

Can Higher PEEP and FiO₂ with Bubble CPAP Reduce Need for Invasive Ventilation in Preterm Babies with Respiratory Distress Syndrome?

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Abstract

Objectives: To evaluate the clinical course and outcome in preterm babies with RDS using higher PEEP and FiO₂ as appropriate on bubble CPAP as the primary mode of respiratory support. CPAP failure and oxygen requirement by 28 days of life were primary outcomes. Incidence of pneumothorax, hypotension, NEC, IVH and ROP and survival till discharge were the secondary outcomes measured.

Method: Preterm babies (gestation 26 to 36 weeks) admitted to tertiary level NICU (both inborn and outborn) with RDS were managed with bubble CPAP as a primary mode of respiratory support. Higher pressure upto 8-10 cm of water and FiO₂ upto 80-100% was given (if required) during CPAP.

Results: Total 73 neonates were studied, out of which 52% received antenatal steroids and 54.8% received surfactant. Overall CPAP success rate was 95.9% with success in severe, moderate and mild RDS cases 84.6%, 97.5% and 100% respectively. Among <28 week age-group, 85.7% cases were successful. Peak CPAP pressure of \geq 8cm water was given to 21.4% babies in success group.

Conclusions: Bubble CPAP may be considered as a primary mode of respiratory support in RDS even in very preterm and ELBW babies irrespective of the severity. Early CPAP and surfactant, peak pressure upto 8-10 cm H₂O and FiO₂ 100% with trained and committed staff with 1:1 care can lead to higher success rate. CPAP is safe even in very preterm infants with RDS and associated with lesser lung injury and other complications.

Keywords: Bubble CPAP; RDS; Preterm; Neonate

Introduction

Bubble CPAP is a popular mode of non-invasive ventilation for preterm neonates with respiratory distress syndrome (RDS). Although its use for RDS goes back to 1971 [1], it was replaced by mechanical ventilators even before it could gain acceptance [2]. Early CPAP is safe and beneficial in treating RDS in terms of less invasiveness and cost effectiveness, thus reducing the need for mechanical ventilation.

Limited published data exists in terms of practical aspects of CPAP, optimal and maximum pressure which can be given and patient interfaces. We conducted this observational study to evaluate effectiveness of early bubble CPAP as a successful primary approach in managing preterm neonates (gestation 26-36 weeks) with RDS. Aim of our study was to find the maximum PEEP and FiO₂ that can be given safely before considering the CPAP as failure and document its efficacy in cases of severe RDS and in extreme preterm babies.

Materials and Methods

This observational study was done in tertiary level NICU in a corporate hospital. All the preterm babies (gestation 26-36 weeks) with RDS who received bubble CPAP as primary mode of respiratory support were included in the study. Bubble CPAP of Fisher and Paykel with binasal prongs was started as soon as clinical signs of RDS appeared. Severity of RDS was classified on the basis of clinical criteria : presence of tachypnea (respiratory rate >60/min), grunting, subcostal retractions and O₂ requirement to maintain SpO₂ in target range (SpO₂ 88-90% for <28 weeks, 90-92% for 28-32 weeks and 92-95% for 32-34 weeks gestation) and radiological findings: mild (mild granularity of lungs), moderate (generalized granularity of lungs with air bronchogram and preserved cardiac borders) and severe RDS (white out lungs with loss of cardiac borders). Both inborn and referred cases meeting the above criteria were recruited. Babies who didn't meet the

criteria and those who required mechanical ventilation prior to CPAP were excluded from the study.

Early surfactant to preterm babies \leq 30 weeks was given irrespective of RDS severity and rescue surfactant for babies >30 weeks gestational age who had moderate-severe RDS. INSURE technique (Intubate, Surfactant and Extubate after 3 to 5 minutes of intermittent positive pressure ventilation) was used for surfactant administration. CPAP was started on initial pressure 4-6 cm of water and its effectiveness was judged by (a) decrease in respiratory rate and retractions, (b) decreased FiO₂ requirement (c) decrease/ absence of grunting (d) improvement in blood gas (PaO₂ >50 mm Hg and PaCO₂ 45-55 mm Hg) and (e) baby comfortable on CPAP. Pressure was decreased as per clinical and blood gas improvement. Once baby maintained SpO₂ in target range, FiO₂ was gradually weaned to 21%.

Higher pressures upto 8-10 cm of water was used if required along with strict bedside monitoring and 1:1 nursing care. CPAP was considered to be successful in babies whose RDS resolved on bubble CPAP itself and did not require mechanical ventilation.

CPAP failure was defined when RDS didn't improve on bubble

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CPAP despite pressure upto 8-10 cm water and FiO₂ upto 80-100% (if not maintaining saturation in target range as mentioned above), that is PCO₂ >60 mm Hg and PO₂ <50 mm Hg on blood gases or recurrent apnoea on CPAP. If the baby's clinical condition didn't improve, mechanical ventilation was initiated.

