Original Articles

A descriptive study on the use of bubble CPAP in a level 2 neonatal intensive care unit in Bangalore, India

Hyalyad Sunita C Parasuramappa[1], **Gangadhar B Belavadi**[2]

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Abstract

Background: Respiratory distress syndrome (RDS) is an important cause of mortality and morbidity in preterm infants. An effective way to reduce the incidence of chronic lung injury is to use continuous positive airway pressure (CPAP) and avoid mechanical ventilation.

Objective: To assess the effectiveness of bubble CPAP (BCPAP) on immediate outcome of preterm infants with mild to moderate RDS in a level 2 neonatal intensive care unit (NICU) in Bangalore, India.

Method: A prospective analytical study was carried out on preterm neonates of gestational age 28 to 36 weeks with mild to moderate RDS admitted to a level 2 NICU in Bangalore, India, from November 2011 to May 2013. Downe score (DS) was used to assess the severity of RDS. Effectiveness of CPAP was judged using DS and fraction of inspired oxygen (FiO2) requirement.

Results: BCPAP was effective in 91% of the studied babies. At the start of CPAP 11%, 48% and 41% of babies had DS of 4, 5 and 6 respectively. At 6 hours of CPAP therapy, 56% of the babies had a score of less than 4. At 12 hours of CPAP therapy 89% of babies had a score of 4 or less, only 3% and 8% of the babies having DS of 5 and 6 respectively. Nine percent of the babies persisted in having a FiO2 requirement of 50% or more at 6 and 12 hours of CPAP therapy.

Conclusion: BCPAP was effective in 91% of the studied preterm neonates of gestational age 28 to 36 weeks with mild to moderate RDS in a level 2 NICU in Bangalore, India.

[1]*Subbaiah Institute of Medical Sciences, India,* [2]*Bangalore Medical College & Research Institute, Bangalore, India*

**Correspondence:* drhyalyads@gmail.com

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(Key words: RDS, Bubble CPAP, Downe score, FiO2 requirement)

Background

Respiratory distress syndrome (RDS) is an important cause of mortality and morbidity in preterm infants[1]. Diagnosis of RDS is based on a chest x-ray consistent with RDS, and response to surfactant therapy[2]. Mechanical ventilation is invasive and can injure the airway and lung parenchyma. An effective way to reduce the incidence of chronic lung injury is the use of continuous positive airway pressure (CPAP) and avoidance of mechanical ventilation[1,3]. Bubble CPAP (BCPAP) prevents alveolar collapse, ensures gas exchange throughout the respiratory cycle and allows lung inflation to be maintained. It can be effectively given through the silastic nasal tubes or nasal prongs which eliminate the need for the endotracheal intubation[4]. CPAP preserves spontaneous breathing, does not require endotracheal intubation and may result in less lung injury than mechanical ventilation[5]. However, not all preterm infants with RDS respond to BCPAP and not all preterm infants with RDS are candidates for initial treatment with CPAP[4,6].

Objective

To assess the effect of BCPAP on immediate outcome of preterm infants of gestational age 28-36 weeks with mild to moderate RDS in a level 2 neonatal intensive care unit (NICU) in Bangalore, India.

Method

A prospective analytical study was carried out on 100 inborn preterm neonates of gestational age 28-36 weeks with mild to moderate RDS admitted to a level 2 neonatal intensive care unit (NICU) in Vani Vilas Hospital and Bowring and Lady Curzon Hospital, Bangalore from November 2011 to May 2013.

Neonates with respiratory distress secondary to birth asphyxia, meconium aspiration, congenital pneumonia, sepsis, congenital anomalies and those requiring intubation at birth were excluded. Consent for inclusion in the study was taken from parents. Inborn babies whose parents refused consent were not included in the study. BCPAP for the treatment of RDS was available 6 months before the study. Ethical clearance was obtained from the Ethical Review Committee, Bangalore Medical College and Research Institute.

