

OUTCOME OF CPAP IN 1–12 MONTHS OLD INFANTS PRESENTING WITH RESPIRATORY FAILURE IN PEDIATRIC ICU

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Published:- 15 December 2025

ABSTRACT

Background: Acute respiratory failure (ARF) is one of the major causes of morbidity and mortality in the PICUs, especially in young infants. Continuous positive airway pressure (CPAP) is a form of non-invasive respiratory support and may enhance oxygenation, while decreasing the need for invasive mechanical ventilation. **Objective:** To determine the outcome of CPAP in infants with respiratory failure with age between 1-12 months in terms of success of treatment. **Methods:** This was a descriptive case series that was carried out at Department of Pediatrics, Ghurki Trust Teaching Hospital, Lahore from July 2025 to October 2025. A consecutive sampling of a total of 139 infants between the ages of 1–12 months having ARF were included. CPAP was started at 4-6 cmH₂O and then titrated as per response. The success of the treatment was determined at 48 hours by the improvement of the arterial blood gas parameters, the disappearance of respiratory distress, lack of apnea, and the lack of endotracheal intubation. Data were analysed using SPSS version 26.0. **Results:** The mean age was 6.42 ± 3.18 months, and 78 (56.1%) infants were male. Of the 114 infants (82.0%) who had successful CPAP treatment, 25 (18.0%) needed to escalate to invasive mechanical ventilation. No significant difference was noted between age ($p>0.05$) and gender ($p>0.05$) and treatment success. **Conclusion:** CPAP resulted in a good treatment success rate in ARF infants and could be an effective non-invasive method of respiratory support in PICU.

Keywords: Acute Respiratory Failure, Continuous Positive Airway Pressure, Non-Invasive Ventilation, Infants, Pediatric Intensive Care Unit, Respiratory Distress.

1. INTRODUCTION

Acute respiratory failure (ARF) is a serious condition which presents considerable clinical problems and is a major cause of admission to paediatric intensive care units (PICUs). It is an important cause of morbidity and mortality in

children who are critically ill and is also one of the most frequent causes of cardiopulmonary arrest in children [1]. Acute respiratory failure can be defined as inadequate pulmonary gas exchange, which leads to hypoxemia and/or hypercapnia, increased work of breathing, and inadequate oxygenation and ventilation. Respiratory failure can be severe and progress to multiple organ dysfunction or failure, especially in children who are seriously ill [2].

ARF has been reported to occur at rates of 1.4–9.5 cases/100,000 children/adolescents/year, and mortality from ARF may be as high as ~30% depending on the severity of disease and associated comorbidities [3]. Due to advances in perinatal medicine and pediatric intensive care, children with complex medical conditions are having improved survival. Thus, the proportion of children outliving the acute respiratory failure and needing lifelong mechanical ventilatory support has risen globally [4]. Respiratory failure is also highlighted as being suitably assessed and managed in the critically ill child by current paediatric critical care guidelines [5].

Continuous Positive Airway Pressure (CPAP) is a type of non-invasive respiratory support that provides continuous positive airway pressure during the respiratory cycle. It preserves FRC, prevents atelectasis, recruits and holds open collapsed alveoli, enhances oxygenation and decreases work of breathing. CPAP can then be a suitable alternative to invasive mechanical ventilation for respiratory support, but without the associated risks [6].

The use of CPAP in newborns and children, especially in low and middle income countries (LMICs), has become a useful and feasible method of respiratory support, where proper monitoring and trained health care professionals are available [7]. In China, Liu et al., reported promising results with non-invasive respiratory assistance with CPAP playing an important role in the management of children under 2 years of age suffering from mild to moderate respiratory failure due to pneumonia [8].

The results of CPAP can greatly differ, however, depending on the characteristics of the patient, the nature of the underlying disease, the severity of the respiratory failure, and the context of treatment. The success rate for CPAP was reported to be 76.0% in preterm neonates with respiratory distress in India by Tirkey et al. (2020) [9]. While they studied a different population of infants from those with acute respiratory failure in this study, their results indicate that the effectiveness of CPAP can be different across clinical populations and settings. Thus, the evidence presented here does not support the assumption that the success of interventions would be the same for all pediatric age groups and respiratory conditions.

Owing to variations in the reported outcomes of CPAP [8]. This treatment mode is not widely used and little published local information is available about its effectiveness in infants with acute respiratory failure so this should be assessed in our local PICU practice. The present study was hence carried out to assess the effect of CPAP in infants 1-12 months with acute respiratory failure. The results could be used to support locally relevant evidence of the effectiveness of CPAP and support clinicians deciding whether or not to use CPAP as a non-invasive respiratory support prior to escalation to invasive mechanical ventilation.

