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Original Article

Neonatology Section

Non-Invasive Ventilation as Primary Ventilator Support for Neonate with Acute Respiratory Failure: A Standardised Regimen of Ventilator Support Decreases Morbidities and Hospital Stay

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ABSTRACT

Background: Both conventional ventilation (CMV) and CPAP are frequently used as the primary modality for infant presenting with Acute respiratory failure, however, evidence regarding the "best" primary ventilatory modality is lacking.

Aims: To report our experience of nasal CPAP as primary ventilator support strategy in infants admitted for ARF.

Design: Retrospective comparative audit over a period of 2 years.

Methods: All the infants admitted to NICU requiring respiratory support, in the form of CPAP and/ or CMV, were included in the study. Two cohort chosen for comparison were

1. The CMV era (January-December 2007): CMV as the primary modality.
2. The CPAP era (January-December 2008): CPAP as the primary modality with standardised ventilator regimen.

Results: The numbers of infants requiring respiratory support (CMV and/or CPAP) were almost similar (CMV era: 77/308, (25%), CPAP era: 94/372, (25.2%). No statistically significant differences were found in the baseline characteristics. The CPAP era was associated with decreased in incidence of total number of hospital stay (23.5 vs 15.4, p= 0.001), days on mechanical ventilations (8.3 Vs 5.9; p= 0.001), ROP (14.2 Vs 2.1; p= 0.01) and NEC (9%, Vs 0%; p= 0.01) but was associated with increased in incidence of pneumothorax (1.2 Vs 9.5; p=0.05). There was no difference in mortality and total number of respiratory support days and culture positive sepsis (16.8% Vs 9.4%; p = 0.23), between the groups.

Conclusions: A standardised ventilator regimen with bubble CPAP can be safely use as primary ventilator support for neonate with ARF and associated with decreased hospital stay, NEC and ROP

Keywords: Acute respiratory failure, Bubble CPAP, Neonate, Non invasive ventilation

BACKGROUND

For ages, conventional mechanical ventilation (MV) had been the primary modality of respiratory support for acute respiratory failure in neonates [1]. Of late, the trend is moving towards non-invasive techniques of support, focusing on minimising the lung injury caused by mechanical ventilation. Consequently continuous positive airway pressure (CPAP) is increasingly being used by neonatal intensive care units (NICUs) for acute management of respiratory disease and is emerging as promising alternative to MV [2,3,4]. Although both MV and CPAP are frequently used as the primary modality for acute respiratory failure, evidence regarding the "best" primary ventilatory modality is lacking.

In January, 2008 the NICU at Lotus Children Hospital (LCH), Hyderabad, India, began managing babies of all gestational ages and weights with standardised ventilatory regimen [Table/Fig-1] using non-invasive ventilation (nasal prong bubble CPAP) as the primary modality for acute respiratory distress. This was significant change from previous practice where MV was primary modality of ventilation and CPAP was used as a weaning mode.

The aim of this study is to compare two different ventilation strategies of respiratory support in terms of complications, duration of hospital stay and mortality.

Type of study

Retrospective comparative audit over a period of two

years.

Setting

This study was performed in a 40-bed Neonatal Intensive care unit of LCH. LCH is an out-born, tertiary level teaching hospital of South India, catering to the needs of surrounding three to four states.

MATERIAL AND METHODS

All the infants, who required respiratory support, in the form of CPAP and/ or mechanical ventilation, between January, 2007 to December, 2008, were included in the study. Two cohort chosen for comparison were:

1. MV era: January to December, 2007 (MV as a primary modality of respiratory support)
2. CPAP era: January to December, 2008 (introduction of the standardised ventilatory regimen (SVR) plus CPAP as the primary modality of ventilatory support)

Those infants who required only supplemental oxygen by nasal prongs or hood were excluded. Neonates with upper airway anomalies, such as choanal atresia, tracheoesophageal fistula, or diaphragmatic hernia also were excluded.

Standardised Ventilatory Regimen (SVR)

All the medical staff agreed to comply with the SVR [Table/Fig-1] and use Bubble CPAP as the primary modality for neonates requiring ventilator support. Rigorous training and hand-on experience were carried out for all medical staffs (nursing, junior and senior doctors) regarding the conceptual and intrinsic details of CPAP therapy prior to implementation of SVR. The aim was to involve and empower nursing staff in the decision making process. The decision as to whether a baby had failed to respond to CPAP and required MV was made based on SVR. Surfactant treatment, ventilation settings, and criteria for extubation were not specified in both the era and were left at the discretion of attending pediatrician.

Continuous positive airway pressure was delivered via nasal prongs using a bubble CPAP system manufactured by Fisher and Paykel (Fisher and Paykel Healthcare, Laguna Hills, California). CPAP was administered, maintained and weaned as per the protocol published by Sankar MJ et al., [5]. Nasal CPAP was started at pressure of 5-6 cmH2O and increased as required up to a maximum 8 cmH2O. MV was performed using Servo900C in both the era.

Data collection and study end points

Data were collected on infants until their death or discharge from hospital. Neonatal morbidities data were recorded from the patient's record and included intraventricular haemorrhage, retinopathy of prematurity, necrotising enterocolitis, culture proven sepsis, duration of antibiotic therapy and length of stay. Respiratory outcomes included incidence of air leaks, the number of infants ventilated, the number receiving surfactant, days of mechanical ventilation and days of CPAP.

STATISTICAL ANALYSIS

Categorical variable between the CPAP and CMV era were compared using Chi-square test or Fischer exact test. For continuous variables, t-test and Wilcoxon Signed-Ranks test were used.

