

A Clinical Study on Role of Bubble CPAP in Respiratory Distress Syndrome in Preterm Neonates

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Abstract

Background: Non- invasive ventilation like continuous positive airway pressure (CPAP) in spontaneously breathing neonates with respiratory distress improves survival and also reduces the incidence of chronic lung disease in newborns. The aim of our study was to study the effectiveness of Bubble CPAP in Respiratory Distress Syndrome (RDS) in preterm neonates in different weight and gestational groups.

Materials and Methods: This cross- sectional descriptive study was performed in the NICU of JANANA (part of JLN hospital Ajmer) and JLN hospital Ajmer itself, tertiary care centres in Ajmer, Rajasthan on 140 preterm neonates admitted immediately or within 24 hours after birth with Silverman Anderson Score 4-7 with Respiratory distress syndrome.

Results: Total 140 preterm neonates with RDS recruited in our study. Among them 71 (50.71%) were males and 69 (49.29%) were females. Overall success rate of B-CPAP was noted to be 72.85%. Good recovery was seen among babies with birth weight of 2-2.5 kg and >2.5 kg i.e 100%. There was a significant difference in outcome of bubble CPAP between birth weight <1000gm(51%) and birth weight \geq 1000 gm(83%) ($p=0.0011$). Most infants with gestational age <28 weeks had B-CPAP failure (60%). Gestational age 28-29 weeks also had higher number of CPAP failure as compared to gestational age 30- 31 weeks(17.88%), 32 to 34 weeks (12%) and \geq 35 weeks of gestation which was lowest around 0% ($p=0.0003$). Outcome of cases of RDS was also affected by initial respiratory severity score – SAS. Higher percentage of CPAP success was seen with initial scores 4(78.9%) and 5(84.75%) as compared to higher scores 6(59.26%) and 7 (62.5%) [p value – 0.018]. Sepsis was seen as the commonest morbidity in this study cohort. Overall, 49 out of 140 cases (35%) had sepsis. Sepsis was seen in larger percentage of cases in failure group. 27 out of 38 failed cases had sepsis (71%) while only 28 cases out of 102 (21%) in recovered group had sepsis but its value as a predictor of CPAP failure could not be proven. Birth weight <1000gm, gestational age <30 weeks and initial SAS score \geq 6 proved to be significant predictors of CPAP failure.

Conclusion: Bubble continuous positive airway pressure is a safe and effective mode of respiratory support in preterm neonates with respiratory distress syndrome.

Keywords: Bubble Continuous Positive Airway Pressure, Respiratory Distress Syndrome.

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Introduction

The current neonatal mortality rate (NMR) in India is 20.3 per 1000 live births[1]. Respiratory distress occurs among 4-7% of all neonates and is the cause for 30-40% of all admissions in neonatal intensive care units.[2,3] Incidence is more common among preterm (30%) followed by post-term (20.9%) and term babies (4.2%)³. Respiratory distress syndrome (RDS), is the single most important cause of neonatal mortality and morbidity in preterm neonates.[4]

CPAP- Continuous positive airway pressure, also known as continuous distending pressure (CDP), refers to application of continuous pressure during both inspiratory and expiratory phase of respiration in a spontaneously breathing baby[5,6,7]. The rationale for the use of CPAP is to stent the airways and maintain functional residual capacity (FRC) to maintain lung volume[8,9,10]. Successful CPAP results in an increase the pharyngeal cross-sectional area, enhanced pulmonary compliance, improvement in diaphragmatic activity and decreased airway resistance which results in reduction in work of breathing, decreases ventilation-perfusion mismatch and also conserves surfactant on alveolar surface. Also, the pulmonary vascular resistance is lowest when lungs are optimally inflated at FRC only with optimal CPAP. This form of non-invasive ventilation in spontaneously breathing neonates with respiratory distress improves survival and also reduces the incidence of chronic lung disease in newborns.

