

Efficacy and Outcome of Bubble Continuous Positive Airway Pressure in Newborn with Respiratory Distress at Special Newborn Care Unit in Rural Area of Telangana State, India

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Abstract

Background: Management of respiratory distress (RD) in newborn in a developing country with limited resources in rural parts in India is still a challenge. A low cost bubble continuous positive airway pressure (CPAP) device has been shown a great promise to fulfill this difficulty. Even though CPAP therapy has been shown to be successful, studies documenting its efficacy and outcome from rural India are very rare.

Materials and Methods: These were a retrospective observational study carried out at special newborn care unit of Siddipet, Telangana, from January 2019 to December 2020. Neonates with RD at birth or after birth that required bubble CPAP were included in the study. The efficacy of CPAP on immediate outcome of these infants was analyzed.

Results: A total of 154 newborns (124 inborn and 30 outborn) were included in the final analysis who received bubble CPAP. Mean gestational age was 35–36 weeks, mean birth weight of 2156 g. Morbidities required bubble CPAP most common were RD syndrome 81 (52.6%) followed by transient tachypnea of newborn 51 (33.1%), meconium aspiration syndrome 13 (8.4%), perinatal asphyxia 7 (4.5%), and congenital pneumonia 2 (1.3%). Of the study population, 119 (77.3%) neonates have successfully been discharged with CPAP only, 14 (19%) babies required further invasive ventilation, and 6 (3.9%) babies required surfactant administration along with CPAP.

Conclusion: Proper and early initiation of low cost non-invasive CPAP for newborn with significant RD has good results in outcome and decreased the need for invasive mechanical ventilation and surfactant administration which helped in early kangaroo mother care and discharge with fewer morbidities.

Key words: Bubble continuous positive airway pressure, Efficacy, Respiratory distress, Special newborn care unit

INTRODUCTION

Approximately one in 10 newborn requires assistance to begin breathing in an extrauterine environment at birth. The most common conditions that compromise respiratory function include prematurity, birth asphyxia,

and pneumonia, which are responsible for more than 50% of 3.6 million deaths every year globally.^[1]

Respiratory distress (RD) is said to be present when tachypnea (respiratory rate >60/min) is accompanied with chest retractions and/or grunt. RD can be due to respiratory and non-respiratory causes. Common respiratory causes include RD syndrome (RDS), meconium aspiration syndrome (MAS), pneumonia, transient tachypnea of newborn (TTNB), persistent pulmonary hypertension, pneumothorax, tracheoesophageal fistula (TEF), and congenital diaphragmatic hernia (CDH). Congestive heart failure, congenital heart disease, hypothermia, hypoglycemia, metabolic acidosis, and perinatal asphyxia constitute common non-respiratory causes.^[2]

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Continuous positive airway pressure (CPAP) is a non-invasive respiratory support option which provides continuous distending pressure in a spontaneously breathing neonate, increases functional residual capacity of lung resulting in better gas exchange. It is also meant to avoid harmful effects of positive pressure ventilation.^[3]

In India, nearly 26 million infants are born every year and assuming an incidence of RD in newborn to about 10%, 2.6 million infants are at need for the treatment of RD of various causes. Despite advances in neonatal care such as mechanical ventilation, surfactant therapy, and CPAP technologies, the accessibility and cost constraints are making neonatal care still a challenging area in most of the developing countries like India. Even though early CPAP therapy has been shown to be successful on some clinical trials in the management of RD, studies documenting its efficacy and outcome in rural areas are very few.

With this background, the present study was done to document the outcome and efficacy of CPAP in newborn with RD in a special newborn care unit (SNCU), rural part of Telangana State in India.

Objectives

The objectives of the study were as follows:

1. To assess the outcome of bubble CPAP in premature and term neonates with RD in a rural SNCU
2. To assess the efficacy of CPAP by comparing the outcome and complications in similar studies conducted in India both rural and urban.

MATERIALS AND METHODS

Study Design

Retrospective observational study analysis.

Study Setting

SNCU of Government Medical College, Siddipet, a tertiary care teaching hospital in rural part of Telangana State, India.

Study Period

The study period was from January 2019 to December 2020.

Inclusion Criteria

The following criteria were included in the study:

- Term neonates with RD with Downes score 4–7
- Preterm neonates with RD with Silverman Anderson score 4–6
- To prevent respiratory failure (apnea of prematurity)
- To treat airway obstruction.

Exclusion Criteria

The following criteria were excluded from the study:

- Neonates with a history of significant birth asphyxia (Stages 2 and 3)
- Term neonate with RD with Downes score <4 and >8
- Preterm neonate with RD with Silverman Anderson score <4 and >7
- Babies with congenital anomalies and surgical conditions such as cleft palate, bilateral choanal atresia, CDH, and TEF.

