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Original Research Article

ROLE OF BUBBLE CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP) IN RESPIRATORY DISTRESS IN PRETERM NEONATES

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ABSTRACT

Background: *Respiratory distress syndrome (RDS) is a leading cause of neonatal morbidity and mortality, particularly in preterm infants. Non-invasive ventilation strategies, such as bubble continuous positive airway pressure (bCPAP), have been shown to reduce the need for mechanical ventilation and improve pulmonary outcomes by preventing alveolar collapse and enhancing functional residual capacity. However, the efficacy and success rates of bCPAP in neonates with RDS require further evaluation.* ***Objective:*** *To assess the success rate of bCPAP therapy in neonates with RDS and determine factors influencing treatment outcomes.* ***Study Design:*** *A descriptive case series.* ***Setting:*** *Department of Pediatrics, Sughra Shafi Medical Complex, Narowal.* ***Duration of Study:*** *Six months, from March 7, 2023, to September 7, 2023.* ***Methods:*** *A total of 193 neonates diagnosed with RDS, meeting the inclusion criteria, were enrolled in the study. bCPAP failure was defined as the need for a fraction of inspired oxygen (FiO2) >40%, CPAP pressure >10 cm H_2O, surfactant administration, or mechanical ventilation. Data were collected on demographic and clinical parameters, including gestational age, birth weight, Apgar score, and Downe's score. Statistical analysis was conducted using SPSS version 25. Data stratification was performed based on gender, age, birth weight, gestational age, Apgar score, and baseline Downe's score. The Chi-square test was used to determine associations, with a p-value of ≤0.05 considered statistically significant.* ***Results:*** *Among the 193 neonates, 128 (66.3%) were male, and 65 (33.7%) were female. The mean age of neonates was 16.35 ± 6.534 days, with a mean gestational age of 35.41 ± 5.341 weeks. The mean birth weight was 2735.41 ± 18.413 grams. The mean Downe's score at baseline was 7.48 ± 1.104, and the mean Apgar score was 7.55 ± 2.35. The success rate of CPAP therapy was observed in 176 (91.2%) neonates.* ***Conclusion:*** *bCPAP is a highly effective non-invasive respiratory support modality for neonates with RDS, demonstrating a high success rate. These findings underscore the importance of early CPAP intervention in reducing the need for mechanical ventilation. Further studies are warranted to explore factors influencing CPAP failure and optimize neonatal respiratory care strategies.*

Keywords: Respiratory Distress Syndrome, Neonates, bCPAP

INTRODUCTION

Premature infants encounter numerous disadvantages and confront various developmental challenges, one of which pertains to their long-term development. One noteworthy challenge that arises from prematurity is the heightened risk for respiratory distress syndrome (RDS). This syndrome occurs due to the absence of surfactant, a substance vital for lung function, leading to damage in the lung tissue (1, 2).

The most significant cause of neonatal morbidity and mortality is indeed respiratory distress, which frequently afflicts premature infants. The severity and occurrence of this condition are inversely correlated with the infant's gestational age and birth weight. The incidence of respiratory distress is relatively low, affecting around 1% of all births. However, the likelihood of developing RDS dramatically increases to 50% at 30 weeks gestation, 75% at 28 weeks, and peaks at a staggering 90% when gestation reaches 26 weeks (3, 4).

Respiratory distress syndrome, a prevalent health issue, mainly afflicts preterm newborns who possess a low birth weight. Prematurity, which accounts for approximately 25% of neonatal mortality, has been identified as the leading cause of deaths linked to RDS. The principal challenge associated with RDS lies in the underdevelopment of the lungs, characterized by a deficiency in surfactant (5).

This crucial substance diminishes surface tension within the alveoli, thus playing a vital role in averting the collapse of the lungs during expiration. It is worth noting that a staggering 40% of child fatalities worldwide transpire during the neonatal period. Consequently, low- and middle-income countries must implement practical, straightforward techniques to enhance neonatal care in hospital settings (6, 7).

Various techniques for administering continuous positive airway pressure (CPAP) through the nasal passages have been explored in newborns. One such method, Bubble CPAP (BCPAP), has been documented as a reliable and efficacious means of delivering CPAP during the peri-extubation phase in premature infants requiring mechanical ventilation (8).

This method involves using tiny bubbles to generate airway pressure, and it has demonstrated both safety and effectiveness in this patient population. Additionally, growing evidence suggests that Bubble CPAP could potentially enhance the quality of respiratory support in healthcare settings within low and middle-income countries. By implementing this innovative approach, healthcare providers in these regions may be able to improve the overall respiratory care they provide to neonates (9).