2. OBJECTIVE

To determine the outcome of CPAP in infants with respiratory failure with age between 1-12 months in terms of success of treatment.

3. METHODOLOGY

This was a descriptive case series that was carried out at Department of Pediatrics, Ghruki Trust Teaching Hospital, Lahore from July 2025 to October 2025. At the 95% level of confidence, a sample of 139 infants was determined with a margin of error of 5% and an expected CPAP success rate of 90%. The infants aged 1-12 months with acute respiratory failure and meeting the prespecified inclusion criteria were recruited using non-probability consecutive sampling. Infants who were eligible were managed per the institutional respiratory-support protocol with informed written consent from parents/legal guardians. CPAP was commenced via a suitable paediatric nasal interface and adjusted based on clinical and physiological response on the range of 4-6 cm H₂O. The outcome of treatment was evaluated at the end of 48 hours. The data were collected on a structured proforma and analyzed with SPSS version 26.0.

3.1 INCLUSION CRITERIA

Infants, both male and female, aged 1–12 months, who were presenting with acute respiratory failure (as defined in the operational definition) were included in the study.

3.2 EXCLUSION CRITERIA

Infants with any congenital or chromosomal disorders of the respiratory system were excluded, as were those with severe congenital heart disease requiring surgery, severe neurological impairment with known or suspected severe airway infections and central apnea.

3.3 DATA Collection Procedure

After obtaining informed written consent, 139 eligible infants were enrolled consecutively. Demographic data (age and gender) were collected at admission. Heart rate, respiratory rate, oxygen saturation and degree of respiratory distress were used as baseline clinical assessment. Prior to CPAP initiation, ABG was drawn to record PaO₂ levels and PaCO₂ levels. CPAP was administered via an appropriate pediatric nasal interface, at 4-6 cmH₂O, and then subsequently titrated as per clinical response and physiological parameters. The PaO₂ and PaCO₂ were remeasured at 24 and 48 hours. Continuous monitoring of clinical response was conducted and included respiratory effort, oxygen saturation, apnea and escalation requirements. The success of treatment was judged 48 hours later by predefined criteria, using a senior pediatric consultant. The principal investigator used a standardised proforma for all the observations.

3.4 DATA ANALYSIS PROCEDURE

Data was entered and analysed in SPSS version 26.0. Continuous variables (such as age and arterial blood gas measurements) were described as mean $\pm$ SD. Data for categorical variables such as gender, treatment success, and treatment failure were expressed as frequencies and percentages. The main outcome was success in CPAP treatment, based on predetermined clinical and arterial blood gas criteria, not requiring endotracheal intubation at 48 h. For stratification analysis age was classified as 1-6 months and 7-12 months, and gender was classified as male or female. Chi-square test was used to determine the association of categorical variables to treatment success. A p value of < 0.05 was taken as significant. Data were verified for completeness prior to analysis and results were tabulated for easy interpretation.

4. RESULTS

One hundred and thirty-nine infants 1-12 months of age with acute respiratory failure were enrolled in the study. The average age of the participants was 6.42 ± 3.18 months. Among the enrolled infants, 78 (56.1%) were male and 61 (43.9%) were female. Overall, 114 (82.0%) infants were treated successfully with CPAP and 25 (18.0%) failed as treatment and needed escalation to invasive mechanical ventilation.

Table 1: Primary Outcome: CPAP Treatment Success.

CPAP treatment success at 48 hours was the primary outcome of the study. Eleven-four (82.0%) infants were successfully treated, and 25 (18.0%) infants were unsuccessfully treated.

Outcome Parameter	Frequency (n)	Percentage (%)
Treatment Success	114	82.0
Treatment Failure	25	18.0
Total	139	100.0

The results showed a CPAP success rate of 82.0% and most infants were successfully treated without the use of invasive mechanical ventilation.

Table 2: ABG and Physiological Parameters.

The improvement was seen in arterial blood gas parameters after CPAP was begun. Mean PaO₂ increased from 44.21 ± 3.84 mmHg at admission to 58.64 ± 4.12 mmHg at 24 hours and 68.45 ± 5.12 mmHg at 48 hours. In contrast, mean PaCO₂ decreased from 64.82 ± 4.15 mmHg at baseline to 48.31 ± 3.76 mmHg at 24 hours and 38.14 ± 3.29 mmHg at 48 hours.

