Original Article

Outcome of Early CPAP Therapy in the Management of Respiratory Distress Syndrome in Preterm Babies: A Prospective Observational Study

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Abstract

Background: Respiratory distress syndrome (RDS) is the leading cause of morbidity and mortality in preterm infants. Continuous positive airway pressure (CPAP) is increasingly used as a first-line non-invasive respiratory support to reduce the need for mechanical ventilation and surfactant therapy. The objective is to assess the outcome of early CPAP therapy in preterm babies between 28-32 weeks of gestational age with RDS and to determine the incidence of CPAP failure, need for surfactant, mechanical ventilation, and associated complications. **Material and Methods:** A prospective observational study was conducted at Gandhi Medical College and Hospital, Secunderabad, over 18 months. Ninety-six preterm neonates (28-32 weeks of gestation) with mild to moderate RDS (Silverman-Anderson score <7) were enrolled. Early CPAP (within 10-30 minutes of birth) was initiated with either bubble CPAP or machine CPAP, depending on severity. Primary outcomes included need for mechanical ventilation, surfactant therapy, and mortality. Complications were documented. **Results:** Of 96 neonates, 51% were males. The majority (89.6%) were appropriate for gestational age. Antenatal steroids were not given in 37.5%, while 33.3% received one dose and 29.1% received two doses. CPAP failure requiring mechanical ventilation occurred in 12.5% (95% CI: 5.8-19.1), surfactant was needed in 21.8% (95% CI: 13.6-30.1), and mortality was 8.3% (95% CI: 2.8-13.8). The most common complication was nasal trauma (19.8%), followed by hypotension (6.3%), sepsis (6.3%), and pulmonary hemorrhage (6.3%). Babies who received two doses of antenatal steroids had better outcomes, with lower mortality. **Conclusion:** Early CPAP therapy is an effective noninvasive respiratory support strategy in preterm neonates with mild to moderate RDS, significantly reducing the need for mechanical ventilation and surfactant therapy while maintaining acceptable complication rates. Antenatal steroid administration improves outcomes.

Keywords: Respiratory distress syndrome, CPAP, preterm infants, mechanical ventilation, surfactant, neonatal intensive care.

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Introduction

Respiratory distress syndrome (RDS) remains the most significant cause of respiratory failure, morbidity, and mortality in preterm infants.[1] It is caused by a lack of surfactants in the infant lung and has an inverse relationship with gestational age, i.e., incidence is about 98 per cent at 24 weeks versus less than 1 per cent at 37 weeks.[2] Pathophysiology includes increased tension at the alveolar level, resulting in atelectasis, decreased functional residual capacity, and ventilation-perfusion mismatch.[3]

Conventionally, the basis of RDS management has been invasive mechanical ventilation. It, however, causes ventilator-induced lung injury, bronchopulmonary dysplasia (BPD), and other complications.[4] Non-invasive positive airway pressure (CPAP) is a development that provides positive end-expiratory pressure (PEEP), alveolar recruitment, stabilizes functional residual capacity, and decreases work of breathing, while preserving spontaneous respiration.[5,6]

CPAP was initially described in 1981, and it is now a common first-line treatment in most neonatal intensive care units across the world.[7] It has been established that early CPAP support may minimize the need for intubation, mechanical ventilation, and surfactant treatment, thereby reducing the rates of BPD and increasing the survival rates of very low birth weight infants.[8,9] The SUPPORT trial demonstrated that results with early CPAP were similar to those with prophylactic surfactant and mechanical ventilation, and less surfactant therapy was needed.[10]

Although it is beneficial, CPAP therapy does not succeed in 20-40% of preterm infants, stimulating the necessity to increase it to mechanical ventilation or the administration of surfactants.[11] Some predictors of CPAP failure encompass low gestational age, severe RDS, high oxygen demand, and late initiation of CPAP.[12] As a nurse-administered, resource-saving, and cost-effective alternative to ventilator-driven systems in resource-limited

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environments, such as India, bubble CPAP (bCPAP) can be effectively used to achieve efficacy.[13] This study was conducted to evaluate the outcomes of early CPAP therapy in preterm infants with RDS at a tertiary care teaching hospital in South India and to assess the incidence of CPAP failure, surfactant requirement, mechanical ventilation need, and associated complications.

