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Research Article

Safety and Efficacy of Continuous Positive Airway Pressure in Pediatric Younger than One Year with Acute Bronchiolitis; Systematic Review

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Abstract

We aimed to look into efficiency of CPAP delivery techniques and see whether using CPAP may be therapeutically helpful for pediatric with bronchiolitis. This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA). We searched PubMed, EMBASE, and the Cochrane Library between 2015 and 2024. The main search phrases were CPAP and bronchiolitis. We considered RCTs, with children under 12 months of age complain of bronchiolitis, and contrasted CPAP with other respiratory support techniques or CPAP enhanced in different ways. For young children with bronchiolitis, HFNC may be a helpful alternative to CPAP. CPAP use did not reduce the need for mechanical ventilation in children with bronchiolitis, despite the weak evidence. Little to no data suggests that children with bronchiolitis who received CPAP fared better. In young infants with moderate to severe bronchiolitis, the failure rate of first HFNC treatment was not comparable to that of nCPAP. When using a helmet instead of a face mask, CPAP is more pleasant and requires less sedation. Both nasal prong-administered and helmet-administered CPAP are equally beneficial for treating acute bronchiolitis in young children.

Keywords: Continuous Positive Airway Pressure; Acute Bronchiolitis; Efficacy; Safety

Abbreviations

nCPAP: Noninvasive Continuous Positive Airway Pressure; HHHFNC: Hot Humidified High-Flow Nasal Cannulae; CPAP: Continuous Positive Airway Pressure; HFNC: High-Flow Nasal Cannulae; MWCA: Modified Wood's Clinical Asthma; FIO2: Fraction of Inspired Oxygen; PaCO2: Partial Pressure of Carbon Dioxide; ICU: Intensive Care Unit; RSV: Respiratory Syncytial Virus.

Introduction

The most prevalent acute lower respiratory tract viral infection in children under two years old is bronchiolitis [1], its mostly brought on by respiratory syncytial virus (RSV) infection [2]. A well-known ailment, bronchiolitis affects around 1% to 3% of children in good health and over 10% of children in high-risk groups [3]. Between 2 and 10 percent of bronchiolitis patients necessitate

hospitalization, making it a significant public health concern globally [4]. Approximately 5% of patients of RSV bronchiolitis necessitate hospitalization to the ICU [5]. While mortality is extremely low in industrialized nations, it is believed to be high in underdeveloped nations, presumably as a result of overcrowding, inadequate nutrition, high vaccination rates, and inadequate medical treatment [6]. The mortality rate is high in high-risk populations, reaching 49.7% for newborns with congenital heart disease and 47% for those with chronic lung disease [7].

The hospitalization rate in the United States is 13.5 per 1000 newborn years, and the cost of hospitalization is more than $700 million [8]. The only treatments for bronchiolitis are fluid replenishment, respiratory support, and more oxygen. Mechanical ventilation and noninvasive ventilation are two categories of respiratory support [9]. According to one observational study [10], mechanical breathing may lengthen hospital stays in pediatric intensive care units (PICUs) and perhaps raise fatality rates. Nonetheless, non-invasive ventilation has demonstrated advantages in lowering the risk of nosocomial infections and preventing intubation [11]. In therapeutic settings, continuous positive airway pressure, or CPAP, has drawn increased attention [12]. Jat and Mathew's earlier meta-analysis [13] shown that CPAP had no effect on the risk of intubation. The data supporting the use of CPAP for the first respiratory treatment of bronchiolitis has to be updated.

In light of the aforementioned considerations and more randomized controlled trials, we want to assess if CPAP usage might be clinically beneficial for bronchiolitis and investigate more effective CPAP delivery methods.

Method

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement [14] is followed in the conduct of this systematic review and meta-analysis. From 2015 to 2024, we conducted searches in the Cochrane Library, PubMed, and EMBASE. Bronchiolitis and CPAP were the primary search terms. Additionally, the reference lists of pertinent papers were carefully reviewed.

We took into account RCTs, including children under 12 months old with bronchiolitis, and compared CPAP with alternative respiratory support methods or CPAP augmented in various ways. Treatment failure is defined as stopping current therapy because of adverse effects or the disease's worsening. To weed out ineligible research, two reviewers separately went through the whole text and records. Any disagreements were settled via dialogue.

The fundamental results were separately retrieved by two reviewers. We requested the data we want from the first author or corresponding author of the listed papers, but we never heard back. Data was extracted in a predesigned Google sheet, information extracted included (study design, aim, participant's characteristics, intervention and control groups and main findings). The disagreements were discussed until a consensus was found.