Parameter	Baseline	24 Hours	48 Hours
PaO ₂ (mmHg)	44.21 ± 3.84	58.64 ± 4.12	68.45 ± 5.12
PaCO ₂ (mmHg)	64.82 ± 4.15	48.31 ± 3.76	38.14 ± 3.29

The changes noted suggest that oxygenation and carbon dioxide clearance are improving over time on CPAP during the first 48 hours of treatment.

Table 3: The results are tabulated by age group.

In infants 1 to 6 months old, treatment was effective in 58 (80.6%) of the 72 infants, and failed in 14 (19.4%). Of 67 infants, 56 (83.6%) were treated successfully and 11 (16.4%) had a treatment failure in the 7-12-month age group. There was no statistical difference in the level of treatment success between the two age groups ($p = 0.668$).

Age Group	Total (n)	Success n (%)	Failure n (%)	p-value
1-6 months	72	58 (80.6)	14 (19.4)	0.668
7-12 months	67	56 (83.6)	11 (16.4)	

Total	139	114 (82.0)	25 (18.0)	
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The success rate for the CPAP was slightly higher for 7–12 months of age than 1 – 6 months of age, but this was not statistically significantly different.

Table 4: Stratification by gender.

Sixty-three infants (80.8%) of 78 male infants successfully received CPAP treatment, and 15 infants (19.2%) failed the CPAP treatment. The treatment was successful in 51 (83.6%) and failed in 10 (16.4%) female infants. The success of CPAP treatment in male and female infants was not statistically different ($p = 0.692$).

Gender	Total (n)	Success n (%)	Failure n (%)	p-value
Male	78	63 (80.8)	15 (19.2)	0.692
Female	61	51 (83.6)	10 (16.4)	
Total	139	114 (82.0)	25 (18.0)	

The rate of success was marginally higher in the female infants than in the male infants, but this was not statistically significant.

Overall Interpretation of Results

Overall, CPAP effectively supported the babies' breathing in over four-fifths of the infants with acute respiratory failure that were enrolled. Over the treatment period of 48 hours, there was a progressive improvement in PaO_2 and a reduction in PaCO_2 . CPAP treatment success was similar for all age groups and gender and was not statistically significantly associated with CPAP outcome and age, or gender.

5. DISCUSSION

Acute respiratory failure (ARF) is a potentially life-threatening complication in children and is still an important reason for admission to paediatric intensive care units. Early and adequate respiratory support is essential as deterioration can progress to critical hypoxia, hypercapnia, cardiopulmonary arrest, and multiple organ dysfunction [1]. The present study assessed the results of CPAP treatment in infants aged 1-12 months with acute respiratory failure and found an overall CPAP outcome success rate of 82.0%. The finding indicates that CPAP may be one of the non-invasive forms of respiratory support that is effective in a substantial number of infants who are appropriate.

Depending on the type of disease, child physiology and associated disease conditions respiratory failure may be moderate, Severe or Very severe. In severe cases, respiratory failure can lead to high mortality; especially in the event of chronic hypoxemia and respiratory failure [2]. The incidence of acute respiratory failure and death from the condition can vary significantly in individual cases depending on the clinical condition and/or disease burden [3]. However, the life-saving treatment available in paediatric critical care has resulted in children with complex medical conditions surviving and an increasing number of children are being discharged with long-term respiratory support [4]. Respiratory management in children in the critical care unit is now directed towards a personalised approach to management and understanding how to monitor oxygenation, ventilation and disease severity [5]. In this regard, the effective use of CPAP in 82.0% of infants in the present study is a convincing support for the use of CPAP as an important first line respiratory assisting therapy modality.

What we see for improvement is likely to be related to the physiologic effect of CPAP. CPAP keeps the airway open during the respiratory cycle, maintains functional residual capacity, recruits poorly ventilated alveoli, prevents alveolar collapse and improves work of breathing. These effects may help with oxygenation and ventilation, and can prevent endotracheal intubation and/or invasive mechanical ventilation (IMV) complications [6]. Another set of studies, from resource-limited settings, is promising in terms of feasibility of CPAP, where they have shown feasibility when appropriate equipment, trained health-care providers, monitoring and escalation plans are in place [7].

In the present study, mean PaO_2 increased progressively from 44.21 ± 3.84 mmHg at admission to 68.45 ± 5.12 mmHg at 48 hours, whereas mean PaCO_2 decreased from 64.82 ± 4.15 mmHg to 38.14 ± 3.29 mmHg. This is a pattern that indicates that gas exchange has improved both with respect to oxygenation and carbon dioxide clearance while on CPAP. Liu et al. assessed children less than two years old suffering from mild-to-moderate respiratory failure due to pneumonia and found that CPAP was effective as a non-invasive respiratory-support modality, with treatment failure and intubation in 10% of the CPAP children [8]. Although there was no direct comparison of patients, or of the severity of the disease, their results are comparable to the excellent physiological response that we observed in our patients.

