Original Article

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Comparison of Bubble CPAP Versus Conventional Ventilation in Neonates Having Respiratory Distress

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Author`s Contribution

[1]Concept and design of the work, acquisition, Drafting, [2]Revised and critical review, [3]Final approval of the study to be published [4,5]interpretation, literature review, [6]Data Analysis

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ABSTRACT

Objective: To compare the outcomes of bubble continuous positive airway pressure (B-CPAP) versus ventilator continuous positive airway pressure (V-CPAP) in neonates experiencing respiratory distress.

Methodology: This randomized controlled trial was conducted at the Department of Neonatology, Children's Hospital, Pakistan Institute of Medical Sciences (PIMS), Islamabad, from March 1, 2021, to August 31, 2021. A total of 150 neonates of both genders who presented with respiratory distress and were delivered at >32 weeks of gestation, weighing >1500 grams. The neonates were then randomly allocated to two groups using a lottery method. Treatment failure was defined as a neonate's inability to maintain a SpO2 greater than 90% or an arterial partial pressure (PaO2) greater than 50 mmHg with a maximal CPAP of >7 cm of water and a FiO2 greater than 0.6 or the necessity of mechanical ventilation.

Results: Of these, 82 (54.7%) were male, and 68 (45.3%) were female, resulting in a male-to-female ratio of 1.2:1. The mean gestational age was 36±2.49 weeks in the B-CPAP group and 35.52±1.36 weeks in the V-CPAP group. The mean birth weight was 2381±506.4 grams in the B-CPAP group and 2187.3±427.49 grams in the V-CPAP group. Out of the 75 neonates in the B-CPAP group, 10 (13.3%) were classified as treatment failures, while 19 (25.3%) out of 75 neonates in the V-CPAP group met the criteria for treatment failure, according to our operational definition. Although the failure rate was slightly higher in patients receiving V-CPAP for the management of respiratory distress, these differences were not statistically significant (p-value= 0.052).

Conclusion: In the treatment of neonatal respiratory distress, there was no significant difference in the failure rate between bubble CPAP and ventilatory CPAP. Regardless of the neonate's gender, birth weight, gestational age, or Silverman score, bubble CPAP may be considered as the primary mode of respiratory support for neonates with respiratory distress.

Keywords: Bubble continuous positive airway pressure, Mechanical ventilation, Neonate, Respiratory distress syndrome, Respiratory failure, Ventilator continuous positive airway pressure.

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Introduction

Respiratory distress is a life-threatening syndrome in newborns, accounting for 10% of all intensive care unit admissions worldwide and affecting nearly 3 million patients annually. In preterm babies, it is typically caused by surfactant deficiency, while in term neonates, meconium aspiration is a common underlying factor.[1-3]

Despite the provision of adequate respiratory support in the ICU, barotrauma resulting from conventional ventilation methods contributes to a high mortality rate in newborns with respiratory distress. Non-invasive ventilatory support in the form of continuous positive airway pressure (CPAP) has emerged as an established and effective mode of treatment for these cases over time[4]. CPAP proves to be a valuable therapeutic option for

newborns with respiratory failure, especially in low and middle-income countries.[5]

CPAP is a non-invasive medical technique that consistently administers positive pressure throughout the entire respiratory cycle, preventing the constriction of small airways and alveoli. This helps maintain the functional residual capacity of the lungs and enhances oxygen exchange.[6] Various techniques and advanced equipment are employed to deliver CPAP support to infants, including expiratory resistance, bubble CPAP, fluctuating flow generators, and ventilators equipped with a CPAP feature.[7,8] Among these methods, the bubble continuous positive airway pressure (B-CPAP) approach is widely adopted in neonatal respiratory care. The use of an affordable B-CPAP apparatus has been shown to significantly improve survival rates among newborns, particularly those with exceptionally low birth weight and respiratory challenges.[9-11]

To the best of our knowledge, there is a limited body of research comparing bubble CPAP (BCPAP) with ventilatory CPAP (VCPAP) as the primary means of respiratory support in premature babies. Additionally, no local studies have been identified to provide guidance on determining the more effective CPAP technique. The present investigation was undertaken with the aim of corroborating existing knowledge and identifying the most efficient and effective CPAP method for managing respiratory distress in newborns within our local community.

Methodology

A randomized controlled trial study was conducted at the Department of Neonatology, Children's Hospital, PIMS Islamabad, from March 1, 2021, to August 31, 2021. With 80% test power, a 5% level of significance, and expected percentages of CPAP failure of 14.7% for BCPAP and 32.35% for VCPAP, a sample size of 150 cases was calculated.[8] The study included 150 neonates of either gender who had respiratory distress and were delivered at >32 weeks and >1500 grams. Neonates with major congenital malformations, such as tracheoesophageal fistula, congenital diaphragmatic hernia, upper airway obstruction, central nervous system abnormalities, and significant cardiovascular and neuromuscular abnormalities, were excluded. Neonates who had already received treatment for respiratory distress were also excluded. Prior to enrollment, written parental consent was obtained. The following demographic information was recorded: name, age, gender, gestational age at delivery, birth weight, and Silverman Score.