Results

We included 6 articles (Figure 1) in this systematic review, 4 randomized controlled trials, one 4 randomized controlled pilot and one prospective cross sectional study (Table 1). According to Mayordomo., *et al*. [15] CPAP significantly decreased respiratory distress. The nasal canula group's MWCA Score improved from 4.2 to 2.8 and to 2.9 points at 60 and 120 minutes, respectively, while the helmet group's improved from 4.8 to 3 and 2.7 points at 60 and 120 minutes, respectively. Only three participants were given sedatives. In both groups, the failure rate was comparable. Heart rate, breathing frequency, FIO2, and transcutaneous oxygen saturation response did not change significantly.

In the Chidini., *et al*. [16] research, CPAP via helmet had a similar intubation rate to the facial mask, but fewer patients needed sedation and the treatment failure rate owing to intolerance was lower. With both interfaces, CPAP improved gas exchange and breathing patterns in patients who received effective treatment. Although there were no significant interface-related problems, CPAP via mask had a greater incidence of skin ulcers and leaks.

According to Milési., *et al*. [17] the conclusion of HFNC non-inferiority was not possible due to the risk difference of -19%. According to superiority analysis, nCPAP had a 1.63 greater relative risk of success. Skin lesions, length of PICU stay, duration of noninvasive and invasive ventilation, intubation rate, and alternate respiratory support success rate were similar among groups. No patient passed away or developed air leak syndrome. In the Vahlkvist., *et al*. trial, the mean baseline pCO2 was 6.7 in both groups, and the mean respiratory rate was 60 vs. 56 in the CPAP and HFNC groups, respectively. There were no variations in

the MWCA score, pCO2, or respiratory rate development. In the group receiving CPAP, NIPS was greater. In both groups, treatment failure was rare. There were no discernible variations in the length of hospital stay or therapy. The main findings and objectives of included articles was presented in (Table 2).

Citation	Study design	Age	Diagnosis	Control group	Intervention group
Vahlkvist., *et al*. [18]	RCT	Less than 1 year	Clinical diagnosis	HFNC initial flow 2 L/kg/min	CPAP 12 to 14 L/min
Sinha., *et al*. [19]	Randomized controlled pilot study	1 to 12 months	Clinical diagnosis	HFNC initial flow 2 L/kg/min	Nasal mask CPAP
Agüera., *et al*. [20]	Prospective observational study	Up to 3 months	Clinical diagnosis	Not available	Not available
Milési., *et al*. [17]	RCT	Less than 6 months	Clinical diagnosis	HFNC	nCPAP
Chidini., *et al*. [16]	RCT	6 - 12 months	Clinical diagnosis	CPAP via mask	CPAP via helmit
Mayordomo., *et al*. [15]	RCT	Less than 3 months	Clinical diagnosis	CPAP via nasal prong	CPAP via helmit

Table 1: Characteristics of the studies included.

Citation	Study aim	Main findings and conclusion
Vahlkvist., *et al*. [18]	To evaluate how young infants with bronchiolitis treated with CPAP or HFNC changed in terms of respiratory rate and pCO2.	HFNC could be a useful substitute for CPAP in bronchiolitis in young children and infants.
Sinha., *et al*. [19]	To evaluate HHHFNC and nCPAP as respiratory support methods for neonates suffering from severe bronchiolitis.	Better heart rate normalization, a higher COMFORT Score, and a reduced incidence of nasal damage all showed that HHHFNC was better tolerated than nCPAP. The two groups' improvements in other outcome metrics were similar. There were no significant patient problems with any approach.
Agüera., *et al*. [20]	To assess the safety of CPAP as a respiratory aid for young children suffering from bronchiolitis in a general ward.	Although the evidence was not strong, CPAP usage did not lessen the requirement for mechanical ventilation in children with bronchiolitis. There is little, uncertain evidence that children with bronchiolitis who got CPAP had better outcome.
Milési., *et al*. [17]	Compared CPAP to HFNC effectiveness and safety in newborns with moderate to severe bronchiolitis.	Initial HFNC therapy did not have a failure rate comparable to nCPAP in young children with moderate to severe bronchiolitis.
Chidini., *et al*. [16]	In this study, treatment failure rates for children with bronchiolitis receiving CPAP via face mask or helmet were compared.	CPAP administered via helmet needs less sedation and is more tolerable than CPAP administered via face mask.
Mayordomo., *et al*. [15]	Authors compared nasal prongs to helmet interface.	For young children suffering from acute bronchiolitis, the effectiveness of CPAP administered by nasal prongs and CPAP administered via helmet is comparable.

Table 2: Study's aim and conclusion.