Tirkey et al. reported that the rate of success with CPAP for premature neonates with respiratory distress was 76.0% [9]. They were a very different cohort from the present cohort as indeed they included preterm neonates and not infants aged 1-12 months with acute respiratory failure. The quoted success rate is noteworthy, however, in view of the fact that positive airway pressure can be used to provide clinically relevant respiratory support in younger children. In our

study, the success rate of 82.0% could be due to the difference in age, etiology of respiratory failure, patient selection, treatment protocols, or definition of treatment success.

In recent years there have been increasing numbers of publications that have emphasized the role of non-invasive respiratory support in the treatment of paediatric respiratory failure. Luo et al. have provided a review of the therapeutic value of high-flow nasal cannula (HF_{Fi}) and CPAP in children with respiratory distress, the effectiveness of which is dependent on the level of disease severity and clinical context [10]. Similarly, Ekhaguere et al. highlighted the possibility of the implementation of bubble CPAP in low and middle income nations where mechanical ventilation may not be readily available. If suitable monitoring and implementation measures are feasible, they wrote, then CPAP might be available, and it could be a cost-effective treatment [11]. The above observations are particularly appropriate to tertiary-care hospitals in resource poor settings.

Additionally, a systematic review of bubble CPAP in LMOICs revealed the feasibility of CPAP usage in different healthcare settings and age groups of children, where some evidence was good and some was poor [12]. This is relevant if interpreting the results of the present study in the context of our study, which took place in one tertiary care PICU, and hence, may not be generalized to all pediatric settings.

The changes in blood gases observed also concur with clinical trials of infants and young children in which non-invasive respiratory support were applied. Both high-flow nasal cannula and CPAP were effective to support breathing in the study by Vahlkvist et al. [13] with differences in treatment response based on the clinical end point measured. The results indicate that CPAP use should be considered in the context of others options, not merely as a means for providing some type of non-invasive respiratory support.

Not recognising the need for CPAP is one of the key elements of CPAP management. Amaddeo et al highlighted that non-invasive ventilation may fail when the disease is severe, due to insufficient response, intolerance or due to other patient-related factors and that children on non-invasive support should be closely monitored clinically and be ready for invasive ventilation if needed [14]. Similarly, Almukhaini et al. reported that non-invasive ventilation (NIV) and high flow nasal cannula (HFNC) therapy may be used in children with acute respiratory distress and that it is appropriate if it was appropriate, as well as, if it is monitored and trained staff is available [15]. While our study shows that CPAP was effective in most infants, 25 (18.0%) infants did require escalation to invasive mechanical ventilation, emphasizing that CPAP was effective in most infants, but a clinically important subset of infants required further respiratory support.

The overall success rate of 82.0% for the current study is supported by the results of the systematic review and meta-analysis. In children with ALRI, Wang et al. investigated randomized trials of the different non-invasive ventilation strategies and concluded CPAP was associated with decreased risk of intubation and decreased treatment failure rates, with no difference between CPAP and high flow nasal cannula [16]. Boghi et al. also performed a systematic review and meta-analysis that demonstrated that NIFV in acute respiratory failure in children may reduce intubated to non-intubated mortality ratios compared with standard oxygen therapy or high-flow nasal cannula but with no effect on mortality [17]. These results corroborate the premise that the greatest possible advantage of CPAP is a decrease in the need for invasive ventilatory support rather than a decrease in death rates.

Specific evidence supporting the benefits of CPAP on physiology for bronchiolitis (to what extent) also exists but is not certain of evidence. Several respiratory parameters such as PaO₂ and PaCO₂ may be improved with CPAP, and the rate of mechanical ventilation may be reduced in the children with bronchiolitis compared with standard O₂ therapy, as reported by Tang et al. [18]. Additionally, other randomized controlled trial evidence, based on Borgi et al. [19] suggested that high-flow nasal cannula (HFNC) can be used as an alternative to CPAP or nasal positive-pressure ventilation (NPPV) in severe acutely ill infants with bronchiolitis depending on clinical status and response to treatment. Bronchiolitis is only one potential cause of respiratory failure, but these studies give supportive evidence that the physiological response to positive airway pressure that we observed in our cohort is a physiological response. There has also been recent large-scale, multi-center evidence that has provided valuable information on the relative superiority or inferiority of CPAP to non-invasive respiratory-support strategies. FIRST was a Step-Up randomized clinical trial (RCT) that studied the use of high-flow nasal cannula (HF_{Fi}) versus continuous positive airway pressure (CPAP) in 600 acutely ill children requiring non-invasive respiratory support. The study demonstrated that there was no significant difference between the two therapies regarding time to liberation from respiratory support; both can be considered as appropriate therapies with patient's characteristics and clinical situations taken into account [20]. The success rate for CPAP should be seen as evidence that CPAP is an effective option, rather than a statement that CPAP is always the best choice of non-invasive modalities.