In 2016, an exploratory investigation was undertaken to examine the outcomes of one hundred and twenty-one infants born preterm, with their gestational age ranging from twenty-seven to thirty-six weeks. Among this cohort, most of the seventy infants, accounting for fifty-seven point nine per cent, were male. The remaining fifty-one infants, comprising forty-two point one per cent, were female. These preterm infants were administered bubble continuous positive airway pressure (bCPAP) for respiratory support. It was duly documented that, out of the total one hundred and twenty-one infants, a remarkable seventy-seven infants were successfully weaned off the four-millimetre bCPAP, indicating a commendable success rate of sixty-three point six per cent (10).

In 2016, a comprehensive study was conducted on a sample of 68 preterm infants, with an equal distribution of 34 cases in each group,

namely bCPAP and CPAP. Within the bCPAP group, 24 individuals, accounting for approximately 71% of the total, were identified as male. The remaining 10 individuals, comprising approximately 29% of the group, were identified as female. On the other hand, within the vCPAP group, there were 11 individuals, accounting for approximately 32% of the total, who were identified as male, while the remaining 13 individuals, making up approximately 68% of the group, were identified as female.

Notably, most of the patients included in the study had a gestational age exceeding 30 weeks. Specifically, within the bCPAP group, there were 20 cases, accounting for approximately 59% of the group with a gestational age greater than 30 weeks. Similarly, within the vCPAP group, there were 26 cases, making up approximately 76% of the group with a gestational age exceeding 30 weeks. The study findings revealed that out of the 34 babies in the bCPAP group, a total of five, equivalent to approximately 14.70%, experienced failure of the CPAP intervention. Consequently, the success rate of the bCPAP intervention was established at an impressive 85.3% (11).

This study was designed to determine whether continuous positive airway pressure (CPAP) bubbles effectively treat preterm neonates' respiratory distress. Even though 121 cases of preterm neonates have been studied, (10) there are still insufficient studies on the specific impact of CPAP. Thus, we plan to include a larger sample size in this study. Additionally, if we find a high success rate (low failure rate), CPAP will likely be used to treat respiratory distress syndrome in premature neonates. This would contribute to a reduction in the likelihood of future RDS-related neonatal morbidity and death.

METHODOLOGY

Between March 7, 2023, and September 7, 2023, the study was carried out at the Sughra Shafi Medical Complex's pediatric department in Narowal. The research design used a descriptive case series. There were 193 newborns enrolled in total who met the inclusion criteria. The sample size of 193 was calculated using 5% absolute precision 95% confidence level and a success rate of bCPAP as 85.3% (11).

Preterm babies with RDS and infants older than 28 days were eligible. The study excluded neonates with significant congenital malformations, sepsis (documented in the clinical record), those who had already undergone resuscitation with intubation, neonates experiencing respiratory distress due to birth asphyxia (noted in the clinical record), and those who had congenital pneumonia.

After receiving approval from the hospital ethical committee and informed consent from the parents or caregivers, all 193 neonates who met the inclusion criteria were enrolled. We also collected information about their birth history, including their gestational age at birth and birth weight, as well as their age, gender, and demographics. Babies between 28 and 32 weeks of gestation received CPAP, while those between 32 and 36 weeks plus 6 days received CPAP at a pressure of 5 cm H2O. When respiratory distress subsided or a ceiling pressure of 7cm H2O was reached, the CPAP was optimized by gradually raising the pressure by 1cm H2O.

Keep the oxygen saturation (SpO2) between 90 and 94 per cent, the flow rate was adjusted to 6 to 8 litres per minute, starting with a FiO2 of 0 points thirty. The ideal CPAP was determined by the baby's comfort level, oxygen saturation, capillary refill time (<3 seconds), typical vital signs, and urine output, all maintained with little to no retractions. 30–40 percent FiO2 and 8–10 cm H2O were the CPAPs that were employed. Following the baby's underlying clinical condition improving, FiO2 was first lowered. Next, the pressure was weaned down to the lowest necessary level by adding 1 cm H2O if the patient maintained stability for 48 hours with CPAP of 4 and FiO2. If < 30 per cent, an attempt was made to discontinue CPAP and place the neonate in the air or ambient oxygen or on low flow nasal cannula at a < 1L/min flow or in an oxygen hood to maintain saturation between 90 per cent to 94 per cent. bCPAP was considered to be effective according to the operational definition. CPAP failure was declared if a premature baby required FiO2 > whenever a ventilator or surfactant was required, or when the percentage of oxygen saturation was more significant than 40%.

A premature infant was defined as an infant born before 37 weeks of gestation from the first day of the LMP (last menstrual period). Respiratory distress was labelled if the score of Downe's criteria was >6. Success was defined as the ability of a baby at 30-32 weeks gestation to maintain FiO_2 30% or for a baby of >32 weeks gestation to maintain FiO_2 40% at a maximum CPAP of 8-10cm of H_2O without any need of Surfactant or ventilator.

