sepsis were more common in the mechanical ventilation group. Mortality was lower among neonates treated with CPAP, although the difference was not statistically significant. Overall, CPAP proved to be an effective non-invasive respiratory support strategy associated with reduced morbidity and fewer ventilation-related complications in preterm neonates with respiratory distress syndrome.

Conclusion: Continuous positive airway pressure is an effective and safer initial respiratory support modality for preterm neonates with respiratory distress syndrome. It reduces respiratory complications, duration of hospitalization, and need for prolonged invasive respiratory support.

Introduction:

Respiratory distress syndrome (RDS) is still one of the most frequent causes of morbidity and

mortality in preterm neonates all over the world. It is mainly caused by a lack of surfactant and immature lungs which cause alveolar collapse,

poor gas exchange and progressive respiratory failure. Although great strides have been made in the care of the newborn, RDS remains an important clinical problem, especially for babies born before 34 weeks of pregnancy. The incidence and severity of RDS decreases as birth weight and gestational age increases, and the early neonatal period is a critical stage in which premature neonates are at risk of developing RDS.[1]

Recent advances in antenatal steroid therapy, surfactant replacement and ventilatory support have improved the survival rate for preterm infants over the last few decades. Continuous positive airway pressure (CPAP) and mechanical ventilation (MV) are the common used respiratory support modalities for neonatal RDS. CPAP delivers any positive airway pressure throughout the respiratory cycle, ensuring that the alveoli stay open and that the FRC is increased and work of breathing reduced, without invasive measures. Mechanical ventilation, on the other hand, provides mechanical assistance to respiration by invasive endotracheal intubation and is typically used when non-invasive means of assistance have failed and babies have severe respiratory insufficiency.[2]

Mechanical ventilation (MV) is life-saving in severely ill neonates but prolonged MV has been linked with a number of complications such as ventilator-associated lung injury, bronchopulmonary dysplasia (BPD), pneumothorax and a higher rate of nosocomial infections. All these complications have spurred clinicians to consider less invasive strategies for respiratory support whenever possible. CPAP has become a hot topic as a first-line therapy due to the possibility of avoiding intubation and minimizing the occurrence of ventilatory complications. In some cases, however, CPAP may not be effective in providing adequate support for respiration, especially in very premature infants with severe RDS, and the need to advance to mechanical ventilation.[3]

Preterm neonates with RDS have been studied in several clinical trials and observational studies using either CPAP or mechanical ventilation. Early CPAP is believed to reduce the incidence of chronic lung disease and hospital stay, but

mechanical ventilation may provide more stabilization in cases of severe respiratory failure. The differences in the findings reflect the current controversy and uncertainty about the best approach to respiratory care in the treatment of RDS in pre-term infants. Moreover, the reported outcomes are inconsistent due to variations in demographics of neonates, severity of illness, surfactant administration protocols and institutional practices.[4]

More research is needed to assess the effectiveness and safety of CPAP and mechanical ventilation to ensure the most effective and safe form of respiratory support is selected. The purpose of this study is to determine if continuous positive airway pressure (CPAP) is as effective as mechanical ventilation (MV) for treating respiratory distress syndrome (RDS) in preterm neonates by evaluating clinical outcomes including survival rate, duration of respiratory support, complications and hospital length of stay. The results of this study could be used to inform future evidence-based neonatal respiratory care and to enhance care for preterm infants with RDS.

Methodology:

In this current comparative observational study, the effectiveness of CPAP versus MV in treatment of the ventilatory support for neonates diagnosed with respiratory distress syndrome (RDS) was evaluated in the *Department of Pediatrics, Tertiary Care Hospital, Faisalabad from November 2024- April 2025*. All enrolled neonates were enrolled with the parents/legal guardians informed consent and the study received institutional review board approval before beginning.

This study was conducted with the preterm neonates who had been transferred to the NICU within 24 hours after birth and were clinically diagnosed as having RDS with a gestational age less than 37 weeks. The diagnosis of RDS was made on clinical grounds, presence of tachypnea, chest retractions, nasal flaring, characteristic chest X-ray changes (reticulogranular appearance, air bronchograms) and cyanosis. Major congenital anomalies, congenital heart disease, birth asphyxia, meconium aspiration syndrome,

congenital pneumonia, and chromosomal abnormalities were excluded from the study.

