Original Research

CLINICAL PROFILE AND OUTCOMES OF NEONATES WITH RESPIRATORY DISTRESS MANAGED WITH BUBBLE CONTINUOUS POSITIVE AIRWAY PRESSURE: A TERTIARY CARE HOSPITAL EXPERIENCE

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ABSTRACT

Background: Respiratory distress is a leading cause of neonatal morbidity and mortality, particularly in preterm infants. Bubble continuous positive airway pressure (bCPAP) has emerged as an effective non-invasive respiratory support modality. This study aimed to evaluate the clinical profile and outcomes of neonates with respiratory distress managed with bCPAP.

Methods: A prospective observational study was conducted over 12 months (April 2023-April 2024) at a tertiary care neonatal unit. Neonates with respiratory distress (Downes/Silverman-Anderson score 4-6) were included. Demographic data, clinical parameters, duration of CPAP support, and outcomes were analyzed. Statistical analysis was performed using chi-square and Fisher's exact tests.

Results: Of 165 neonates enrolled, 68.5% were preterm. The most common etiology was respiratory distress syndrome (RDS, 61.8%), followed by transient tachypnea of newborn (TTN, 17.0%). Overall success rate of bCPAP was 77.0%. CPAP failure requiring mechanical ventilation occurred in 23.0%, with 17.6% mortality. Gestational age significantly influenced outcomes, with <28 weeks showing 100% failure rate ($p<0.001$). Complete antenatal steroid coverage improved outcomes in preterm neonates (77.8% recovery vs 47.6% in non-recipients, $p=0.02$). Higher Downes/SA scores (≥6), PEEP ≥6 cm H_2O, and FiO_2 >60% predicted CPAP failure. Pneumothorax was associated with 75% mortality.

Conclusion: Bubble CPAP is an effective first-line respiratory support for neonatal respiratory distress with a 77% success rate. Gestational age, antenatal steroids, disease severity scores, and oxygen requirements are significant predictors of outcome. Early identification of failure predictors enables timely intervention.

Keywords: Bubble CPAP, Respiratory Distress Syndrome, Neonates, Non-Invasive Ventilation, Outcome.

INTRODUCTION

Neonatal respiratory distress affects approximately 4-7% of newborns globally and remains a leading cause of morbidity and mortality in neonatal intensive care units (NICUs).[1] The condition is characterized by abnormal respiratory effort, manifesting as tachypnea, retractions, grunting, nasal flaring, and cyanosis. Preterm infants are particularly vulnerable due to surfactant deficiency, immature lung development, and compliant chest walls.[2]

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The etiology of respiratory distress varies with gestational age and includes respiratory distress syndrome (RDS), transient tachypnea of newborn (TTN), meconium aspiration syndrome (MAS), congenital pneumonia, and birth asphyxia. While RDS predominantly affects preterm neonates due to surfactant deficiency, term infants more commonly present with TTN or infection-related causes.[3]

Bubble continuous positive airway pressure (bCPAP) has gained widespread acceptance as a primary mode of non-invasive respiratory support. By delivering continuous distending pressure to the airways, bCPAP prevents alveolar collapse, improves functional residual capacity, reduces work of breathing, and enhances oxygenation.[4] Compared to mechanical ventilation, bCPAP offers several advantages including reduced ventilator-associated complications, lower risk of bronchopulmonary

dysplasia (BPD), and cost-effectiveness, making it particularly suitable for resource-limited settings.[5–6] Despite its widespread use, predictors of bCPAP failure remain incompletely characterized, and success rates vary considerably across different populations and settings. Identifying clinical and demographic factors associated with treatment failure enables early intervention and improved patient outcomes. This study aimed to evaluate the clinical profile, management patterns, and outcomes of neonates with respiratory distress managed with bCPAP at our tertiary care center, and to identify factors predicting CPAP failure.