Data entry and analysis were done using SPSS v25. I used mean ± S.D. for age, APGAR score, birth weight, gestational age, and Downe's criteria for the quantitative data. Frequency and percentages were utilized for categorical data. e. bCPAP success and gender. Data were stratified by gender, age, gestational age, birth weight, Apgar score, and baseline Downe's score to address the effect modifiers. Following stratification, the p-value ≤0.05 was considered significant when using the Chi-square test to ascertain the impact on CPAP success.

RESULTS

A total of 193 newborns with respiratory distress syndrome were included. Among 193 newborns, 128(66.3%) were males and 65(33.7%) were females. The mean age of neonates was 16.35±6.534 days. According to age distribution, 80(41.5%) were in ≤14 days age group, while 113(58.5%) were in >14 days age group. The mean gestational age of neonates was 35.41±5.341 weeks. According to gestational age distribution, 104(53.9%) were in 32-34 weeks group, while 89(46.1%) were in 35-36 weeks group.

The mean birth weight of neonates was 2735.41±18.413 grams. According to birth weight distribution, 88(45.6%) were in the ≤2500 gram weight group, while 105(54.4%) were in the>2500 gram weight group. The mean Downes score at baseline was 7.48±1.104. According to downe's score distribution, 102(52.8%) had downe's score <8, while 91(47.2%) had downe's score ≥8. The mean APGAR score was 7.55±2.35. According to APGAR score distribution, 102(52.8%) had APGAR score ≤7, while 91(47.2%) had APGAR score >7.

The success rate of CPAP therapy was noted in 176(91.2%) neonates. According to the stratification of CPAP success concerning gender, no significant difference was seen between the genders (p>0.05). According to the stratification of CPAP success in terms of age, an insignificant difference was seen in either group (p>0.05). According to the stratification of CPAP success about gestational age, a negligible difference was seen in either group (p>0.05).

According to the stratification of CPAP success concerning birth weight, no significant difference was seen in either birth weight group (p>0.05). According to the stratification of CPAP success concerning Downes's score at baseline, an insignificant difference was seen in either Downes score group (p>0.05). According to the stratification of CPAP success about the APGAR score, a negligible difference was seen in either APGAR score group (p>0.05).

Table 1: Frequency distribution of demographic variables

Gender	Frequency	Per cent
Male	128	66.3
Female	65	33.7
Total	193	100.0
Age groups		
≤14 days	80	41.5
>14 days	113	58.8
Total	193	100.0
Gestational age		

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32-34 weeks	104	53.9
35-36 weeks	89	46.1
Total	193	100.0
Birth weight		
≤2500 gram	88	45.6
>2500 gram	105	54.4
Total	193	100.0
Downes score		
Downes score <8	102	52.8
Downes score ≥8	91	47.2
Total	193	100.0
APGAR score		
APGAR ≤7	102	52.8
APGAR >7	91	47.2
Total	193	100.0
CPAP success		
Yes	176	91.2
No	17	8.8
Total	193	100.0

Table 2: Stratification of bCPAP success concerning different variables

Variables		bCPAP success		p-value
		Yes	No	
Gender	Male	114(89.1%)	14(10.9%)	0.143
	Female	62(95.4%)	3(4.6%)	
Age groups	≤14 days	69(86.3%)	11(13.8%)	0.052
	>14 days	107(94.7%)	6(5.3%)	
Gestational age	32-34 weeks	93(89.4%)	11(10.6%)	0.349
	35-36 weeks	83(93.3%)	6(6.7%)	
Birth weight	≤2500 gram	77(87.5%)	11(12.5%)	0.098
	>2500 gram	99(94.3%)	6(5.7%)	
Downes score	Downes score <8	90(88.2%)	12(11.8%)	0.125
	Downes score ≥8	86(94.5%)	5(5.5%)	
APGAR score	APGAR ≤7	89(87.3%)	13(12.7%)	0.051
	APGAR >7	87(95.6%)	4(4.4%)	

DISCUSSION

The current study aimed to determine how well bCPAP worked in treating preterm infants' respiratory distress syndrome by evaluating Downe's score. The confirmation of the diagnosis of respiratory distress syndrome requires a positive postnatal gastric aspirate test and a chest x-ray, which can be a long process in developing nations due to logistical issues. The lecithin/sphingomyelin ratio is one example of an advanced biochemical test that is not commonly available. A clinical score such as Downe's score can be used to evaluate the severity of respiratory distress syndrome, which is primarily diagnosed based on clinical presentation (12-15).

Similar to the findings by Koti et al. and Urs et al., the success of bCPAP in the current study was not influenced by the newborn's gender. According to Urs et al.'s prospective analytical study, birth weights weighing between 1000 and 2500 grams were substantially correlated (p<0.001) with the effectiveness of bubble CPAP. However, in the prospective analytical study by Koti et al. and our investigation, no statistically significant correlation was found between birth weights ranging from 1000 to 2500g and the effectiveness of bubble CPAP (16, 17).

