



Original Article

## Spectrum of Complications Associated with Bubble CPAP in Very Low Birth Weight Neonates with Respiratory Distress Syndrome

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### ABSTRACT

**Background:** Respiratory Distress Syndrome (RDS) is a major cause of morbidity and mortality among very low birth weight (VLBW) neonates. Bubble Continuous Positive Airway Pressure (bCPAP) has emerged as an effective non-invasive respiratory support modality that helps maintain functional residual capacity and improves oxygenation in preterm infants. Despite its widespread adoption, bubble CPAP therapy may be associated with several complications, including nasal trauma, pneumothorax, abdominal distension, and secondary infections. Understanding the pattern and frequency of these complications is essential for optimizing clinical management and improving neonatal outcomes.

**Objective:** To evaluate the spectrum and incidence of complications associated with bubble CPAP in very low birth weight neonates with respiratory distress syndrome.

**Materials and Methods:** This hospital-based observational study was conducted in the Department of Pediatrics, after obtaining ethical approval. The study included 100 inborn preterm neonates with birth weight  $\leq 1500$  g and gestational age between 28 and 34 weeks who presented with respiratory distress and required bubble CPAP support. Neonates with major congenital malformations, perinatal asphyxia, or those requiring mechanical ventilation at birth were excluded. Clinical parameters, duration of CPAP therapy, and occurrence of complications were monitored throughout NICU stay. Complications evaluated included pneumothorax, CPAP belly, secondary infection, intracranial hemorrhage, feed intolerance, meningitis, and nasal septum injury. Nasal injury severity was assessed using a standardized scoring system. Statistical analysis was performed using SPSS version 25.0, and categorical data were expressed as frequencies and percentages.

**Results:** Among the 100 neonates studied, several complications were observed during bubble CPAP therapy. Nasal septum injury was the most frequent complication, occurring in 29% of infants, followed by secondary infections in 26%, feed intolerance in 17%, and intracranial hemorrhage in 15%. Meningitis occurred in 10% of cases, while pneumothorax and CPAP belly were less common, observed in 5% and 4% of neonates respectively. The mean nasal septum injury score was  $1.01 \pm 1.82$ , indicating mostly mild injuries. These findings highlight that although bubble CPAP is an effective respiratory support modality, careful monitoring is necessary to prevent device-related complications.

**Conclusion:** Bubble CPAP is a safe and effective non-invasive respiratory support strategy for VLBW neonates with RDS. However, complications such as nasal trauma, infections, and feeding intolerance may occur. Early recognition, proper interface care, and vigilant monitoring can minimize these adverse events and improve neonatal outcomes.

## INTRODUCTION

Respiratory Distress Syndrome (RDS) remains one of the leading causes of morbidity and mortality among premature neonates, particularly those with very low birth weight (VLBW).[1-3] The condition primarily results from surfactant deficiency and structural immaturity of the lungs, which leads to alveolar collapse, impaired gas exchange, and progressive respiratory failure. Advances in neonatal intensive care have significantly improved survival rates among preterm infants; however, respiratory complications remain a major challenge in the management of these neonates. Non-invasive respiratory support techniques have increasingly replaced invasive ventilation strategies in an effort to reduce ventilator-induced lung injury and improve long-term pulmonary outcomes.[4]

Continuous Positive Airway Pressure (CPAP) is widely recognized as an effective method for maintaining functional residual capacity and preventing alveolar collapse in preterm infants with respiratory distress. By providing a constant distending pressure to the airways, CPAP helps stabilize the lungs, reduces the work of breathing, and improves oxygenation. Among the various CPAP delivery systems, bubble CPAP has gained particular attention due to its simplicity, affordability, and clinical effectiveness.[5]

Bubble CPAP works by delivering positive airway pressure through nasal prongs, while the expiratory limb of the breathing circuit is submerged in water, generating continuous bubbling. This bubbling produces small oscillations in airway pressure, which may enhance gas exchange and mimic the benefits of high-frequency ventilation. Because the system is relatively inexpensive and easy to assemble, bubble CPAP is especially valuable in low- and middle-income countries where access to sophisticated ventilators may be limited.[6]

Several studies have demonstrated that early initiation of bubble CPAP in preterm infants with RDS can reduce the need for mechanical ventilation and decrease the risk of chronic lung disease. Additionally, it allows infants to maintain spontaneous breathing while receiving respiratory support, thereby avoiding the complications associated with endotracheal intubation.[7,8]