METHODS

Study Design and Setting

This prospective observational study was conducted in the Neonatology Unit, Department of Pediatrics, S.V.R.R. Government General Hospital, Tirupati, over a one-year period from April 26, 2023, to April 25, 2024, following institutional ethics committee approval.

Study Population

Term and preterm neonates admitted to the NICU with respiratory distress were screened for eligibility. Inclusion criteria comprised neonates with respiratory distress severity scores (Downes score or Silverman-Anderson score) of 4-6, and parental consent. Exclusion criteria included unstable cardiovascular status, prolonged refractory seizures, and major congenital anomalies (airway anomalies, pulmonary hypoplasia, diaphragmatic hernia, congenital heart disease).

Sample Size

Based on a 7% prevalence of neonatal respiratory distress with 5% precision and 95% confidence interval, the calculated sample size was 110. However, 165 neonates meeting inclusion criteria were enrolled during the study period.

Data Collection

Detailed clinical and demographic data were collected including gestational age, birth weight, mode of delivery, place of birth, antenatal steroid exposure, presenting diagnosis, respiratory severity scores (Downes/Silverman-Anderson), CPAP parameters (PEEP, FiO_2), duration of support, surfactant administration, complications, and final outcome (recovery, mechanical ventilation requirement, mortality).

CPAP Management Protocol

Bubble CPAP was initiated with standard settings (PEEP 5-6 cm H_2O, FiO_2 titrated to maintain SpO_2 90-95%). CPAP failure was defined as SpO_2 <90% on FiO_2 >70% with PEEP >7 cm H_2O, moderate to severe retractions despite PEEP >7 cm H_2O, recurrent apneas, shock, multi-organ dysfunction, or $PaCO_2$ >60 mmHg with poor respiratory effort. Failed cases were transitioned to mechanical ventilation. Surfactant administration in RDS cases followed standard protocols.

Statistical Analysis

Data were analyzed using descriptive statistics for demographic and clinical parameters. Categorical variables were compared using chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

Among 165 neonates, 52.1% (86/165) were male. The majority (68.5%, 113/165) were preterm, with gestational age distribution as follows: <28 weeks (3.6%), 28-<32 weeks (28.5%), 32-<37 weeks (36.4%), and ≥37 weeks (31.5%). Birth weight categories included <1000g (3.6%), 1000-1499g (20.6%), 1500-2499g (45.5%), and ≥2500g (30.3%). Cesarean section accounted for 64.2% of deliveries. Inborn deliveries comprised 60% of the cohort (Table 1).

Table 1: Demographic and Clinical Characteristics of Study Population

Characteristic	n (%)
Gender	
Male	86 (52.1)
Female	79 (47.9)
Gestational Age	
<28 weeks	6 (3.6)
28-<32 weeks	47 (28.5)
32-<37 weeks	60 (36.4)
≥37 weeks	52 (31.5)
Mode of Delivery	
Cesarean section	106 (64.2)
Vaginal delivery	59 (35.8)

Etiology and Clinical Presentation

Respiratory distress syndrome was the predominant diagnosis (61.8%, 102/165), followed by TTN (17.0%), MAS (8.5%), birth asphyxia (8.5%), and congenital pneumonia (4.2%). At presentation, 49.7% had Downes/SA scores of 5, while 26.7% scored 6. Most neonates (77.6%) were initiated on

PEEP of 5 cm H_2O, with 13.9% requiring PEEP of 6 cm H_2O.

Treatment Outcomes

The overall success rate of bCPAP was 77.0% (127/165), with 23.0% (38/165) experiencing CPAP failure requiring mechanical ventilation. Among failures, 5.4% eventually survived with mechanical ventilation, while 17.6% died despite escalated support. Duration of CPAP varied: 11.5% required <6 hours, 13.9% needed 6-12 hours, 27.9% required 12-24 hours, and 46.7% needed >24 hours of support (Table 2).