An association between the success of bubble CPAP and gestational age of 32–34 weeks was found by Urs et al. to be statistically insignificant. Our study's conclusions were comparable to this. In a retrospective study, all babies born with gestations longer than thirty weeks passed the CPAP test. Before the initiation of bCPAP, 9 per cent, 52 per cent, and 39 per cent of the infants in the current study had Down's scores of4,5, and 6, respectively. Before beginning bCPAP, 32%, 62%, and 6% of the babies in the study by Urs et al. had Downe's scores of 4, 5, and 6, respectively (16, 18).

Downe's score was used in the current study to evaluate the efficacy of BCPAP. Six hours after starting bCPAP, 55.4 per cent of the 9 per cent of babies with a Downe's score of 4 had a score of. <4 and 44.6 percent had an unchanged score of 4 which was statistically significant. These findings were similar to those found by Urs et al., where out of 16 babies who had a Downe's score of 4 at the initiation of bCPAP, after 6 hours, 75 per cent had a score of <4 and 25 per cent had a score of > 4, indicating statistical significance. At the 12-hour mark in our study, when the babies were assessed again, 78.6% had a score of less than 4, which was statistically significant (p=0.00001) (16).

Recent research conducted in India indicates that neonates who required intubation at birth, had congenital pneumonia, or experienced respiratory distress due to birth asphyxia were not included in the study. Sepsis, congenital abnormalities, and meconium aspiration also facilitate exclusion. A success and failure group system was used to grade the research on newborns. Regarding the usage of bubble CPAP, the study's findings indicated that 91% of the infants had success with it. Nevertheless, nine percent of the cases did not yield a favourable outcome (19).

At the onset of CPAP therapy, the average Downe's score (DS) was 5 points30±0.66. Approximately six hours into treatment, the mean DS dropped to 3.79±1.03, and twelve hours in treatment dropped to 3.39±0.86. There were 63.6% and 81.8% of newborns with a Downe's score among the success group that received CPAP therapy for four and six hours, respectively. < 4 at the start of CPAP therapy. The frequency of success was 100 per cent in newborns with a Down's score of <4 and 57 per cent with a Down's score > 4 (19).

Studying 121 preterm infants with gestational ages ranging from 27 to 36 weeks, 70 males (57.9 per cent) and 51 females (42.1 per cent) were included in the study, in 2016. CPAP was used on every infant. The success rate at weaning off 4m bCPAP was reported to be 77 out of 121 preterm infants, or 63.6% (10).

A study involving 68 preterm infants (34 cases in each group) was conducted in 2016. e. bCPAP and CPAP), there were 10 females (29%) and 24 males (71%) in BCPAP. 11 (32%) male and 13 (68%) female cases were found in vCPAP. Most patients' gestational ages were over 30 weeks (i). e. Twenty cases (or 59 per cent) in bCPAP and 26 cases (or 76 per cent) in vCPAP, respectively, had gestational ages that were greater than 30 weeks. According to reports, the success rate for the BCPAP group was 85.3% despite five out of 34 (or 14.7%) infants failing CPAP (11).

The current study supports the notion that, in resource-constrained settings, Downe's score and FiO2 requirement are more clinically applicable and practical tools to evaluate the improvement in respiratory distress syndrome in infants on CPAP than chest x-rays and

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arterial blood gas analysis. This study demonstrates the safety, simplicity, non-invasiveness, and effectiveness of bilevel continuous positive airway pressure (bCPAP) in treating preterm infants with mild to moderate respiratory distress syndrome.

CONCLUSION

This investigation illuminated the subject of care for neonatal respiratory support and demonstrated that the utilization of neonatal bCPAP therapy has become firmly established, with an impressive success rate of 91.2%. Areas that have been identified as having potential for improvement encompass the infrequent employment of CPAP in extremely premature infants as a primary means of respiratory support, the absence of a monitoring protocol for newborns receiving CPAP, and the dearth of criteria for gradual reduction of CPAP usage in premature infants.

DECLARATIONS

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-SMCM-2e34/24)
Consent for publication
Approved
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Not applicable

CONFLICT OF INTEREST

The authors declared the absence of a conflict of interest.

AUTHOR CONTRIBUTION

MARIA AFTAB (Resident)
Conception of Study, Development of Research Methodology Design, Study Design, manuscript Review, and final approval of manuscript. Manuscript drafting.
EMRAN ROSHAN (HOD)
Conception of Study, Final approval of manuscript.
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Study Design, Review of Literature.
MUHAMMAD UZAIR (Medical Officer)
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Data entry, data analysis, and drafting of the article.
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Coordination of collaborative efforts.

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