Various risk factors for RDS and factors which affect the outcome were recorded and analysed which included maternal details and baby details. Maternal details like: antenatal history of pregnancy induced hypertension, diabetes, infection, antenatal steroids, preterm premature rupture of membrane were recorded. Babies gestational age, birth weight, gender, APGAR at 1 and 5 minutes, IUGR, need for resuscitation at birth, surfactant administration, O₂ requirement, FiO₂ required, inborn or outborn, referral time (in outborn), severity of RDS and requirement of mechanical ventilation were noted. Other parameters recorded were blood pressure, CPAP intolerance, PDA, pneumothorax, sepsis, NEC, CLD, IVH, ROP, duration of hospital stay, mortality and condition during follow up. The study was approved by ethical committee of the hospital and informed consent was obtained from the parents.

Statistical analysis was done using SAS version 9.3. Variables distributed normally are represented as mean ± SD. Univariate and multivariate logistic regression analysis were performed to see the impact of various factors on the outcome. Fisher Exact test and Chi square test (as appropriate) were used for binary/categorical data.

Results

Total 73 neonates were enrolled in the study. Mean birth weight ± SD was 1773 ± 570 grams. Mean gestation ± SD was 31.9 ± 3weeks. There were 25 (34.25%) females and 48 (65.75%) males. 79.5% babies were inborn. Total 38 (55.8%) babies received antenatal steroids.

Among CPAP success cases, 37 (52.9%) had received antenatal steroids. Mild, moderate and severe RDS was seen in 26%, 56.2% and 17.8% cases respectively. Surfactant was given to 55% babies. Mean time of start of CPAP was 5.3 hrs (Table 1).

CPAP success is depicted in table 2. CPAP success rate in our study was 70 (95.9%). Overall, only 3 (4.1%) of the babies who were started on bubble CPAP required ventilation. Success of bubble CPAP in severe, moderate and mild RDS was 84.6%, 97.5% and 100% respectively. In <28 week age-group, 85.7% cases were successful, while in 28-30 wks gestation, improvement was observed in 94.4% .

Peak CPAP pressure of ≥ 8cm water was given to 15 (21.4%) babies in success group, of which 2 babies received peak pressure 9 cm water while one received 10 cm water pressure. Out of the babies who received peak pressure >8 cm water, no baby developed pneumothorax. In CPAP success group, 16 (22.8%) received FiO₂ 50%-80% and 7 (10%) babies received >80% FiO₂. Only one baby required FiO₂>80% along with PEEP of 8 cm water who improved on CPAP.

Complications with bubble CPAP are shown in Table 3. No baby had nasal trauma or hypotension. Overall all, 2 (2.7%) babies required oxygen at 28 days (weaned off oxygen before discharge), 2 (2.7%) developed pneumothorax, 6 (8.2%) had NEC stageI/II, 1 (1.3%) developed IVH and 2 (2.7%) had ROP (improved after laser).

RDS severity had significant impact on CPAP outcome after adjusting for gestational age, prophylactic antenatal steroids, infection and Apgar score (p value=0.05). The factors responsible for CPAP success are early administration of surfactant, early initiation of CPAP and higher peak pressure and FiO₂ to maintain SpO₂ and PaO₂,

committed and trained staff with 1:1 care and a positive outlook to bubble CPAP.

Discussion

Our study has documented effectiveness of bubble CPAP as a first line approach in severe RDS and in extreme preterm babies, along with the safe limit of PEEP and FiO₂. Higher peak CPAP pressure had statistically significant association with severe RDS which could be responsible for the success of CPAP. In our study success rate is high even in severe RDS as compared to previous studies.

In a study by Ammari et al. [3], CPAP was failure in 24% of infants ≤ 1250 g birth-weight and 50% of infants ≤ 750 g birth-weight. CPAP failure was associated with PPV requirement at birth, alveolar-arterial oxygen tension gradient >180 mm Hg on first ABG and severe RDS on chest X ray. In our study in <1.5 kg birth-weight group, only 4.3% failed CPAP, and in <1 kg group, 14.3% cases failed. The success rate was good even in very preterms (26 weeks-31 weeks) and ELBW babies.