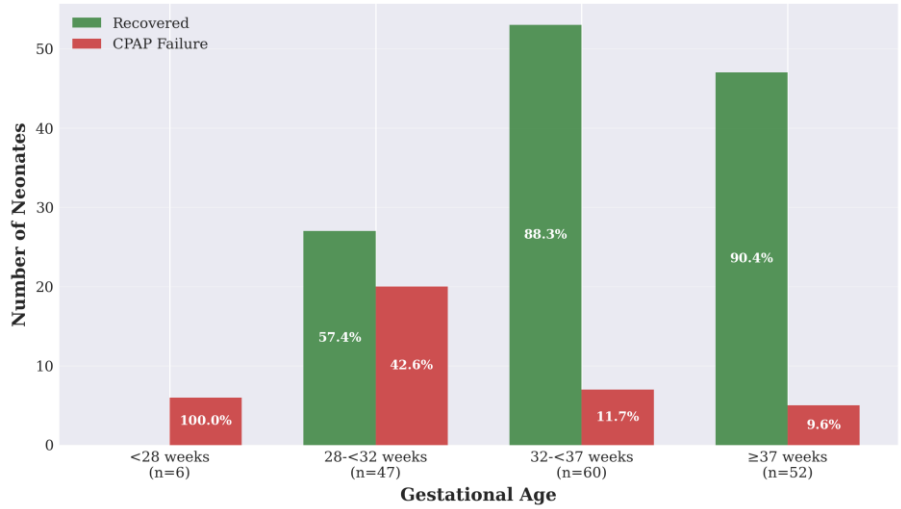
Table 2: Overall Outcomes and CPAP Duration

Parameter	n (%)
Outcome	
Recovered on CPAP	127 (77.0)
CPAP failure - survived with MV	9 (5.4)
CPAP failure - death	29 (17.6)
CPAP Duration	
<6 hours	19 (11.5)
6-12 hours	23 (13.9)
12-24 hours	46 (27.9)
>24 hours	77 (46.7)

Predictors of CPAP Failure

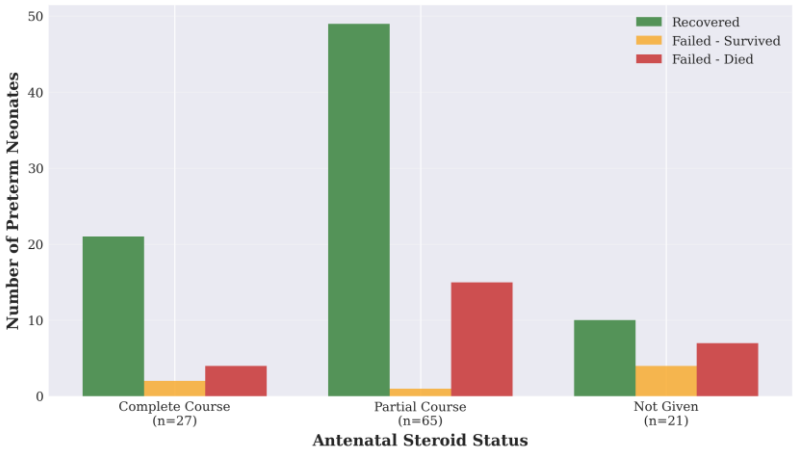
Gestational age significantly influenced outcomes ($p<0.001$). Extremely preterm neonates (<28 weeks) had 100% CPAP failure, while success rates improved with advancing gestational age: 57.4% in 28-<32 weeks, 88.3% in 32-<37 weeks, and 90.4% in term neonates (≥37 weeks) (Figure 1).

Figure 1: Outcomes by Gestational Age



Among preterm neonates (n=113), antenatal steroid coverage significantly impacted outcomes ($p=0.02$). Recovery rates were 77.8% with complete courses, 75.4% with partial courses, and only 47.6% in non-recipients. Mortality was highest in the no-steroid group (33.3% vs 14.8% in complete course recipients) (Figure 4).