Eligible babies were started on BCPAP with bi-nasal prongs (Fisher and Paykel Healthcare, New Zealand). Positive end-expiratory pressure (PEEP) was started at 5 cm of water and adjusted to minimize chest retractions. Fraction of inspired oxygen (FiO2) was started at 50% at the start of CPAP following which the FiO2 was adjusted to maintain arterial oxygen saturation (SpO2) between 87% and 95%. Flow was titrated to the minimum necessary to produce continuous bubbling in the bubble chamber (4-7 litres /minute). The Fisher and Paykel BCPAP involves a source of gas flow, an air oxygen blender, humidifier, and a respiratory circuit. The respiratory circuit consists of an inspiratory end, an expiratory end and a patient interface. The expiratory end of circuit is inserted into a bottle of water. The CPAP level delivered is equivalent to the distance that the distal end of the expiratory tubing is under water. Downe score (DS) was used for grading the RDS and also for evaluating the clinical improvement in RDS. Septic screen and septic work up was done to rule out sepsis in the studied babies.

BCPAP was considered to be successful if the respiratory distress improved and the baby could be successfully weaned off from CPAP. The criteria for weaning were absence of respiratory distress (minimal or no retractions and respiratory rate between 30 and 60 per minute) and, SpO2>90% on FiO2 <30% and PEEP <5 cm of water. Infants were diagnosed to have failed CPAP and were started on mechanical ventilation when they: (a) remained hypoxic, i.e. SpO2<87% despite FiO2>70% and PEEP >7cm of water; (b) had severe retractions on PEEP >7cm of water; (c) had prolonged (>20 seconds) or recurrent apnoeas (>2 episodes within 24 hours associated with bradycardia) requiring bag and mask ventilation. Infants failing CPAP within first 72 hours of life were considered as CPAP failures.

Data collection of maternal variables included multiple births, pregnancy induced hypertension, preterm premature rupture of membrane, caesarean section and antenatal steroids. Gestational age was calculated with the New Ballard score. Infant variables evaluated included birth weight, gestational age, presence of intrauterine growth retardation (weight <10th on Lubchenko percentile), Apgar score at 1 minute, delivery room management (oxygen, bag and mask, intubation), arterial blood gas, FiO2 requirement, DS at starting of CPAP and at 6 and 12 hours of CPAP, patent ductus arteriosus (clinical), culture positive sepsis, intraventricular haemorrhage (IVH), pulmonary haemorrhage and duration of CPAP requirement.

Descriptive and inferential statistical analysis was done in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level. Student t test (two tailed, independent) was used to find the significance of study parameters on continuous scale between two groups on metric parameters. Chi-square/ Fisher Exact test was used to find the significance of study parameters on categorical scale between two or more groups.

Results

The baseline characteristics of the participants are showed in Table 1.

Table 1: ***Baseline characteristics of participant babies and mothers (n=100)***

Characteristic	Number (%)
Male	61 (61)
Intrauterine growth retardation	01 (01)
Multiple pregnancy	29 (29)
Gestation <32 weeks	33 (33)
Very low birth weight (≤1500)	69 (69)
Pregnancy induced hypertension	45 (45)
Premature rupture of membranes	23 (23)
Primipara mother	77 (77)
Maternal anaemia	42 (42)
Vaginal delivery	90 (90)
Caesarean section	10 (10)
Antenatal steroids	90 (90)

The mean gestational age of the babies was 32.12 ± 2 weeks. Mean birth weight was 1.431 ± 283g and 90% of the mothers of studied babies had received one or 2 doses of antenatal steroids. Mean age of commencement of CPAP was 121.2 ± 8.2 minutes. Among the studied babies 11%, 48% and 41% had DS of 4, 5 and 6 respectively at the initiation of CPAP (Table 2).