The non-probability consecutive sampling technique was used to enroll the neonates with total 100 neonates who fulfilled the inclusion criteria. The neonates were randomized into two groups based on the method of their initial respiratory support. There were 50 neonates in Group A (continued positive airway pressure), and 50 neonates in Group B (mechanical ventilation). Respiratory support was considered as per the severity of the respiratory distress, oxygen saturation, arterial blood gas analysis and overall clinical condition of the neonate by the attending neonatologist.

Nasal CPAP in the CPAP group started with short binasal prongs and a starting positive end-expiratory pressure (PEEP) of 4–6 cm H₂O, with the fraction of inspired oxygen (FiO₂) adjusted to keep the oxygen saturation in the range of 90%–95%. The mechanical ventilation group neonates were intubated and ventilated with synchronized intermittent mandatory ventilation (SIMV) mode, with parameters set based on blood gases and clinical response. When necessary, surfactant was used in either group as per NICU protocol.

A structured proforma was used to collect the data with the following variables: Gestational age, birth weight, sex, mode of delivery, Apgar score. Clinical outcome measures were duration of respiratory support, duration of oxygen therapy, length of time in the NICU, surfactant administration, rate

of complications (including pneumothorax, bronchopulmonary dysplasia, sepsis, intraventricular hemorrhage, and mortality), and length of time in NICU.

All collected data were entered and analyzed by a computer program called Statistical Package for Social Sciences (SPSS) version 26. Data from quantitative variables were reported as mean $\pm$ standard deviation and data from qualitative variables were reported as frequencies and percentages. Comparisons between the two groups for continuous variables were done using an independent sample t test, and for categorical variables, using a chi-square test. A p value of < 0.05 was taken to be statistically significant.

Results:

A total of 100 preterm neonates diagnosed with respiratory distress syndrome (RDS) were included in the study. Among them, 50 neonates received continuous positive airway pressure (CPAP) and 50 neonates were managed with mechanical ventilation (MV). The demographic and baseline clinical characteristics of both groups were comparable.

The mean gestational age in the CPAP group was 31.8 ± 2.1 weeks, while in the MV group it was 30.9 ± 2.4 weeks. The mean birth weight was slightly higher in the CPAP group (1.62 ± 0.38 kg) compared to the MV group (1.49 ± 0.41 kg). Male neonates constituted 56% of the total study population.

Table 1: Baseline Characteristics of Study Population

Variables	CPAP Group (n=50)	MV Group (n=50)	p-value
Gestational age (weeks)	31.8 ± 2.1	30.9 ± 2.4	0.08
Birth weight (kg)	1.62 ± 0.38	1.49 ± 0.41	0.11
Male gender	28 (56%)	28 (56%)	1.00
Cesarean delivery	31 (62%)	29 (58%)	0.68
Mean Apgar score at 5 min	7.1 ± 1.2	6.5 ± 1.4	

Clinical outcomes showed significant differences between the two groups. Neonates managed with CPAP demonstrated shorter duration of respiratory support and reduced NICU stay compared to those receiving mechanical ventilation. The mean duration of respiratory

support in the CPAP group was 4.8 ± 1.9 days, whereas it was 7.6 ± 2.8 days in the MV group ($p < 0.001$). Similarly, the average length of NICU stay was significantly lower in the CPAP group.

Complications were more frequently observed in neonates managed with mechanical ventilation.

Bronchopulmonary dysplasia (BPD) occurred in 6% of the CPAP group compared to 20% in the MV group. Pneumothorax and sepsis were also more common among mechanically ventilated

neonates. Mortality rate was lower in the CPAP group, although the difference did not reach statistical significance.