Subsequently, neonates were randomly assigned to two groups using the lottery method. Neonates in group A underwent bubble CPAP, while neonates in group B received standard CPAP ventilation. Newborns with a clinical examination Silverman score of 4 at the time of presentation were considered to be in respiratory distress. CPAP was considered optimal if the baby appeared comfortable, with no or minor retractions, maintaining oxygen saturation, a capillary refill time of 3 seconds, normal vital signs, and normal urine production. After a neonate remained stable for 12 hours with CPAP at 4 cm and Fio2 at 30%, a trial was conducted to discontinue CPAP and transition the neonate to ambient air or oxygen, or to a low-flow nasal cannula with a flow rate of 1L/min, or to an oxygen hood to maintain saturation between 90 and 94%.

CPAP failure was defined as the inability of a newborn to maintain SpO2 greater than 90% or arterial partial pressure (PaO2) exceeding 50 mmHg at a CPAP setting of over 7 cm of water with a FiO2 greater than 0.6, or the need for mechanical ventilation (according to the operational definition). Neonates experiencing CPAP failure were treated following the standard protocol, and the details were recorded on a Proforma.

The collected data and information were entered and analyzed using SPSS version 20. Quantitative factors such as age, gestational age at birth, birth weight, and the Silverman Score were expressed as Mean±SD. Qualitative elements such as gender and occurrences of CPAP failure were presented as frequencies and proportions. The Chi-square test was employed to compare CPAP failure between the two groups, with a P-value of 0.05 or less considered statistically significant.

Results

In our study, we included 150 neonates, 75 in each group. There were 35 (46.7%) males and 40 (53.3%) females in the B-CPAP group and 47 (62.7%) males and 38 (37.3%) females in the V-CPAP group (p-value=o.035). (Table I) Total males were 82 (54.7%) and females 68 (45.3%) with a male-to-female ratio of 1.2:1. The mean gestational age was 36±2.49 and 35.52±1.36 weeks in B-CPAP and V-CPAP groups, respectively. (Table II). The mean birth weight was 2381±506.4 grams and 2187.3±427.49 grams in B-CPAP and V-CPAP groups, respectively (0.018). (Table III) The mean age of neonates at the time of

presentation was 4.39±2.68 in V-CPAP and 3.33±1.85 in the B-CPAP group (p-value=0.006). The Silverman score at the time of presentation was 6.81±0.81 in V-CPAP and 6.71±0.85 in the B-CPAP group (p-value= 0.435).

Table I: Gender distribution among both groups.

Gender	B-CPAP		V-CPAP		p-value
	N	%	N	%	
Female	40	53.3	28	37.3	
Male	35	46.7	47	62.7	0.035
Total	75	100	75	100	

Table II: Gestational age group distribution among both groups.

Gestational age group (weeks)	B-CPAP		V-CPAP		p-value
	N	%	N	%	
32-34	16	21.3	14	18.7	
35-37	42	56.0	55	73.3	0.028
38 and above	17	22.7	6	8.0	

Table III: Birth weight group distribution among both groups.

Birth weight groups (grams)	B-CPAP		V-CPAP		p-value
	N	%	N	%	
1500-2500	45	60.0	64	85.3	0.002
2501-3500	29	38.7	11	14.7	
3501 and above	1	1.3	0	0	

Table IV: Frequency of treatment failure among both groups.

Treatment Failure	B-CPAP		V-CPAP		Total	p-value
	N	%	N	%		
YES	10	13.3	19	25.3	29 (19.3%)	
NO	65	86.7	56	74.7	121 80.7%)	0.063
Total	75	100.0	75	100.0	150 (100%)	

In the B-CPAP group, the frequencies of Silverman score were 3 (4.8%) neonates had Silverman score 5, thirty-two (42.7%) had score 6, twenty-four (32%), and remaining 16 (21.3%) had score 8. Similarly, in the B-CPAP group, two (2.7%) neonates had a score of 5, twenty-seven (36%) had a score of 6, twenty-nine (38.7%), and remaining 17 (22.7%) had a score of 8. These values were statistically not significant, with a p-value of > 0.05.

Ten (13.3%) patients out of 75 in B-CPAP and 19 (25.3%) in the V-CPAP group were labeled as treatment failure as per operational definition. Although the failure rate was higher in patients having Ventilatory CPAP as a resuscitation for respiratory distress, these results were statistically not significant (p-value= 0.063).