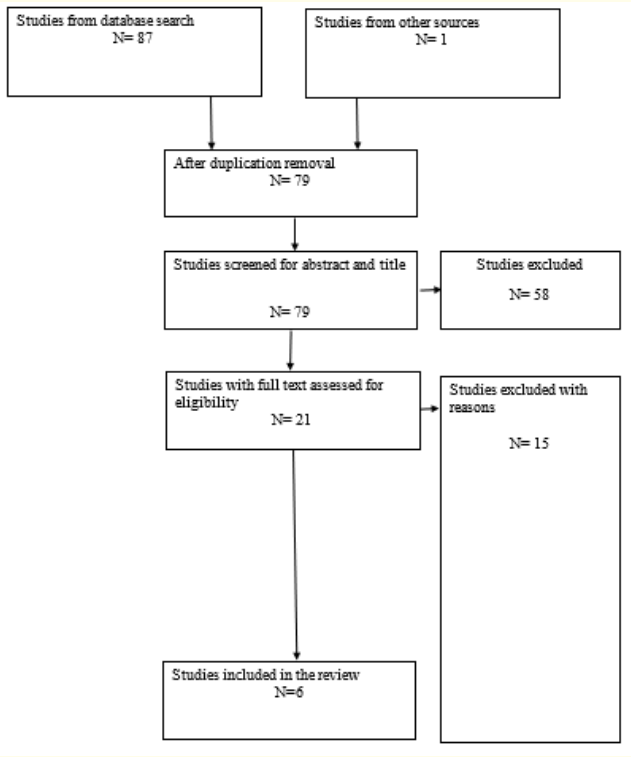

Figure 1: PRISMA consort chart.

Discussion

In PICU patients with bronchiolitis, CPAP treatment has been linked to decreased ventilation time [21], improved respiratory distress [12], shorter hospital stays [22,23], and, ultimately, lower hospital expenses. Nonetheless, even in wealthy nations, PICU bed shortages throughout the winter months are common. They have a greater nurse-to-patient ratio than ICU, although it is still somewhat lower than that of the ICU. These units are asked to offer non-invasive ventilation in an emergency, in order to lower the number of PICU admissions [24].

The benefits and safety of CPAP for the early respiratory therapy of bronchiolitis was assessed in this additional systematic evaluation of six original research. The findings demonstrated that children with bronchiolitis benefit greatly from CPAP for initial respiratory treatment. Wearing a helmet to administer CPAP appears to improve tolerance and lower the risk of side effects.

When compared to oxygen treatment, CPAP did not lower LOS or PaCO2, according to a prior meta-analysis by Jat and Mathew [13]. In contrast, this investigation demonstrated that CPAP had an impact on lowering PaCO2, and respiratory rate while treating children with bronchiolitis, which is in line with the retrospective study conducted by Essouri., *et al*. [25].

Compared to the HFNC group, we observed fewer treatment failures in the CPAP group. Similar findings regarding the prevalence of intubation were also identified in the systematic study by Lin., *et al*. [26], however the HFNC group experienced noticeably fewer adverse events. Our findings on treatment failure were consistent with those of two retrospective investigations [27,28]. Furthermore, the retrospective and non-random character of the Pedersen and Vahlkvist [28] investigation may have contributed to the finding that CPAP was more helpful in lowering respiratory rate and the proportion of inspired oxygen.

Several studies have proven the efficacy of CPAP in treating moderately severe bronchiolitis. In a randomized controlled experiment, Thia., *et al*. [29] found that beginning CPAP administration was more successful than initial spontaneous breathing at lowering PCO 2. The effectiveness of nasal-prong CPAP in alleviating respiratory distress and unloading respiratory muscles was documented by Cambonie., *et al*. [30]. Additionally, Martino-Torres., *et al*. [31] discovered that CPAP was useful in lowering CO2 levels and raising clinical scores. The addition of heliox seems to improve these qualities. Additionally, noninvasive respiratory support techniques have been demonstrated to reduce the intubation rate in children with severe bronchiolitis, according to previous research [32,33].

There are several hypothesized explanations for these benefits of CPAP. By extending the terminal airways, this kind of respiratory support recruits under ventilated regions, keeps the airways from collapsing, and eventually increases alveolar ventilation [29,30]. Additionally, this support appears to lessen airway resistance, which may lessen the strain on the inspiratory muscles. As a result, CPAP can improve ventilation-perfusion mismatch and lessen respiratory effort.

Conclusion

According to the study, there is insufficient data to support the claims that CPAP is superior to oxygen treatment, HFNC, or helmet-

based CPAP administration. Larger sample numbers and more well planned research are required.

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