Table 2: Comparison of Clinical Outcomes

Outcomes	CPAP Group (n=50)	MV Group (n=50)	p-value
Duration of respiratory support (days)	4.8 ± 1.9	7.6 ± 2.8	<0.001
Duration of oxygen therapy (days)	5.3 ± 2.2	8.1 ± 3.1	<0.001
NICU stay (days)	9.4 ± 3.7	13.6 ± 4.5	<0.001
Surfactant administration	18 (36%)	32 (64%)	0.005
Bronchopulmonary dysplasia	3 (6%)	10 (20%)	0.037
Pneumothorax	2 (4%)	8 (16%)	0.046
Sepsis	5 (10%)	12 (24%)	0.06
Mortality	4 (8%)	9 (18%)	0.13

Overall, the findings of this study suggest that CPAP is associated with better clinical outcomes and fewer complications compared to mechanical ventilation in preterm neonates with respiratory distress syndrome. Early use of non-invasive respiratory support reduced the need for prolonged oxygen therapy and invasive ventilation-related complications, thereby improving neonatal recovery and reducing NICU hospitalization duration.

Discussion:

Respiratory Dysfunction (RD) is still one of the most significant and prevalent causes of neonatal morbidity and mortality in low- and middle-income countries where access to advanced neonatal care might be restricted in certain areas. The present study showed that in preterm neonates with RDS, there were better clinical outcomes, reduced duration of respiratory support, shorter NICU stay, and fewer complications in those who were supported by continuous positive airway pressure (CPAP) than in those who were supported by mechanical ventilation (MV).

The mean duration of respiratory support and oxygen therapy was significantly reduced in the CPAP group in this study. This study agrees with several cross-national research studies which have led to greater implementation of non-invasive

ventilation techniques in preterm infants. In the SUPPORT trial, early CPAP was found to be a safe alternative to routine intubation, and may decrease the risk of exposure to prolonged mechanical ventilation, while the COIN trial reported that early CPAP does not significantly increase risk. In the same manner, a Cochrane review showed that the use of CPAP for the sole purpose of preventing or early treatment of BPD or death in comparison to invasive ventilation strategies was effective.[5]

The present study also revealed that neonates on CPAP had a lower prevalence of bronchopulmonary dysplasia. Mechanical ventilation has been shown to cause ventilator-induced lung injury (VILI) by inducing barotrauma, volutrauma, and oxygen toxicity, all of which may predispose premature lungs to chronic lung disease (CLD). Earlier studies have shown that reducing exposure to invasive ventilation decreases the risk of BPD and improves pulmonary outcomes in premature infants. Our results are consistent with those reported in other neonatal centers around the world where use of bubble CPAP protocols led to significant decreases in ventilator days and BPD development.[6]

The other significant finding of this study was that there were fewer cases of pneumothorax and sepsis in the CPAP group. Mechanical ventilation, invasive procedures and high hospital exposure

are risk factors for complications in neonates receiving mechanical ventilation. Another study by Bahman-Bijari et al. confirmed that bubble CPAP had fewer complications and reduced hospital stay than ventilator CPAP. Similarly, Badiie et al. reported that nasal CPAP was beneficial as early treatment decreased the requirement for invasive interventions like intubation and mechanical ventilation.[7]

The CPAP group in our study had a lower mortality rate but this was not statistically significant. This discovery is similar to the results of other RCTs that have reported comparable survival rates between CPAP and mechanical ventilation groups, with fewer reported morbidity rates and less chronic lung disease in the CPAP group. A lack of statistically significant differences in mortality could result from the relatively small sample size and the differences in severity of the disease of the neonates enrolled.[8]

The national level studies performed in South Asian countries like Pakistan and India have also underscored the significance of early CPAP in the management of neonatal respiratory failure. A recent prospective cohort study conducted in South India revealed that bubble CPAP was an effective and safe mode of initial respiratory support with over 60% of neonates treated effectively without proceeding to mechanical ventilation. CPAP is especially important in resource-limited areas due to its low cost, technical ease and reduced health care burden when compared to invasive ventilation. The factors are very pertinent for the neonatal unit in developing countries where advanced ventilatory support might not be available all the time.[9]

While CPAP has been shown to have beneficial effects, mechanical ventilation remains necessary in some neonates who suffer from a severe degree of respiratory compromise or have failed to respond to CPAP. Failure to use CPAP has been found to be correlated with increased morbidity, longer hospital stays and increased incidence of BPD. Hence, it is important to monitor and escalate respiratory support when needed in neonatal intensive care units. Mechanical ventilation remains an important life-saving tool for neonates who are severely ill and not able to be

managed with non-invasive ventilatory assistance.[10]