Sample Size

A total of 154 eligible newborn babies both preterm and term were included in this study of 2 years.

Study Procedure

Whenever neonatal baby presented to SNCU with RD as per protocol to maintain temperature, airway, breathing, and circulation, babies after keeping under the radiant warmer babies are given supplemental oxygen with nasal prongs 1–2 L/min to all babies with mild RD keeping target oxygen saturation of 90–95% as per NRP. As per the criteria of Silverman Anderson score for premature babies and Downes score for term neonates, babies with RD were started on bCPAP with rule of 5, as 50% FIO₂, 5 L of flow, and 5 positive end-expiratory pressure (PEEP) with target SPO₂ saturations for the neonates between 90% and 95% in the right upper arm. CPAP machine settings of flow, FIO₂, and PEEP were changed as per clinical improvement of the neonates. Whenever baby RD comes down, we gradually tapered the FIO₂ by 5% (from 50% to 45%) later from 45% to 40% in stepwise, followed by flow from 5 L to 4 L. Then FIO₂ 40–35%, next 35–30% followed by flow changed from 4 L to 3 L. We kept the PEEP constant in maximum cases. Once the baby is stable on FIO₂ 30%. Flow 3 L and PEEP 5, when the baby is hemodynamically stable, the baby is gradually weaned off to hood oxygen or nasal prongs with oxygen 1–2 L/min. Vice versa whenever required to increase the settings. We have used Neotech Company bubble CPAP machine with appropriate size nasal prongs of small, medium, and large as per the weight, gestational age of the baby. Orogastric tube was inserted in all newborns on CPAP for abdominal decompression and early initiation of OG feeds once baby is hemodynamically stable, neonates were monitored clinically and regular arterial blood gases (ABGs) were done when ever required. Chest X-rays (CXRs) were done in all neonates on bubble CPAP. Respiration rate, heart rate, SPO₂, and blood pressure were monitored regularly.

Babies were observed for outcomes until discharge. Premature babies with hyaline membrane disease (HMD) whenever there is high requirement of oxygen of more than 50% FIO₂, surfactant is given by INSURE technique and those babies

requiring further respiratory support and not maintaining saturations on CPAP and surfactant, were mechanically ventilated and termed as CPAP failure. If there were signs of shock such as tachycardia, prolonged capillary refill time, dull activity volume expansion by fluid boluses, and inotropic support were given. If there were symptoms and signs of sepsis, antibiotics were started as per unit protocol. All premature neonates admitted in SNCU were screened for retinopathy of prematurity and neurosonogram as per protocol.

CPAP failure is defined as:^[4]

1. Increased work of breathing (intercostal retractions and accessory muscle contribution for respiration) with respiratory rate >60/min
2. Increased apnea and bradycardia and/or desaturations >2 in 1 h for a previous 6 h period
3. Increased oxygen requirement: SpO₂ <90% on FiO₂ >60% for >30 min with requirement of CPAP >8 cm of H₂O.
4. Blood gases showing
 - a. PH <7.2
 - b. PCO₂ >65 mm of Hg
 - c. PO₂ <50 mm of Hg on FiO₂ >60%
5. Major apnea/bradycardia requiring resuscitation.

Outcomes

Initiation of CPAP, duration, neonates discharged successfully from CPAP, CPAP failure, requiring surfactant, mechanical ventilation, nasal damage, incidence of pneumothorax, intraventricular hemorrhage, periventricular leukomalacia, retinopathy of prematurity, chronic lung disease, and duration of hospital stay were analyzed.

RESULTS

During the study period, a total of 1963 babies were admitted in our unit of which 1264 (64.39%) were given supplemental oxygenation in view of minimal RD which got resolved with oxygen only. Among the admitted neonates with significant RD, 154 neonates were started with bCPAP in the final study as per the inclusion criteria. Beyond those 71 neonates required mechanical ventilation that had severe RD.

The maternal characteristics [Table 1] of neonates who received CPAP support for RD when analyzed showed a predominance primigravida mothers who constituted 50.60% (78) of study group, second gravida mothers are 26.60% (41) followed by G3 16.90% (26), and higher order pregnancies consist of 5.8% (9). Maternal age of <25 years comprises >75% of study population. Of the 77 preterm deliveries, full course of antenatal steroids (two doses of

Betnesol 12 mg with 24 h gap or dexamethasone injection 6 mg, 4 doses with 12 h interval) was given in 42 (54.54%), incomplete steroids (at least one dose of antenatal steroids) given in 28 (36.36%), and not given antenatal steroids in 7 (9.10%). Five twin deliveries were present in the study and remaining all are singleton pregnancies. Urinary tract infection (maternal fever) is the most common complication seen in 15.6% (24) of mothers followed by diabetes mellitus in 7.1% (11), hypertension in 4.5% (7), and patient-reported outcome measures in 3.2% (5) of cases.