Variable	CPAP success (n=70)	CPAP failure(n=3)	P value
Birth wt kg (mean+/- SD)	1.78±0.57	1.5 ±0.7	-
Gestation wks (mean +/- SD)	31.97±2.96	31 ±4.58	-
Gestational age			0.06
26-28 wks	6	1	
28-30wks	17	1	
31-33 wks	17	0	
≥ 34 wks	30	1	
Birth wt			0.11
≤1.5kg(23)	22	1	
≤1.0 Kg(7)	6	1	
Sex			0.27
Male	4	3	
Female	22	0	
Inborn(58)	55	3	0.49
Referred(15)	15	0	
Received antenatal steroids(38)	37	1	0.28
Antenatal risk factor for infection :- (PROM/maternal fever/chorioamnionitis/ UTI)	8	0	0.7
PIH	12	0	0.57
Maternal Diabetes(5)	5	0	0.8
Apgar score < 3 at 1 minute (3)	2	1	0.08
RDS Severity			0.05
Mild RDS(19)	19	0	
Moderate RDS(41)	40	1	
Severe RDS(13)	11	2	
Peak FiO2			
< 30%	11	0	
30-50%	36	2	
50-80%	16	1	
>80%	7	0	
Peak pressure			0.23
< 8(57)	55	2	
≥8(16)	15	1	
Mean age at the start of CPAP-in hrs(Mean ±SD)	5.5±9.1	2.6±2.8	
Surfactant given(40)	37	3	0.15

Fisher exact -T test is used

Table 1: Variables in CPAP Success and Failure Cases(total N=73).

Variable		Success (%)
Severity of RDS	Mild RDS	100%
	Moderate RDS	97.50%
	Severe RDS	84.60%
Birth Weight	<1.5 kg	95.70%
	<1 kg	85.70%
Gestation	28-30 weeks	94.40%
	<28 weeks	85.70%

Table 2: Success % of Bubble CPAP.

Variable	CPAP success(n=70)	CPAP failure(n=3)	P value
Hypotension*	5	0	0.8
EOS	8	0	0.07
CLD	1	1	0.0009
ROP	1**	1***	0.0009
IVH	0	1	0.04
Pneumothorax	1	1	0.05
NEC	6#	0	0.7

*Not during CPAP but later due to sepsis

** improved with laser

*** improved spontaneously

#(Stage 1 /Stage2 Improved with medical management)

Table 3: Associated complications in babies.

The cautious use of peak CPAP pressure in our unit could have resulted in higher success rate in severe RDS.

Hameed et al. [4] studied 70 neonates, of which 52.9% babies failed on CPAP. Their criteria for failure include FiO₂ requirement $\geq 50\%$ at 20 min of CPAP, PIP ≥ 5.5 cm water, birth weight ≤ 1500 gms, gestational age ≤ 30 weeks and white out lung on chest X ray. In our study, CPAP failure was only 4.1%. The difference could be because of changes in the criteria of CPAP failure. Our study allowed PEEP upto $> 8-10$ cm water and FiO₂ upto 80-100%.

In the COIN trial [5], comparison between early CPAP (50% receiving surfactant) and intubation and ventilation, mostly with surfactant administration was done. Maximum pressure of 8 cm water was used in CPAP group, and failure rate was 46%. CPAP group had higher rate of pneumothorax (9%) than the ventilator group (3%). It concluded that in infants born at 25-28 weeks' gestation, early nasal CPAP didn't significantly reduce the death rate or CLD compared with intubation. In our study, failure rate was only 14.3% in preterm with gestation <28 weeks, with overall 2.7% cases of pneumothorax.

In a study by Koti et al. [6] in preterm babies (gestation 28-34 weeks), 25% failed on CPAP and required ventilation. No baby required oxygen for more than 8 days. Two babies developed pneumothorax but both were stabilized on Bubble CPAP itself. The predictors of failure were no or partial exposure to antenatal steroids, white-out on the

chest X ray, PDA, sepsis and Downe's score >7 or FiO₂ $\geq 50\%$ after 15-20 minutes of CPAP. Criteria of CPAP failure were: SpO₂ $<87\%$ despite FiO₂ $>70\%$ and PEEP >7 cm of water, severe retractions on PEEP >7 cm of water, prolong/recurrent apnea, severe metabolic acidosis or shock requiring inotropic support and failure of CPAP in the first week of life.

In another study by Urs et al., bubble CPAP was failure in 20%. Surfactant was used only in the neonates who failed bubble CPAP and required ventilation. The success rate of bubble CPAP in mild, moderate and severe RDS was 100%, 93.1% and 46.6% respectively [7]. Our study has higher improvement with 100% success in mild RDS, 97.5% in moderate RDS and 84.6% success in severe RDS, emphasizing the use of bubble CPAP in severe RDS as well.

The SUPPORT trial to evaluate comparison of nasal CPAP with prophylactic surfactant and ventilator in babies (24-27 weeks gestation) also favours CPAP as an alternative to intubation and surfactant in preterm infants [8].

We conclude that Bubble CPAP may be considered as a primary mode of respiratory support even in very preterm babies and ELBW babies irrespective of the severity of RDS. In our study RDS severity was significant and it had significant impact on CPAP outcome after adjusting for gestational age, prophylactic antenatal steroids, infection and Apgar score (p-value=0.05). Early CPAP, early surfactant, trained and committed staff with 1:1 care lead to higher success rate. CPAP is safe even in very preterm infants with RDS and associated with lesser lung injury. Our complication rate of CLD, pneumothorax, ROP and IVH was very low. A higher CPAP pressure had significant association with RDS severity.

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