Figure 4: Impact of Antenatal Steroids on Preterm Outcomes



Diagnosis-specific outcomes revealed significant differences (p=0.021). TTN had 100% recovery, while RDS showed 67.6% recovery with 25.5% mortality. MAS, congenital pneumonia, and birth asphyxia had intermediate outcomes (Table 3).

Table 3: Association between Clinical Parameters and Outcomes

Parameter	Recovery (%)	CPAP Failure (%)	p-value
Gestational Age			<0.001
<28 weeks	0 (0)	6 (100)	
28-<32 weeks	27 (57.4)	20 (42.6)	
32-<37 weeks	53 (88.3)	7 (11.7)	
≥37 weeks	47 (90.4)	5 (9.6)	
Downes/SA Score			0.001
Score 4	38 (97.4)	1 (2.6)	
Score 5	69 (84.1)	13 (15.9)	
Score 6	20 (45.4)	24 (54.6)	
Initial FiO_2			<0.001
≤40%	83 (92.2)	7 (7.8)	
41-60%	36 (75.0)	12 (25.0)	
>60%	8 (29.6)	19 (70.4)	

Higher Downes/SA scores predicted poorer outcomes (p=0.001). CPAP failure rates were 2.6%, 15.9%, and 54.6% for scores of 4, 5, and 6 respectively (Figure 2). Similarly, initial FiO_2 requirements >60% were associated with 70.4% failure rate compared to 7.8% in those requiring ≤40% (p<0.001) (Figure 3).

Figure 3: Outcomes by Oxygen Requirement

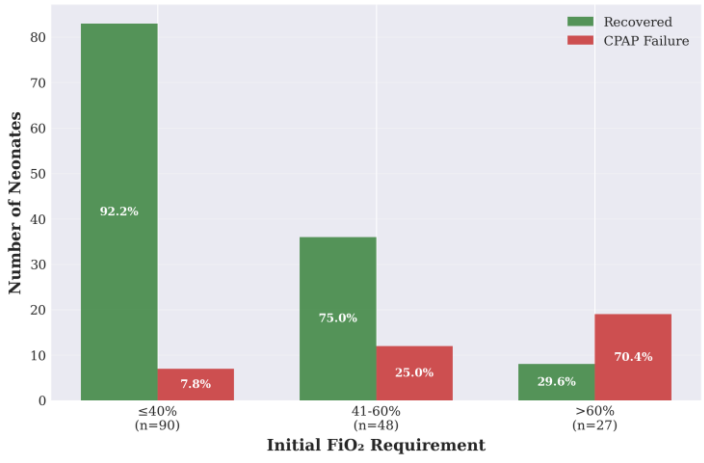
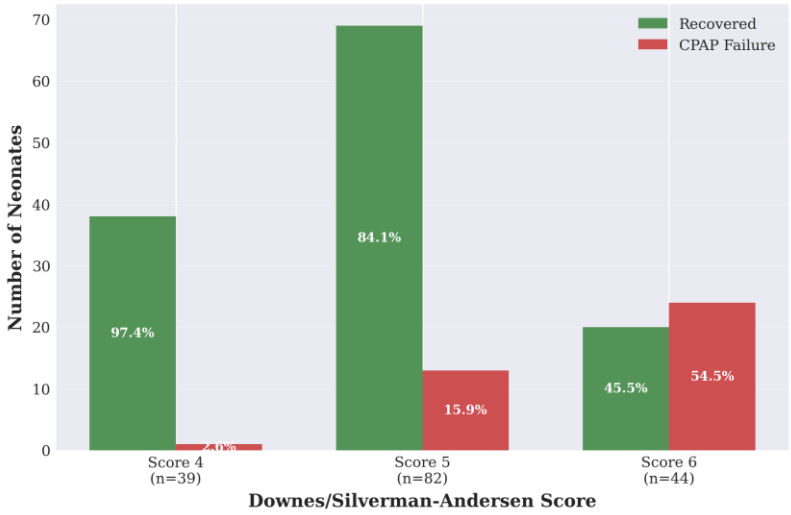


Figure 2: Outcomes by Disease Severity Score



PEEP requirements also correlated with outcomes (p=0.004). Neonates requiring PEEP of 6 cm H_2O had 69.6% failure rate versus 30.4% recovery, while those on PEEP of 5 cm H_2O showed 82.0% recovery. Complications, particularly pneumothorax, were associated with 75% mortality.