Despite these advantages, bubble CPAP is not completely free of adverse effects. The most commonly reported complications include nasal trauma due to prolonged pressure from nasal prongs, gastric distension resulting from swallowed air, and air leak syndromes such as pneumothorax. Prolonged respiratory support and invasive monitoring may also predispose neonates to secondary infections and feeding intolerance. In very low birth weight infants, the risk of complications may be further increased because of fragile tissues, immature immune systems, and prolonged hospitalization in neonatal intensive care units.[9,10]

Nasal injury is one of the most frequently encountered complications associated with CPAP therapy. Continuous pressure from nasal interfaces can lead to skin breakdown, ulceration, and even necrosis of the nasal septum if not detected early. Other complications such as pneumothorax, though less common, can be life-threatening and require immediate intervention. Therefore, understanding the incidence and pattern of complications associated with bubble CPAP is essential for optimizing neonatal care and improving patient outcomes.[11]

Although numerous studies have explored the effectiveness of bubble CPAP in managing neonatal respiratory distress, relatively fewer have focused specifically on the spectrum of complications associated with this therapy in VLBW infants. Identifying these complications and their frequency can help clinicians develop preventive strategies, refine monitoring protocols, and improve overall safety of bubble CPAP therapy.

The present study was conducted to evaluate the spectrum of complications associated with bubble CPAP in very low birth weight neonates with respiratory distress syndrome admitted to a tertiary care neonatal intensive care unit.

## OBJECTIVE

To study the spectrum of complications associated with bubble CPAP in very low birth weight neonates with respiratory distress syndrome.

## MATERIALS AND METHODS

**Study setting:** This hospital-based observational study was conducted in the Department of Pediatrics, Dr. Sampurnanand Medical College, Jodhpur, Rajasthan, after obtaining approval from the Institutional Ethical Committee.

**Study Design:** Hospital-based observational study.

**Study Population:** The study population consisted of inborn preterm neonates admitted to the neonatal intensive care unit with respiratory distress requiring bubble CPAP support.

**Study Period:** The study was conducted after ethical approval until the required sample size was achieved.

**Sample Size:** The sample size was calculated using a 95% confidence interval, assuming an expected CPAP success rate of 75% among preterm neonates with respiratory distress syndrome. The minimum calculated sample size was 72; however, the study included 100 neonates to improve statistical reliability.

#### Inclusion Criteria

- Inborn preterm neonates with birth weight  $\leq 1500$  g
- Gestational age between 28 and 34 weeks
- Presence of respiratory distress at birth
- Silverman Anderson score  $\geq 4$
- Neonates requiring bubble CPAP as respiratory support

#### Exclusion Criteria

- Perinatal asphyxia
- Major congenital malformations
- Genetic syndromes incompatible with life
- Neonates requiring mechanical ventilation immediately after birth

**Methodology:** After obtaining informed written consent from parents or guardians, eligible neonates were enrolled in the study. Detailed maternal, perinatal, and neonatal histories were recorded using a structured data collection form. Clinical parameters including respiratory rate, oxygen saturation (SpO<sub>2</sub>), fraction of inspired oxygen (FiO<sub>2</sub>), and Silverman Anderson score were monitored regularly.

All neonates received bubble CPAP according to standard NICU protocols. The timing of CPAP initiation, pressure settings, and oxygen requirements were documented. Neonates were closely monitored during their NICU stay for the development of complications.

#### Complications Monitored

The following complications were recorded during bubble CPAP therapy:

- Pneumothorax
- CPAP belly (abdominal distension due to air swallowing)
- Secondary infection
- Intracranial hemorrhage
- Feed intolerance
- Meningitis
- Nasal septum injury

**Nasal Injury Assessment:** Nasal injury severity was evaluated using a standardized nasal septum injury scoring system. The injury score was documented for each neonate and categorized according to severity.

**Statistical Analysis:** Statistical analysis was performed using SPSS version 25.0. Continuous variables were expressed as mean  $\pm$  standard deviation, while categorical variables were expressed as frequencies and percentages.