Term deliveries [Table 2] comprise 50.1% (77) while 34.4% are with gestational age of 33–36 weeks, 12.3% are 29–32 weeks, and 3.2% with gestational age <28 weeks. The mean gestational age of the study group was 35.48 weeks. Of the 154 deliveries, 124 were C-section and 30 were vaginal deliveries. When weight of the baby is taken for the criteria, 36.4% of neonates were more than 2500 g appropriate for gestational age, 42.9% are between 1500 g and 2500 g low birth weight (LBW), 16.2% are between 1000 g and 1499 g very LBW, and 4.5% are <1000 g extremely LBW with mean birth weight of 2156 g.

In gender variation, study shows that 101 (65.6%) neonates were male and 53 (34.4%) are female with M: F ratio of 1.9:1. There is increase admission rate in male newborn babies. Appearance, pulse, grimace, activity, and respiration (APGAR) score at 5 min in the study group shows 100 (64.9%) babies having an APGAR of 8–10, 50 (32.5%) with 5–7 score and 4 (2.6%) babies had APGAR score of 4.

Orogastric tube [Table 3] was inserted in all newborns on CPAP for abdominal decompression and early initiation of OG feeds which was done in 18% of study neonates once they were hemodynamically stable. In the study group, 21 (13.6%) of newborn babies with RD were started with bCPAP soon after birth and 133 (86.4%) newborn babies required bubble CPAP after 6 h of life. Twenty-six (16.9%) newborn babies required initial FiO₂ of <40% at the beginning of CPAP therapy and 128 (83.1%) required more than 40% FiO₂ which was gradually decreased as per clinical improvement. If FiO₂ requirement of more than 50% with significant RD in premature babies with CXR features suggestive of HMD, surfactant was given by INSURE technique.

RDS is the most common primary diagnosis with 81 (52.6%) babies requiring CPAP followed by TTNB 51 (33.2%), MAS 13 (8.4%), mild perinatal asphyxia 7 (4.5%), and congenital pneumonia 2 (1.3%). Clinical sepsis was a comorbid factor in 82 (53.2%) neonates of study group. Complications of CPAP therapy were nasal septum injury which was seen only 2 (1.29%) babies which subsided later without any complication with

local antibiotic ointment application. None of the babies developed nasal bridge injury, abdominal distension, and pneumothorax in our study.

In the study group, 130 (84.40%) neonates with significant RD were successfully discharged with CPAP alone and 24 neonates [Table 4] being required mechanical ventilation of which six premature babies required surfactant administration and three babies who were ventilated from CPAP got expired due to other complications. Three babies were referred to higher center in view of complex cardiac disease. The overall success rate of our study group is 98% and success rate with exclusive CPAP is 86.1%.

DISCUSSION

This is a retrospective observational study conducted in a level 2 neonatal unit of rural part of Telangana state, India, with a high-risk delivery unit that conducts at an average of 4500 deliveries per year with about 1000 newborn admitted annually in our unit. During the study period, a total of 1963 newborn babies were admitted of which 1264 (64.39%) with mild RD got resolved with oxygen supplementation only. Among the babies with significant RD, 154 babies required bubble CPAP as per the inclusion criteria. With such a background, this study was done to find the efficacy and immediate outcome of bCPAP when started timely and escalated/de-escalated appropriately based on babies clinical condition. Diagnosis was done mainly clinically and was aided by CXR, ABGs, and Downes score and Silverman Anderson scores.

In the present study, the success of bCPAP was 84.4% which is much higher than earlier studies by Byram *et al.*^[5] (64%), Shamil *et al.*^[6] (66%), and Sethi *et al.*^[7] (60%). This may be due to the structured approach followed in our unit in assessing the newborn and early and timely initiation of bCPAP.

BCPAP was started to babies with RD irrespective of gestation age and weaned off as per clinical improvement. All term babies were weaned within the first 48 h of life than those of early and preterm babies. Babies with gestation age <32 weeks required CPAP for longer duration and CPAP failure was seen exclusively in this group. Three babies were referred due to complex cardiac disease and three babies in the study group expired secondary to extreme prematurity associated comorbidities. Of the six babies administered with surfactant, four were discharged successfully and two expired. Overall CPAP failure rate in our unit was 15.58% which is comparatively less when compared with studies by Koti *et al.*^[8] (25%), Sethi *et al.*^[7] (40%), and consistent with study by Roberts *et al.*^[9] (13%).