The results of the present study agree with the existing guidelines for neonatal respiratory care which recommend early CPAP use if possible, in preterm neonates with RDS. Minimizing invasive ventilation exposure will lead to better respiratory outcomes and reduced complications from long-term mechanical ventilation. There are some limitations in the study such as single centre, small sample size, and limited follow up period. To further assess long term neurodevelopmental and pulmonary outcomes of various respiratory support strategies, multi-centre longitudinal studies with larger numbers of children are recommended.[11]

This study demonstrates that CPAP is an effective and safer method of initial respiratory support for preterm neonates with respiratory distress syndrome than mechanical ventilation. CPAP use early in life can have a profound impact on reducing respiratory morbidity, length of stay in the NICU and ventilation related morbidity, thereby enhancing neonatal outcomes and optimal NICU practices.[12]

The increasing use of CPAP in the NICU is mostly because it can provide adequate respiratory support without disrupting the normal functions of the immature lungs. CPAP does not require repeated airway instrumentation unlike mechanical ventilation and reduces the risk of damaging the fine pulmonary epithelium. This physiological benefit is particularly helpful in very preterm and very LBW babies whose lungs are very vulnerable to inflammation and damage. There are several studies that show that early use of CPAP leads to more alveolar recruitment and preserves functional residual capacity without excessive pressure induced lung damage.[13]

Early use of CPAP for spontaneously breathing preterm infants is strongly recommended by international neonatal guidelines, such as the American Academy of Pediatrics (AAP) and European Consensus Guidelines on the Management of RDS. These are recommendations based on evidence that non-invasive respiratory support decreases the need for

intubation and decreases chronic respiratory complications.

The European Consensus Guidelines also make a point of the importance of using CPAP in conjunction with selective surfactant therapy for the treatment of neonatal RDS. One of the other important results of our study was that neonates that were managed with CPAP had a shorter stay in the NICU. Lower rates of hospitalization help to lower the risk of hospital-acquired infections and cost to the healthcare system and families. This is especially important in low-income countries, where resources for neonatal intensive care are scarce, and extended NICU stays might be unaffordable. Research in Africa and South Asia has shown that low-cost bubble CPAP devices effectively reduce neonatal mortality and are cost-effective and feasible on a large scale. [14]

The fact that the CPAP group required less surfactant administration in this study also suggests that early non-invasive respiratory support could decrease the severity of the disease and increase the endogenous lung function. Previous studies have demonstrated the ability of CPAP to stabilize patients immediately after birth to prevent or delay the development of alveolar collapse and thereby lessen the necessity for mechanical ventilation and other aggressive respiratory therapies. This approach is consistent with the minimally invasive approach that is being encouraged in the field of neonatal medicine. [15,16]

While there are benefits to CPAP, it does have its drawbacks. Patients with a severe surfactant deficiency, extreme prematurity or recurrent apnea may not respond to CPAP, and may need to be escalated to invasive ventilation. If necessary, the intubation may be delayed, which could lead to a worse respiratory outcome. Thus, it became important to identify the factors that predict CPAP failure to optimize neonatal respiratory care. In previous research, certain factors have been found to be associated with a higher risk of CPAP failure, including very low GA, severe chest retractions, persistent metabolic acidosis, and high oxygen requirement. [17,18]

In addition, CPAP therapy is very effective if it is monitored, nursed and staffed by trained health

care workers. Common problems with CPAP use are inadequate nasal prong fitting, air leaks, abdominal distention, and nasal trauma. Staff training and the use of standard NICU protocols is therefore essential in order to maximize the effectiveness of the therapy, while minimizing complications.

Conclusion:

Continuous positive airway pressure (CPAP) is more effective and safer to use as a first-line respiratory support modality than mechanical ventilation in infants born prematurely with RDS according to the present study. Neonates treated with CPAP had a shorter duration of respiratory support, decreased oxygen dependency, and fewer complications related to ventilation, and shorter length of NICU stay. Non-invasive respiratory support can be used early in moderate-to-severe cases of respiratory failure to enhance the outcome of neonates, and to minimize morbidity from invasive ventilation in the event of CPAP failure. Promoting the use of evidence-based CPAP protocols and early clinical surveillance could further improve survival and quality of care for preterm infants who have RDS.

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