Materials and Methods

Study Design and Setting: This prospective observational study was conducted in the Neonatal Intensive Care Unit (NICU) of Gandhi Medical College and Hospital, Secunderabad, Telangana, over 18 months (2023-2025). Institutional ethics committee approval was obtained (EC/180/Inst/AP/2013/RR-19, dated 26-08-2019).

Study Population

Inclusion criteria

Preterm neonates born between 28 and 32 weeks of gestational age at Gandhi Hospital with clinical features of RDS (tachypnea, nasal flaring, grunting, subcostal/intercostal retractions, cyanosis) and Silverman-Anderson Score (SAS) <7 (mild to moderate respiratory distress).

Exclusion criteria

Congenital anomalies, neonates requiring intubation at birth, and babies born at other hospitals.

Sample Size: Ninety-six preterm neonates meeting the inclusion criteria were enrolled after obtaining informed parental consent.

Intervention: Early CPAP was initiated within 10-30 minutes of birth. Bubble CPAP was used for babies with SAS 4-6 (mild RDS), while machine CPAP was used for babies with SAS 7-10 (moderate RDS). Initial settings included PEEP of 5-6 cm H_2O with FiO_2 adjusted to maintain SpO_2 90-95%. Babies were monitored for vital signs, work of breathing, blood gases, and complications.

Criteria of CPAP failures were: unremitting hypoxemia (SpO 2 <88 per cent despite FiO 2 >0.4), respiratory acidosis (pH <7.20, PaCO 2 >60 mmHg), the increasing work of breathing, or repetitive apneas. Such infants were intubated and placed on a mechanical ventilator, and surfactant was administered per unit protocol.

Data Collection: Demographic data, antenatal history (steroid administration), mode of delivery, birth weight, gestational age calculation, and Silverman-Anderson scores were collected using a structured pro forma. Primary outcomes included need for mechanical ventilation, surfactant therapy, and mortality. Secondary outcomes included complications such as nasal trauma, pneumothorax, sepsis, necrotizing enterocolitis (NEC), intraventricular hemorrhage (IVH), and others.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS. Descriptive statistics (frequencies, percentages, means, and standard deviations) were calculated. Confidence intervals (95% CI) were assessed using the Z-test for proportions. P-value <0.05 was considered statistically significant.

Results

Demographic and Baseline Characteristics: Of 96 neonates enrolled, 49 (51%) were males, and 47 (49%) were females. The majority (89.6%) were appropriate for gestational age (AGA), while 10.4% were small for gestational age (SGA). Two-thirds (65.6%) were delivered by lower segment cesarean section (LSCS), and 34.4% by normal vaginal delivery (NVD).

Table 1: Baseline characteristics of study population (n = 96)

Variable	Category	n	%
Sex	Male	49	51.0
	Female	47	49.0
Weight for gestational age	AGA	86	89.6
	SGA	10	10.4
Mode of delivery	NVD	33	34.4
	LSCS	63	65.6

Antenatal Steroid Administration: Antenatal corticosteroids were not administered in 36 mothers (37.5%), one dose was given in 32 cases (33.3%), and two doses in 28 cases (29.1%). The most common antenatal complications were pregnancy-induced hypertension (PIH) (16.6%), gestational diabetes mellitus (GDM) (15.6%), and foul-smelling liquor (15.6%), followed by third-trimester fever (9.3%) and oligohydramnios (8.3%).