Table 1: Maternal characteristics

Maternal age	Number	Percentage
<20 years	67	43.5
20–25 years	50	32.5
26–30 years	23	14.9
31+years	14	9.1
Gravida status		
Primi	78	50.6
G2	41	26.7
G3	26	16.9
G4 and above	9	5.8
Mode of delivery		
NVD	40	26.0
C-section	114	74.0
No. of babies delivered		
Singleton	149	96.8
Twins	5	3.2
Triplets	0	
Place of delivery		
Inborn	124	80.5
Outborn	30	19.5
Antenatal steroid		
Yes (complete two doses)	42 (among 77 preterm)	54.5
Incomplete (at least one dose received)	28 (among 77 preterm)	36.4
No	7 (among 77 preterm)	9.1
Complications		
DM	11	7.1
Hypertension	7	4.5
PROM	5	3.2
UTI	24	15.6

NVD: Normal vaginal delivery, DM: Diabetes mellitus, PROM: Patient-reported outcome measures, UTI: Urinary tract infection

Table 2: Neonatal characteristics

Gestation age	Number	Percentage
<28 weeks	5	3.2
29–32 weeks	19	12.3
33–36 weeks	53	34.4
37–40 weeks	77	50.1
Gender		
Male	101	65.6
Female	53	34.4
Birth weight		
<1000 g	7	4.5
1000–1499 g	25	16.2
1500–2499 g	66	42.9
>2500 g	56	36.4
Resuscitation at birth		
Routine	146	94.8
Bag and mask ventilation	8	5.2
5 min APGAR score		
0–4	4	2.6
5–7	50	32.5
8–10	100	64.9
RD signs		
Tachycardia	102	66.2
Grunting	134	87
Retractions	27	18.1
Cyanosis	17	11.2
Apnea	6	4

RD: Respiratory distress, APGAR: Appearance, pulse, grimace, activity, and respiration

Table 3: Characteristics of bubble CPAP therapy in neonates

Starting age of CPAP therapy	Number	Percentage
At birth	21	13.6
>6 h	133	86.4
FiO ₂ needed on CPAP therapy		
<40%	26	16.9
>40%	128	83.1
Orogastric tube insertion	154	100
Feeding while on bCPAP	46	18.2
CPAP therapy duration		
<24 h	34	22.1
24 h–48 h	113	73.4
>48 h	7	4.5
Primary diagnosis		
RDS	81	52.6
TTNB	51	33.2
MAS	13	8.4
Mild perinatal asphyxia	7	4.5
Congenital pneumonia	2	1.3
Comorbidities		
Sepsis (probable)	82	53.2
Complications		
Nasal septum injury	2	
Nasal bridge injury	Nil	
Abdominal distension	Nil	
Pneumothorax	Nil	

CPAP: Continuous positive airway pressure, bCPAP: Bubble continuous positive airway pressure, RDS: Respiratory distress syndrome, MAS: Meconium aspiration syndrome, TTNB: Transient tachypnea of newborn

Table 4: Outcome

Primary outcome	Number	Percentage
Discharge		
130	84.40	
CPAP failure requiring ventilation	24	15.58
Referred	3	1.94
Secondary outcome		
Deaths	3	1.94
Surfactant therapy	6	3.89

The analysis of maternal characteristics showed that mothers of <25 years form 75% of the study group with 50% of the babies are born to primi mothers. This can be attributed to our high-risk delivery unit which acts as a referral center for the district and depicted with 74% of deliveries being conducted by C-section. The present study showed that of the preterm deliveries, seven mothers did not receive any antenatal steroid of which 2 (28.6%) babies expired and 28 mothers received single dose of steroid 1 (3.6%) baby died. No mortality was seen in babies of mother who received two doses of antenatal steroids before delivery. This is similar to studies by Sanghvi and Rasanias^[10] Robert and Dalziel.^[11]

CONCLUSION

This study concludes that early initiation of non-invasive CPAP in newborn with significant RD has definitely reduced the need of invasive mechanical ventilation, need of costly surfactant administration, and aids in early recovery and discharge with least morbidities in the neonate.

It is a safe and cost-effective method that can be employed in resource-limited settings and requires good monitoring and supportive care. Antenatal steroids have good impact in outcome of babies with RD on CPAP and CPAP failure is mainly seen in preterm babies whose mother did not receive no or full dose of antenatal steroids.

ETHICAL APPROVAL

This study was approved by Institutional Review Board.

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