A bubble-CPAP incorporates an ingenious switch where pressure generation by the flow dependent resistor principle is replaced with that of the flow-independent positional energy of water. The fundamental mechanism for pressure generation is water submersion but this device will also gradually act as a flow

dependent resistor system due to the expiratory tubing resistance adding to the total distending pressure.

Objective:

To study the effectiveness of CPAP in preterm neonates with RDS in different weight and gestational groups.

Materials and Methods:

This cross-sectional descriptive study was performed in the NICU of JANANA (part of JLN hospital Ajmer) and JLN hospital Ajmer itself, tertiary care government hospitals in Ajmer, Rajasthan for a period of 12 months from Dec 2021 to Nov 2022 on 140 eligible preterm neonates admitted in NICU in view of Respiratory distress syndrome during the study period.

Inclusion criteria were preterm neonates with RDS admitted in Newborn Unit with Silverman Anderson Score 4-7 and presented immediately or within 24 hours after birth. Exclusion criteria were babies with Silverman Anderson score > 7/10, Prolonged & refractory seizures and major congenital anomalies including upper airway anomalies, pulmonary hypoplasia diaphragmatic hernia, tracheo-esophageal fistula, etc.

Eligible neonates were enrolled after obtaining written consent from one of their parents. Clinical and demographic data were documented using a predefined proforma. Respiratory distress and other clinical data were recorded.

Babies having total score between 4 - 7, were put on Bubble CPAP. If the distress increased, they were intubated and started on mechanical ventilation. If the distress decreased, they were weaned to oxygen gradually. CPAP was started with pressure 5cm of H₂O. It was increased or decreased by increasing or decreasing the depth of immersion of expiratory limb into the

bubble chamber. Pressure was adjusted to minimize chest retractions and to observe 6-8 posterior rib spaces in Chest X-Ray. It was increased in increments of 1cm of H₂O at a time up to a maximum of 7 cm of H₂O. Flow was kept at minimum 5L/min and adjusting for bubbling. FiO₂ was started with 30% and after adjusting the pressure, titrated to maintain SpO₂ between 90 to 94%.

Investigations to diagnose the cause of respiratory distress were done including radiograph of the chest in all cases. Blood sample was collected under sterile conditions and sent for analysis (Complete Blood Count, Glucose, Urea, Creatinine, Calcium, other electrolytes, Culture & Sensitivity etc.). The pulse oximeter was used to continuously monitor the SPO₂ and heart rate. All babies were nursed under radiant warmer on servocontrol mode.

The decision to administer surfactant was as follows-

- Infants with radiological features suggestive of RDS.
 - High oxygen requirement/ pressure - defined as the fractional inspired oxygen concentration (FiO₂) > 30% or CPAP pressure > 6 cm of water, were considered eligible for surfactant administration.
- Surfactant when required was given with Insure technique.

CPAP FAILURE - was defined as

- High FiO₂ requirement >70%
- Pressure required was greater than 7 cm of water.
- PaO₂ <50mmHg on maximum acceptable setting.
- Inadequate ventilation: arterial pH <7.2 and PaCO₂ >60mmHg on maximum acceptable setting.
- Frequent episodes of apnoea despite caffeine citrate therapy requiring stimulation or even a single episode requiring bag and mask ventilation.

Statistical analysis:_The data analysis was done using SPSS software. The categorical variables were presented using frequencies (percentages). The continuous variables were summarized using mean and standard deviation. The association between two categorical variables was assessed using Chi square/ Fisher's exact test. The mean difference between two following normality assumptions was tested using student's T test and for non- normal variable Mann- Whitney U- test was done. P value less than 0.05 was considered statistically significant.

Results

Total 140 preterm neonates with RDS recruited in our study. Among them 71 (50.71%) were males and 69 (49.29%) were females.