Table 2: Antenatal steroids, complications and initial respiratory status

Variable	Category	n	%
Antenatal steroids	Not given	36	37.5
	One dose	32	33.3
	Two doses	28	29.1
Antenatal complications*	PIH	16	16.6
	GDM	15	15.6
	Foul-smelling liquor	15	15.6
	3rd trimester fever	9	9.3
	Oligohydramnios	8	8.3
Silverman–Anderson score	Mild RDS (4–6)	60	62.5
	Moderate RDS (7–10)	36	37.5

*More than one complication could be present in the same pregnancy

Respiratory Distress Severity and CPAP Mode: Sixty neonates (62.5%) had mild RDS (SAS 4-6) and were managed with bubble CPAP, while 36 (37.5%) had moderate RDS (SAS 7-10) and required machine CPAP.

Table 3: Mode of CPAP and primary outcomes

Variable	Category	n	%
Mode of CPAP	Bubble CPAP	60	62.5
	Machine CPAP	36	37.5
Primary outcomes	Mechanical ventilation	12	12.5 (95% CI 5.8–19.1)
	Surfactant given	21	21.8 (95% CI 13.6–30.1)
	Mortality	8	8.3 (95% CI 2.8–13.8)

CPAP Failure and Mechanical Ventilation: Twelve neonates (12.5%; 95% CI: 5.8-19.1) failed CPAP and required mechanical ventilation. The failure rate was significantly lower than previously reported rates of 22-30% in similar settings.[14]

Surfactant Requirement: 21 babies (21.8%; 95% CI: 13.6-30.1) required surfactant therapy, comparable to other Indian studies.[15]

Mortality: Eight neonates (8.3%; 95% CI: 2.8-13.8) died. Mortality was associated with severe complications, including NEC (n=3), sepsis with shock (n=2), pulmonary hemorrhage (n=2), and ventilator-associated pneumonia with sepsis (n=1).

Table 4: Mortality distribution by major complications (n = 8 deaths)

Complication	Frequency of complication	Deaths (n)
NEC	4	3
Sepsis with shock	2	2
Pulmonary hemorrhage	6	2
VAP with sepsis	5	1
Nasal trauma, sepsis, hypotension	–	0

Influence of Antenatal Steroids on Outcomes

Table 5: Primary outcomes by antenatal steroid exposure

Steroid exposure	n	Need for surfactant n (%)	Need for MV n (%)	Mortality n (%)
Not given	36	8 (22.2)	5 (13.9)	5 (13.9)
One dose	32	5 (15.6)	3 (9.4)	2 (6.3)
Two doses	28	8 (28.6)	4 (14.3)	1 (3.6)

Babies whose mothers received two doses of antenatal steroids had better outcomes: only 1 (3.6%) died compared to 2 (6.3%) in the one-dose group and 5 (13.9%) in the no-steroid group. The need for surfactant and mechanical ventilation was also lower in the two-dose group, highlighting the protective role of antenatal corticosteroids.[16]

Complications: The most common complications were nasal trauma (19.8%), hypotension (6.3%), sepsis (6.3%), pulmonary hemorrhage (6.3%), ventilator-associated pneumonia with sepsis (5.2%), necrotizing enterocolitis (4.1%), and sepsis with shock (2%). No cases of pneumothorax were recorded, likely due to the non-invasive nature of CPAP and avoidance of high pressures.

Table 6: Complications during hospital stay (n = 96)

Complication	n	%
Nasal trauma	19	19.8
Hypotension	6	6.3
Sepsis	6	6.3
Sepsis with shock	2	2.1
NEC	4	4.1
Pulmonary hemorrhage	6	6.3
VAP with sepsis	5	5.2

Discussion

This paper indicates that early CPAP intervention is a safe and effective non-invasive mode of respiratory support that can be used on preterm infants who have mild to moderate instances of RDS. We found a 12.5% CPAP failure rate, which was lower than the international literature's 20-40%,[11] and closer to a similar Indian study's 22.1%.[14] This reduced rate of failure could have been explained by the prompt initiation of CPAP within 10-30 minutes of birth and the prudent application of bubble and machine CPAP, depending on the judgment of severity.