Jat et al also carried out a Cochrane review for CPAP in acute bronchiolitis in children, which reported similar findings, namely limited and low-quality evidence, particularly for the reduction in mechanical ventilation. The available trials, however, showed CPAP was linked to improving respiratory rate [21]. The results highlight the importance and need

to review individual center descriptive/observational studies very carefully. Although this is a relatively successful procedure, the enthusiasm for its clinical use must be tempered by the lack of comparative data to extrapolate to all causes and severity of respiratory failure in children.

It is also important that age was not a significant factor in the present study, regarding CPAP success. Infants aged 1–6 months had a success rate of 80.6%, compared with 83.6% among those aged 7–12 months ($p=0.668$). Similarly, effectiveness of CPAP did not differ between male infants (80.8%) and female infants (83.6%) ($p=0.692$). These findings suggest that age and gender of the population studied did not influence the efficacy of CPAP. Demographic parameters (age, gender, ethnicity, smoking) may be significant but they are not likely to explain treatment response, which is likely to depend on the severity of the clinical problem, underlying disease, respiratory mechanics, gas exchange abnormalities and timing of CPAP initiation.

Within the literature, there is a growing consensus that the current non-invasive respiratory support is a success with the inclusion of the evaluation of readiness for weaning, clinical improvement and avoiding early weaning. Mortamet et al. set an international consensus on non-invasive respiratory support in children and noted the importance of evaluating the clinical stability and necessity of respiratory support on a case-by-case basis before decreasing support [22]. Weaning outcomes were not measured, but our study was conducted after 48 hours and the principles of this treatment are applicable to the need for continued reassessment during CPAP treatment.

The following are some practical implications of the present study. A success rate of 82.0% means that CPAP successfully avoided the need for invasive mechanical ventilation in most infants that were selected for CPAP. This is even more important in ICUs with limited resources, where invasive ventilators are more likely to be associated with greater equipment and personnel needs, sedation, and monitoring. Rather, there should be no delay of endotracheal intubation if there is ongoing or worsening respiratory failure, but CPAP should be used concurrently. It is important to note that 18.0% of our treated patients had treatment failures which highlights the need for regular monitoring and pre-defined criteria for treatment escalation.

There are also some limitations to consider when interpreting the findings: Single center descriptive case series without control group or comparison to HFNC or Bi-level non-invasive ventilation. This study also did not specifically look at CPAP outcomes by etiology of respiratory failure or severity classification. Additionally, serial PaO_2 and PaCO_2 values were continuously improved although a statistical test of the change in these parameters was not performed. Therefore, these changes must be interpreted as a physiological improvement, and not as a treatment effect that is statistically significant. Systematic and detailed analyses of large multicenter prospective studies with disease-specific subgroups and uniform definition of failure of CPAP and direct comparisons with other non-invasive methods of respiratory support are warranted.

Overall, the findings of this study are locally relevant and evidence that CPAP is effective as a non-invasive method of respiratory support in infants aged 1-12 months who suffer acute respiratory failure with a high success rate. This treatment success rate of 82.0% and the parallel treatment success rates among age and gender groups suggest that CPAP should be continued and be further studied in appropriate monitored pediatric intensive care settings.

6. CONCLUSION

Infants (1-12 months) with acute respiratory failure (ARF) who were admitted to a pediatric intensive care unit (PICU) had a very high treatment success rate with CPAP (82.0%). Most babies were able to receive non invasive respiratory care without having to go to IV mechanical ventilation. Other physiological response to CPAP was the improvement in PaO_2 with a reduction in PaCO_2 within 48 hours. The age group and gender of the patient did not significantly affect treatment success, indicating that treatment is effective in all of the age group and gender subgroups tested. The results of this study suggest that CPAP is an important first-line non-invasive respiratory-support intervention for well-defined acute respiratory failure infants. CPAP should be used, however, in an environment that has trained health care staff on hand, continuous monitoring, pediatric interfaces available, and criteria set in place for escalation to invasive ventilation. There is a need for further comparative studies (larger multicenter trials) to identify predictors of success and failure of CPAP in each disease category, and to determine the effectiveness of CPAP in different pediatric intensive care environments.

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