Table 2: ***Downe Scores in the 100 babies at the start, 6 and 12 hours of continuous positive airway pressure***

Downe score (DS)	DS at start Number (%)	DS at 6 hours Number (%)	DS at 12 hours Number (%)	% change
<4	0 (0.0)	56 (56.0)	79 (79.0)	+79.0
4	11 (11.0)	19 (19.0)	10 (10.0)	-01.0
5	48 (48.0)	15 (15.0)	04 (04.0)	-44.0
6	41 (41.0)	10 (10.0)	07 (07.0)	-34.0
Total	100 (100.0)	100 (100.0)	100 (100.0)	-

The mean DS at the start of CPAP therapy was 5.30 ± 0.66. By 6 hours of therapy mean DS reduced to 3.79 ± 1.03 and after 12 hours of therapy to 3.39 ± 0.86. This was statistically significant (p<0.001). Studied babies were graded as success and failure groups. Out of 100 babies, bubble CPAP was successful in 91% of babies. The response to BCPAP in studied babies is shown in Table 3.

Table 3: ***Response to Bubble CPAP in studied babies (n=100)***

Downe score	Success *(n=91)*	Failure *(n=09)*	Total *(n=100)*
At start of BCPAP		p value- 0.004	
<4	0	0	0
4	11 (100%)	0	11 (11%)
5	47 (97.9%)	01 (02.1%)	48 (48%)
6	33 (82.9%)	08 (17.1%)	41 (41%)
At 6 hours of BCPAP		p value- <0.001	
<4	56 (100%)	0	56 (56%)
4	18 (18.0%)	0	18 (18%)
5	14 (93.3%)	01 (06.7%)	15 (15%)
6	03 (27.3%)	08 (72.7%)	11 (11%)
At 12 hours of BCPAP		p value- <0.001	
<4	79 (100%)	0	79 (79%)
4	10 (100%)	0	10 (10%)
5	01 (33.0%)	02 (66.7%)	03 (03%)
6	01 (12.5%)	07 (87.5%)	08 (08%)

In the success group, 12.1%, 51.6% and 36.3% of the babies had DS of 4, 5 and 6 respectively at the start of CPAP therapy. In the failure group 11.1% and 88.9% of the babies had DS of 5 and 6 respectively at the start of CPAP therapy. None of the babies in the failure group had DS of 4 at the start of CPAP therapy. In the success group, 63.6% and 81.8% of babies who had a DS of 4 at the start of CPAP therapy improved to a score of <4 at 6 hours and 12 hours of CPAP therapy respectively, which was statistically significant (Table 4).

Table 4: ***Distribution according to Downe scores at 6 and 12 hours in studied babies with initial score of 4***

Downe score	Success	Failure	Total
At 6 hours		p value <0.001	
<4	07 (63.6%)	0	07 (63.6%)
4	04 (36.4%)	0	04 (36.4%)
5		0	0
6	0	0	0
Total	11(100%)	0	11 (100%)
At 12 hours		p value <0.001	
<4	09 (81.8%)	0	09 (81.8%)
4	02 (18.2%)	0	02 (18.2%)
5	0	0	0
6	0	0	0
Total	11 (100%)	0	11 (100%)

Among the babies having an initial score of 5, 63.8% and 95.8% showed statistically significant improvement to a score of <4 at 6 hours and 12 hours of CPAP therapy (Table 5).

Table 5: ***Distribution according to Downe score at 6 and 12 hours in babies with initial score of 5***

Downe score	Success	Failure	Total
At 6 hours	p value- <0.001		
<4	30 (63.8%)	0	30 (62.5%)
4	07(14.9%)	0	07 (14.6%)
5	10 (21.3%)	01 (100%)	11 (22.9%)
6	0	0	0
Total	47 (97.9%)	01 (02.1%)	48 (100%)
At 12 hours	p value- <0.001		
<4	45 (95.8%)	0	45 (93.8%)
4	02 (04.3%)	0	02 (04.2%)
5	0	01 (100%)	01 (02.1%)
6	0	0	0
Total	47 (97.9%)	01 (02.1%)	48 (100%)

Among the babies having an initial score of 6, 57.6% and 75.8% of the babies improved to a score <4 at 6 hours and 12 hours of CPAP therapy which was statistically significant (Table 6).