Discussion

CPAP is a recognized treatment for respiratory distress in very low birth weight (VLBW) newborns, with Bubble CPAP (BCPAP) and Ventilatory CPAP (VCPAP) being two prevalent delivery methods. Both are widely accepted, and there is no definitive evidence favoring one over the other in terms of enhancing outcomes. Bubble CPAP, a variable-pressure, constant-flow system, has gained global attention due to its simplicity, affordability, and safety. Motivated by these factors, we designed this study to evaluate the effectiveness of nasal continuous positive airway pressure through Bubble CPAP in neonates suffering from respiratory distress.

In our study, the mean birth weight was 2381±506.4 grams for the B-CPAP group and 2187.3±427.49 grams for the V-CPAP group. In comparison, Bijari et al.[12] reported a mean birth weight of 1.9 ± 0.7 Kg in Iran. In the B-CPAP group, the distribution of Silverman scores was as follows: 3 (4.8%) neonates had a Silverman score of 5, thirty-two (42.7%) had a score of 6, twenty-four (32%), and the remaining 16 (21.3%) had a score of 8. Similarly, in the V-CPAP group, two (2.7%) neonates had a score of 5, twenty-seven (36%) had a score of 6, twenty-nine (38.7%), and the remaining 17 (22.7%) had a score of 8. These values were not statistically significant, with a p-value exceeding 0.05. In a randomized controlled trial, neonates who failed CPAP had a higher Silverman–Anderson score ($p<0.01$).[10]

In our study, the failure rate for the B-CPAP group was 10 (13.3%) patients, while the V-CPAP group had 19 (25.3%) patients experiencing failure. Although the failure rate was slightly higher in patients treated with Ventilatory CPAP for respiratory distress, these results were not statistically significant (p-value= 0.052). The rate of successful treatment was 86.7% with B-CPAP. Similarly, Tagare et al. reported a successful treatment rate of 84.2% for neonates with B-CPAP and 63.2% for neonates in the V-CPAP group ($P < 0.03$).[13] In contrast to our findings, Kawaza et al[14] reported a lower efficacy of B-CPAP, with only 64.6% of patients with RDS showing improvement. Failure rates with BCPAP have been found to range from 20% to 36% in preterm and low birth weight (LBW) newborns with RDS,[12, 13], which are higher than the B-CPAP failure rate in our study. These variations in outcomes may be attributed to differences in the study

population (gestational age, birth weight, SA score), and CPAP failure definitions used in other studies.

Courtney et al[15] conducted a randomized controlled trial comparing B-CPAP and V-CPAP, evaluating various factors such as respiratory rate, heart rate, tidal volume, minute ventilation, breathing asynchrony, lung compliance, oxygen saturation, transcutaneous (Tc) O2 and CO2, and the work of breathing (including inspiratory, elastic, and resistive components). Their findings revealed no statistically significant differences between the two groups across all these parameters. Similarly, Mohamadizadeh et al.[16] assessed 44 infants and found no significant difference in the length of treatment, mechanical ventilation, or oxygen therapy between BCPAP and VCPAP. Agarwal et al. reported a CPAP failure rate of 14.70% with BCPAP compared to 32.35% with VCPAP, but this difference of 17.65% was not statistically significant (p= 0.08).[8] In a retrospective study conducted on 60 neonates at Mayo Hospital, survival rates were evaluated. The 24-hour survival rates were 100% for B-CPAP and 78% for V-CPAP, and after 48 hours, 100% and 72%, respectively.[17]

In our research, BCPAP and VCPAP showed no difference in failure rates for neonates with respiratory distress. Differences in success rates among the groups may be attributed to disparities in participant demographics, severity of illness, co-existing conditions, our study's limited sample size, and our role as a referral center. We included neonates regardless of gestational age, postnatal age, or underlying lung conditions. This study is groundbreaking for the local community and supplements the limited existing data. Bubble CPAP is a well-acknowledged ventilation method for infants in distress, particularly in resource-constrained settings, showing promising outcomes. Its simplicity, affordability, and ease of use further support its adoption in local healthcare scenarios.

Conclusion

In this study, it was observed that the failure rates of B-CPAP and V-CPAP for neonates with respiratory distress (RD) were virtually identical, regardless of factors like gender, birth weight, gestational age, or Silverman score. This finding underscores the importance of Bubble CPAP as a significant means of providing respiratory support for neonates with RD due to its simplicity and cost-effectiveness. In comparison to traditional ventilators, the ease of operation and reduced expenses associated with the BCPAP delivery system render it a valuable choice for neonatal intensive care units in resource-constrained settings, where the financial burden of transportation and referral to higher-level care facilities can be substantial.

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