The surfactant needs to have a value of 21.8 per cent, which is in line with other studies conducted in India.[15,17] This is a relatively lower rate that highlights the importance of CPAP in sustaining alveolar recruitment and functional residual capacity, reducing surfactant inactivation, and enhancing endogenous surfactant activity. It is also encouraging with the mortality rate of 8.3%, which is less than the 15.6% recorded in other research on preterm babies who did not receive early CPAP support.[18]

Antenatal Corticosteroids Role: Our results justify the significant role of antenatal corticosteroids. Infants of mothers who were exposed to two doses of steroids had significantly lower mortality (3.6 versus 13.9) than infants of mothers who were not steroidized. The same could be said about the Polish national Survey, in which the use of antenatal steroids minimized the effects of RDS and surfactant demand.[16] This emphasizes the significance of better antenatal care and the use of steroids at the right time during pregnancy, which is at risk.

Complications: The most common complication was nasal trauma (19.8%), which is in line with other studies into CPAP.[14,19] This is mild and can normally be managed with proper nasal interface care, alternating prongs, and proper sizing. Our cohort did not present with pneumothorax, as was reported in other cases, and this is probably due to careful pressure titration and close surveillance.

Cases of serious complications such as NEC, pulmonary hemorrhage, and sepsis facilitated deaths. These highlight the susceptibility of the group of extremely preterm babies and the multifactoriality of the adverse outcomes of this group. Before hospital discharge, CPAP cannot avert all the risks but greatly suppresses all the complications that are associated with mechanical ventilation, such as ventilator-associated pneumonia and BPD.

Comparison and Confusion with the Past: The SUPPORT trial showed that early CPAP was as effective as prophylactic surfactant in infants who are extremely preterm and also reduced the need for mechanical ventilation.[10] We can generalise our results to the 28-32 weeks of gestational age, in an Indian environment with limited resources. The use of bubble CPAP in developing nations, particularly Nepal, has also been found in studies to be feasible, cost-effective, and likely to yield better results despite limited resources.[13,20]

Strengths and Limitations: The strengths of this research include its prospective design and clear inclusion criteria, with emphasis on a specific gestational age and a detailed description of outcomes and complications. The lack of a control group to directly compare results, a comparatively small sample size, limited follow-up time, and the exclusion of very preterm (below 28 weeks) and late preterm (above 32 weeks) infants are some of the limitations that limit the generalizability of the results.

Clinical Implications: We conclude that the preliminary CPAP should be introduced as the primary ventilator in neonates with a preterm birth with RDS in resource-intensive units. Bubble CPAP is a cheap substitute for high-cost ventilator equipment that performs ineffectively. Emphasis should be placed on:

- Early CPAP introduction within the first 30 minutes of life.
- Silverman-Anderson scoring systematic evaluation.
- Provision of befitting antenatal steroid use in high-risk pregnancies.
- Close detection of CPAP failure and immediate progression onto mechanical ventilation and surfactant treatment.

Conclusion

First-line respiratory support intervention, i.e., early CPAP therapy, has proven to be safe and effective as the management intercessor towards preterm infants (gestation 28-32 weeks) with mild to moderate RDS. It shows a high requirement for mechanical ventilation (12.5) or surfactant therapy (21.8) and satisfaction with an acceptable mortality and complication profile (8.3). There are significant benefits to using antenatal corticosteroids. The most frequent complication is nasal trauma, which is usually curable. Bubble CPAP represents an inexpensive nurse-administered substitute that can be used in resource-constrained environments. The extensive randomized controlled trials that require long-term follow-up should proceed to determine the best CPAP regimens and predictors of CPAP failure among this at-risk group.

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Conflicts of interest

There are no conflicts of interest.

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