## RESULTS

**Bubble CPAP-Associated Adverse Events:** Nasal septum injury was the most common complication observed in neonates receiving bubble CPAP, occurring in 29% of cases. Secondary infections were the second most frequent complication (26%), followed by feed intolerance (17%) and intracranial hemorrhage (15%). Meningitis was observed in 10% of infants, while pneumothorax (5%) and CPAP belly (4%) were relatively uncommon. (Table 1)

**Nasal Septum Injury Score: Inference:** The mean nasal septum injury score was  $1.01 \pm 1.82$ , suggesting that most nasal injuries were mild in severity. Severe nasal damage was rare. (Table 2)

**Table 1. Bubble CPAP associated adverse events (n=100)**

Adverse events	Frequency	Percentage
Pneumothorax	5	5%
CPAP belly	4	4%

<b>Secondary infection</b>	26	26%
<b>Intracranial hemorrhage</b>	15	15%
<b>Feed intolerance</b>	17	17%
<b>Nasal septum injury</b>	29	29%
<b>Meningitis</b>	10	10%

**Table 2. Nasal septum injury score in neonates (n=100)**

<b>Parameter</b>	<b>Value</b>
<b>Mean score</b>	1.01
<b>Standard deviation</b>	1.82
<b>Minimum</b>	0

## DISCUSSION

Bubble CPAP has become an important non-invasive respiratory support modality for preterm infants with respiratory distress syndrome. While its effectiveness in improving oxygenation and reducing the need for mechanical ventilation has been well established, attention must also be given to the potential complications associated with its use. The present study evaluated the spectrum of complications occurring in VLBW neonates receiving bubble CPAP therapy.

In this study, nasal septum injury was the most common complication, affecting 29% of neonates. Nasal trauma is a well-recognized adverse effect of CPAP therapy due to prolonged pressure from nasal prongs and inadequate interface care. Guimarães et al. reported nasal trauma in nearly 65% of very low birth weight infants receiving nasal CPAP, highlighting the vulnerability of immature skin and mucosa in preterm infants.[12] Preventive strategies such as proper positioning of nasal prongs, regular inspection of nasal skin, and use of protective barriers can significantly reduce the risk of nasal injury.

Secondary infections were observed in 26% of neonates in the present study. Preterm infants are particularly susceptible to infections because of their immature immune systems and prolonged hospitalization in neonatal intensive care units. The use of respiratory support devices and invasive monitoring further increases the risk of nosocomial infections. Similar findings have been reported in previous studies evaluating neonatal respiratory support modalities.[13] Strict infection control practices, including hand hygiene and equipment sterilization, are therefore essential to minimize infection rates in NICUs.[14,15]

Feed intolerance was noted in 17% of neonates receiving bubble CPAP. Air swallowing during CPAP therapy can lead to gastric distension and feeding difficulties. This phenomenon, commonly referred to as “CPAP belly,” may interfere with enteral feeding and increase the risk of aspiration. In the present study, CPAP belly was observed in 4% of neonates, which is relatively lower compared with reports from other studies. Early use of orogastric tubes for gastric decompression may help reduce abdominal distension and feeding intolerance.[16]

Intracranial hemorrhage occurred in 15% of neonates in this study. Although intraventricular hemorrhage is primarily associated with prematurity and fragile cerebral vasculature, fluctuations in cerebral blood flow and oxygenation during respiratory support may contribute to its occurrence. Studies have suggested that non-invasive respiratory support techniques such as CPAP may reduce the risk of severe intracranial hemorrhage compared with invasive mechanical ventilation.[17]

Meningitis was reported in 10% of neonates in the present study. Neonatal meningitis is a serious complication that may occur as a consequence of systemic infections. Preterm infants receiving prolonged respiratory support are particularly vulnerable to such infections. Early diagnosis and prompt antibiotic therapy are essential to reduce morbidity and mortality associated with neonatal meningitis.

Pneumothorax was observed in 5% of neonates receiving bubble CPAP. Although CPAP is generally considered safer than mechanical ventilation, excessive airway pressure can occasionally lead to air leak syndromes. Previous studies have reported pneumothorax rates ranging from 2% to 10% among preterm infants receiving CPAP therapy.[18] Careful monitoring of CPAP pressure settings and clinical status is therefore important to prevent this complication.

Overall, the findings of this study suggest that bubble CPAP is relatively safe but requires vigilant monitoring to prevent device-related complications. Most complications observed in this study were mild and manageable with appropriate clinical care.

## CONCLUSION

Bubble CPAP is an effective and relatively safe non-invasive respiratory support modality for very low birth weight neonates with respiratory distress syndrome. However, complications such as nasal septum injury, infections, feed intolerance, and intracranial hemorrhage may occur during therapy. Nasal trauma was the most frequently observed

complication in this study. Careful monitoring, proper device handling, and adherence to infection control practices are essential to minimize these complications and improve neonatal outcomes.

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