Table 6: ***Distribution according to Downe score at 6 and 12 hours in babies with initial score of 6***

Downe score	Success	Failure	Total
At 6 hours	p value- <0.001		
<4	19 (57.6%)	0	19 (46.3%)
4	07 (21.2%)	0	07(17.1%)
5	05 (15.2%)	0	05 (12.2%)
6	02 (06.1%)	08 (100%)	10 (24.4%)
Total	33 (80.5%)	08 (19.5%)	41 (100%)
At 12 hours	p value- <0.001		
<4	25 (75.8%)	0	25 (61.0%)
4	06 (18.2%)	0	06 (14.6%)
5	02 (06.1%)	1	03 (02.4%)
6	0	7	07 (17.1%)
Total	33 (80.5%)	08 (19.5%)	41 (100%)

In the failure group, none of the babies had a score of 4 at the start of CPAP therapy. None of the babies having initial score of 5 improved to a score <4 (Table 5). Among the babies who had initial score of 6, none of the babies had decrease in score at 6 hours and 12.5% of the babies improved to a score of 5 at 12 hours of CPAP therapy (Table 6).

Distribution according to FiO2 requirement at start, at 6 hours and at 12 hours of CPAP is shown in Table 7.

Table 7: ***Distribution according to FiO2 requirement at start, at 6 hours and at 12 hours of CPAP***

FiO2	At start of CPAP Number (%)	At 6 hours of CPAP Number (%)	At 12 hours of CPAP Number (%)	% change
30%	0 (0)	0 (0)	45 (45)	+45.0
31-50%	100 (100)	91 (91)	46 (46)	-54.0
>50%	0 (0)	09 (09)	09 (09)	+9.0
Total	100 (100)	100 (100)	100 (100)	-

P value- <0.001

All the studied babies were started on FiO2 of 50% at the start of CPAP. At 6 hours of CPAP therapy, the FiO2 requirement was reduced with a mean of 42.03 ± 2.57 % in the success group, which was statistically

significant. By 12 hours of CPAP therapy, FiO2 requirement in the success group was reduced significantly with a mean of 34.01 ± 4.42%.

Correlation of clinical variables according to outcome of CPAP patients studied is shown in Table 8.

Table 8: ***Correlation of clinical variables according to outcome of CPAP patients studied***

Variable	Outcome		P value
	Failure (n=9)	Success (n=91)	
Age at the start of CPAP			
Up to 60 minutes	03 (33.3%)	39 (42.9%)	
61-120 minutes	04 (44.4%)	28 (30.8%)	0.672
121-240 minutes	02 (22.2%)	15 (16.5%)	
>240 minutes	0 (0%)	09 (09.9%)	
Gender			
Female	04 (44.4%)	35 (38.5%)	0.733
Male	05 (55.6%)	56 (61.5%)	
Birth weight			
1000-1500g	07 (77.8%)	62 (68.1%)	
1501-2000g	02 (22.2%)	27 (29.7%)	1.000
>2000g	0 (0%)	02 (02.2%)	
Gestational age			
28-31 weeks	04 (44.4%)	26 (28.6%)	
32-35 weeks	05 (55.6%)	58 (63.7%)	0.042
36 weeks	0 (0%)	07 (07.7%)	
Antenatal steroids			
Not received	07 (77.8%)	02 (02.2%)	<0.001
Received	02 (22.2%)	89 (97.8%)	
Downe score			
At start of CPAP	5.88±0.33	5.24±0.66	0.004
At 6 hours of CPAP	5.89±0.33	3.58±0.83	<0.001
At 12 hours of CPAP	5.78±0.44	3.15±0.42	<0.001
Duration of CPAP (hours)	34.0±12.06	41.62±14.77	0.138
Complications	09 (100.0%)	0	<0.001

In the present study, 5 (5%), babies had intraventricular haemorrhage, 3 (3%) babies had pulmonary haemorrhage and 1 (1%) baby had PDA.