Discussion

Invasive ventilation is one of the most expensive modalities to treat neonates with respiratory distress. Non- invasive ventilation like bubble CPAP is relatively simple and less expensive. With the help of trained staff and pulse oximeter monitoring neonates can be managed effectively. This sort of low - cost intervention also helps to reduces morbidity and mortality. So, this cross- sectional descriptive study was conducted to study the outcome of nasal Bubble CPAP in preterm neonates with RDS. A total of 140 neonates were included in this study after meeting the inclusion criteria. Efficacy of BCPAP ventilation was analysed based on various parameters such as weight, gestational age, and respiratory severity score.

In our study the success rate of B-CPAP in case of RDS was noted to be 72.85%. Some studies conducted in low and middle income countries have shown a varying effect of B-CPAP on survival of preterm babies with RDS ranging from 42-85%.[11-17] J koti et al[18] in their study suggested that BCPAP is a safe modality in moderately preterm babies with RDS with less lung injury, however babies with

severe RDS had poor outcome in BCPAP. Their study had a failure rate of 25%. Similarly in a study by Byram et al also noted 42% failure rate in babies with RDS.[19]

In our study almost around half of the infants with birth weight <1000gm had B-

Table 1: Outcome of RDS Cases According to Birth Weight

Birth weight Group VS outcome	Total		No. of cases recovered		No. of failures		P-value
	No.	%	No.	%	No.	%	
< 1kg	45	32.14%	23	51.11%	22	48.99%	0.0011
1 to 1.49kgs	58	41.43%	46	79.31%	12	20.69%	
1.5 to 1.99kgs	23	16.43%	19	82.61%	4	17.39%	
2 to 2.49kgs	11	7.86%	11	100%	0	0%	
≥2.5kgs	3	2.14%	3	100%	0	0%	
Total	140	100%	102	72.85%	38	17.15%	

Table 2: Outcome of RDS Cases According to Gestational Age

Gestational age VS outcome	Total		No. of cases recovered		Failures		P-value
	No.	%	No.	%	No.	%	
< 28weeks	25	17.86%	10	40%	15	60%	0.0003
28 to 29 ^{6/7} weeks	38	27.14%	26	68.42%	12	31.58%	
30 to 31 ^{6/7} weeks	45	32.14%	37	82.22%	8	17.88%	
32 to 34 ^{6/7}	25	17.86%	22	88%	3	12%	
≥35weeks	7	5%	7	100%	0	0%	
Total	140	100%	102	72.85%	38	17.15%	

CPAP failure (48.9%) compared with those whose birth weight was ≥1000gm (16.8%). In RDS babies, good recovery was seen among babies with birth weight of 2-2.5 kg and >2.5 kg i.e 100%. There was a significant difference in outcome of bubble CPAP between birth weight <1000gm and birth weight ≥1000 gm (p=0.0011). A higher percentage of failure cases was reported by Mathai et al in their study where

2 out of 3 babies with body weight less than 1 kg failed B-CPAP²⁰. In study done by Ammari et al²¹ CPAP was successful in 76% of infants with ≤1250gm birth weight and 50% of infants with ≤750gm birth weight.

In our study most infants with gestational age <28 weeks had B-CPAP failure (60%).

Table 3: Respiratory Distress Score of RDS Cases and their Outcome of B-CPAP

SAS SCORE	Total		No. of cases recovered		Failures	
	No.	%	No.	%	No.	%
4	19	13.57%	15	78.95%	4	21.05%
5	59	42.14%	50	84.75%	9	15.15%
6	54	38.57%	32	59.26%	22	40.74%
7	8	5.71%	5	62.5%	3	37.5%
Total	140	100%	102	72.85%	38	27.15%

Table 4: Surfactant Required in RDS Cases as Per Gestational Age

ANTENATAL STEROIDS VS GA	YES		NO		Total	
	Number	%	Number	%	No.	%
< 28weeks	24	96%	1	4%	25	17.85%
28 to 29weeks	15	39.47%	23	60.53%	38	27.14%
30 to 31weeks	5	11.11%	40	88.89%	45	32.14%
32 to 34weeks	3	12%	22	88%	25	17.85%
≥35weeks	0	0%	7	100%	7	5%
Total	47	33.5%	93	66.5%	140	100%