DISCUSSION

This prospective observational study of 165 neonates demonstrates that bubble CPAP is an effective first-line respiratory support modality with a 77% success rate, consistent with previous reports ranging from 70-93%.[7–8] Our findings reinforce the established role of bCPAP in reducing the need for mechanical ventilation and its associated complications, particularly in resource-limited settings.

The predominance of preterm neonates (68.5%) and RDS as the leading etiology (61.8%) aligns with global epidemiological patterns. Similar studies have reported RDS prevalence of 56-70% among neonates receiving CPAP.[9–10] The higher cesarean section rate (64.2%) reflects both the tertiary referral nature of our institution and associations between cesarean delivery and respiratory morbidity, particularly delayed fetal lung fluid clearance.[11]

The strong correlation between gestational age and CPAP success (p<0.001) underscores lung maturity as the critical determinant of respiratory support outcomes. The 100% failure rate in extremely preterm neonates (<28 weeks) reflects severe surfactant deficiency, poor lung compliance, and immature respiratory drive, paralleling findings of Dargaville et al., who reported 65% CPAP failure rates in neonates <28 weeks.[13] The progressive improvement in success rates with advancing gestation demonstrates the benefit of pulmonary maturation.

The significant benefit of complete antenatal steroid courses (77.8% recovery vs 47.6% in non-recipients, p=0.02) reaffirms the critical role of corticosteroids in accelerating fetal lung maturation. These results support extensive evidence demonstrating 30-50% reductions in RDS and neonatal mortality with antenatal corticosteroid administration.[14–15]

The progressive increase in CPAP failure rates with higher Downes/SA scores (2.6% at score 4 to 54.6% at score 6, p=0.001) validates these scoring systems as reliable bedside predictors of disease severity and treatment response, consistent with Singh et al. and Verma et al.[16–17] The strong association between high initial FiO_2 requirements (>60%) and CPAP failure (70.4%, p<0.001) suggests severe underlying lung disease. Previous studies have identified FiO_2 thresholds of 30-50% as predictors of CPAP failure.[13,18]

The 75% mortality rate associated with pneumothorax underscores this complication's severity. While pneumothorax incidence with bCPAP is generally low (1-3%), it remains a serious adverse event.[20–21] Strategies to minimize barotrauma include careful pressure monitoring, proper interface fitting, and avoiding excessive PEEP escalation.

Our study provides evidence-based guidance for CPAP utilization in resource-limited settings. Early initiation in appropriate candidates can prevent mechanical ventilation in three-quarters of cases. However, extremely preterm neonates, those with high severity scores, and those requiring FiO_2 >60% or PEEP ≥6 cm H_2O warrant close monitoring for early failure.

CONCLUSION

Bubble CPAP demonstrates 77% effectiveness as first-line respiratory support for neonatal respiratory distress. Gestational age remains the strongest

predictor of outcome, with extremely preterm neonates requiring alternative strategies. Antenatal steroid administration significantly improves preterm outcomes and should be prioritized in threatened preterm deliveries. Clinical severity scores (Downes/SA), initial oxygen requirements, and PEEP settings provide valuable bedside tools for predicting CPAP failure and guiding timely intervention. Early recognition of failure predictors—including gestational age <28 weeks, Downes/SA score ≥6, FiO_2 >60%, and PEEP ≥6 cm H_2O—enables proactive escalation of care, potentially reducing mortality. Bubble CPAP remains an essential, cost-effective intervention in neonatal respiratory care, particularly valuable in resource-limited settings where mechanical ventilation access is restricted.

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