Discussion

Most studies on BCPAP are either from developed countries or level 3 neonatal units of developing countries where arterial blood gases, chest x-rays and surfactant are available round the clock. This is one of the few prospective studies from a level 2 neonatal unit of a developing country. The present study was done to assess the effectiveness of BCPAP on immediate outcome of RDS in preterm babies using the DS. Diagnosis of RDS is supported by positive postnatal gastric aspirate test and x-ray chest which may be delayed many times because of logistic reasons in developing countries like India[9-11]. Similarly, sophisticated biochemical tests such as lecithin/sphingomyelin ratio are not routinely available. Diagnosis of RDS is primarily based on clinical presentation and its severity can be assessed by using a clinical score like the DS[12].

In the present study, success of BCPAP was independent of gender of the newborn which is similar to that found in studies by Koti et al and Urs et al.[6,13]. In the prospective analytical study by Urs et al, success of bubble CPAP was significantly associated with birth weights between 1000-1500g (p <0.001)[13]. However, in the prospective analytical study by Koti et al.[6] and in our study there was no statistically significant association between success of bubble CPAP and birth weights between 1000-1500g. Urs et al found a statistically significant association between success of bubble CPAP and gestational age of 32-34 weeks. This was similar to the findings in our study. In a retrospective study by Ammari et al[14], none of the babies with gestation >30 weeks failed CPAP.

In the present study, 11%, 48% and 41% of the babies had DS of 4, 5 and 6 respectively before the start of CPAP. In the study conducted by Urs et al[13], 32%, 62% and 6% of the studied babies had DS of 4, 5 and 6 respectively before the start of CPAP. In the

present study effectiveness of BCPAP was assessed using DS. Out of the 11% babies who had a DS of 4 at the initiation of BCPAP, after 6 hours, 7 (63.6%) had a score of <4 and 4 (36.4%) had an unchanged score of 4 which was statistically significant. These findings were similar to those found by Urs et al.[13], where out of 16 babies who had a DS of 4 at initiation of BCPAP, after 6 hours, 12 (75%) had a score of <4 and 4 (25%) had a score of >4, which was statistically significant. In our study, the babies were further evaluated after 12 hours, at which stage 81.8% had a score of <4, which was statistically significant (p <0.001). However, none of the other studies had followed up the babies after 12 hours of CPAP to assess improvement in DS. In the present study, 48% babies had a score of 5 before initiation of CPAP and after 6 hours 77.1% babies had a score of <5 and at 12 hours 97.9% had a score of <5, which was statistically significant (p<0.001). This was similar to the findings of Urs et al,[13] where 31 babies had a score of 5 before initiation of BCPAP and after 6 hours 25 (80%) had improved to a score of 4 or less and 6 (20%) had a score of more than 6 (p <0.05). In the present study, among 41% of the babies who had a score of 6 before the initiation of BCPAP, 75.6% improved to a score of <6 at 6 hours after starting of BCPAP and at 12 hours, 82.9% of babies had a score <6, which was statistically significant. The findings at 6 hours of CPAP are similar those by Urs et al,[13] where three (6%) babies had a score of 6 initially, and all of them improved by 6 hours. Thus there was a statistically significant improvement in DS following BCPAP therapy in newborns with RDS.

DS of 6 at the start of CPAP, persistence of DS of 6 at 6 hours and 12 hours of CPAP therapy in babies with mild to moderate RDS may predict failure of CPAP. In the present study, there was marked reduction in FiO2 requirement following CPAP therapy, which was statistically significant. FiO2 requirement of >50% at 6 hours and 12 hours following CPAP therapy may predict CPAP failure. The present study confirms that DS and FiO2 requirement are more clinically relevant and easily accessible tools to assess the improvement in RDS in babies on CPAP in comparison to chest x-ray and arterial blood gas analysis in resources limited settings. This study confirms that BCPAP is a safe, simple, noninvasive and effective mode of respiratory support in treating mild to moderate RDS in preterm babies.

Conclusions

BCPAP was effective in 91% of the studied preterm neonates of gestational age 28 to 36 weeks with mild to moderate RDS in a level 2 NICU in Bangalore, India.

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