Table 5: Predictors of Failure of Bubble CPAP in RDS

RISK FACTOR	RECOVERED n=102		FAILURE n=38		P VALUE
	No.	%	No.	%	
Bt. Weight <1kg	23	51.11%	22	48.89%	0.03
GA <30weeks	36	57.14%	27	42.46%	0.005
SEPSIS	22	44.9%	27	55.1%	1

Gestational age 28-29 weeks also had higher number of CPAP failure as compared to gestational age 30-31 (17.88%), 32 to 34 weeks (12%) and ≥35 weeks of gestation which was lowest around 0%. (p-0.0003)

In our study outcome of cases of RDS was also affected by initial respiratory severity score – SAS. Higher percentage of CPAP success was seen with initial scores 4(78.9%) and 5(84.75%) as compared to higher scores 6(59.26%) and 7 (62.5%)[p value – 0.018]

Out of 140 cases of RDS, surfactant was required in 47 babies (33.5%), of which 28 babies (59.57%) ultimately required mechanical ventilation indicating severity of disease. Verder et al[22] published the first randomized control trial of administration of surfactant during CPAP showing that in infants with moderate to severe respiratory distress the need for subsequent mechanical ventilation could be reduced to half after single dose of surfactant.

Sepsis was seen as the commonest morbidity in this study cohort. In this study we included probable sepsis (clinical features with positive septic screen) and proven sepsis cases (culture positive). Clinical sepsis was defined by presence of clinical signs and symptoms suggestive of

sepsis. Overall, 49 out of 140 cases (35%) had sepsis. Sepsis was seen in larger percentage of cases in failure group. 27 out of 38 failed cases had sepsis (71%) while only 28 cases out of 102 (21%) in recovered group had sepsis but its value as a predictor of CPAP failure could not be proven. Many studies have reported a higher incidence of sepsis in such vulnerable populations. The incidence of sepsis was found to be around 42% in a recent randomized controlled trial comparing prophylactic versus early surfactant therapy in spontaneously breathing preterm neonates below 30 weeks of gestation receiving CPAP.²³ Few other studies from India have also reported similar incidence of sepsis.[24,25] Kandraju et al. have reported 21% incidence of culture-positive sepsis in their study.[26]

So, the most influential factors of outcome of B-CPAP in case of RDS seen in our study were birth weight, gestational age and initial SAS score. Birth weight <1000gm, gestational age <30 weeks and initial SAS score ≥ 6 proved to be significant predictors of CPAP failure.

A study on CPAP in preterm neonates: An update on current evidence and implications for developing countries by Neeraj Gupta et al. showed that CPAP had a good outcome on babies of more than 32

weeks gestational age and birth weight of more than 1000grams.[27] Study by Koti et al¹⁸ reported that no or partial exposure to antenatal steroid, white out lung on chest Xray, PDA, sepsis/pneumonia, Downs score >7, FiO₂ >=50% after 15 to 20 mins of CPAP might predict CPAP failure. Another study conducted by Ammari et al[21] also proved that extreme low birth weight, gestational age <26 weeks, severe RDS on the initial chest Xray and the need for positive pressure ventilation at birth were the predictors of nasal CPAP failure. Another case control study conducted in Malaysia found moderate or severe RDS, septicaemia and pneumothorax to be associated with CPAP failure.[28]

The disparities in results could be due to difference in the study population studied, coverage of ANS, nature of CPAP interface, varied nursing practices and device used, method of statistical analysis (univariate or multivariate) and criteria used for CPAP failure.

Conclusion

Bubble continuous positive airway pressure is a safe and effective mode of respiratory support in preterm neonates with respiratory distress syndrome with a success rate of around 73%. Birth weight <1000gm, gestational age <30 weeks and initial SAS score ≥ 6 are predictors of CPAP failure.

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