A p value of <0.05 was considered statistically significant. All analyses were conducted using SPSS program [Table/Fig-1].

RESULTS

The numbers of infants requiring respiratory support (CPAP and/ or MV) were almost similar (MV era:

Criteria for initiation of CPAP:
1. Neonates with tachypnoea and retractions 2. Oxygen saturations < 90 % with FiO2 > 30%
Criteria for mechanical ventilation and best practices:
1. Neonates in an impending arrest situation, or if their disease proceeded too rapidly for a trial of CPAP 2. Worsening tachypnoea and retractions on CPAP 3. Recurrent apnoea with bradycardia on CPAP requiring bag and mask ventilation (≥2 episodes per hour) 4. Oxygen saturations < 90 % in FiO2 > 60- 70 % 5. PH: < 7.25 Pco2: > 65 6. Minimal sedation and avoidance of muscle relaxations 7. Early enteral nutritional support, 8. Developmentally appropriate care (minimal handling, early breast feeding, kangaroo care)
Oxygen saturation targets
Neonates ≤ 36 weeks 88 – 92% > 36 weeks 90 – 94%

[Table/Fig-1]: Standardised Ventilatory Regimen

Maturity	No. of Infants	No. of Respiratory Distress Babies	No. of Infants
Pre-term	158 (28.6)	46 (61.0)	158 (28.6)
Term	395 (71.4)	30 (39.0)	395 (71.4)
Total	553 (100)	76 (100)	553 (100)

[Table/Fig-2]: Demographic information of study patients
P< 0.05 is significant, NS not significant

	MV era	CPAP era	p-value
Mechanical ventilation only	64/77 (83.3%)	49/94 (52%)	0.04
CPAP as primary mode	6/77 (7.7%)	33/94 (35.1%)	0.01
CPAP only	4/77 (5.1%)	22/94 (23.4%)	0.02
CPAP failure	2/6 (33.3%)	10/33 (30%)	NS
Both CPAP and ventilation	9/77 (11.6%)	23 (24.4%)	0.02
CPAP as a weaning mode	6/64 (9.3%)	16/49 (32.6%)	0.04
MV total days (mean)	8.31± 6.32	5.98± 7.78	0.001
CPAP total days (mean)	3.3	3.1	NS
Total respiratory support (days)	11.61	9.11	0.02

[Table/Fig-3]: Respiratory outcomes of study patients
P< 0.05 is significant, NS not significant

	MV era	CPAP era	P value
Infections (culture proven) (%)	13 (16.8%)	9 (9.5%)	0.04
NEC (%)	7 (9%)	0 (0%)	0.01
Pneumothorax (%)	3 (3.8%)	13 (13.8%)	0.05
ROP (treated) (%)	11 (14.2%)	2 (2.1%)	0.01
IVH (%)	9 (11.6%)	10 (10.6%)	NS
LOS (days) (Mean)	23.40 ± 16.99	14.54 ± 13.15	0.001
Survived %	69 (72%)	57 (74%)	NS
Case fatality rate (excluding cardiac) (% of total admissions)	5.8%	4.3%	NS

[Table/Fig-4]: Other neonatal outcomes of study patients
P=< 0.05 is significant, NS not significant

77/308, 25%, CPAP era: 94/372, 25.2%) Demographic information for two cohorts is presented in [Table/Fig-2].

DISCUSSION

Ever since the introduction of bubble CPAP as an alternative modality to mechanical ventilation for management of acute respiratory distress in neonates, "to intubate or to put on CPAP" has remained a perennial dilemma for the neonatologist. This study, demonstrated that a ventilation strategy based on BCPAP as the primary modality along with SVR in neonates with acute respiratory failure was associated with reduction in: length of hospital stay, need for mechanical ventilation, ROP, NEC and culture proven sepsis. There was no difference in mortality between the groups. SVR implemented by us were the combo of evidence based best clinical practices (permissive hypercapnia, targeted oxygen saturations, minimal sedation with avoidance of muscle relaxation, stringent infection control and optimal early enteral nutrition) and have shown to decrease CLD rate by many centers [6,7,8]. By implementing SVR practices we showed that intubations rate and duration of mechanical ventilation were reduced by almost 25% during CPAP era.

This study results are partly conjunction with an earlier study by Morley CJ et al in very preterm infants [3], where they found a decrease in the need for intubation and duration of respiratory support, but have not found a difference in the overall mortality. Koyamaibole et al. have also found a significant reduction in the need for mechanical ventilation but no difference in overall mortality with introduction of CPAP [4]. Narendran V et al. reported a significant reduction in the need for delivery room intubations and duration of ventilation with early CPAP in preterm neonates [9]. In Cochrane review by Ho JJ et al. reported a decrease in overall mortality with application of continuous distending pressure in preterm neonates [10].

In majority of the studies done earlier CPAP was primarily compared with mechanical ventilation in preterm neonates less than 32 weeks [3,4,9,11,12]. Data regarding safety and efficacy of CPAP in more mature (> 32 weeks) and term babies is limited. More so, the results of these studies can not be extrapolated completely to the Indian neonates as they are more mature and their disease spectrums are different. To the best of our knowledge, this is the first study to report the utility of bubble CPAP as the primary modality for respiratory distress in both term and preterm neonates. More than 80% of this study populations in both the cohorts were premature neonates above 30 weeks gestational age. We used CPAP successfully in bigger neonates for various indications like respiratory distress syndrome in borderline term infants, meconium aspiration syndrome and congenital pneumonia. Contrary to belief, CPAP was well tolerated by majority of bigger neonates. We found that early initiation of CPAP was well tolerated, before the hypoxia and hypercapnoea sets in. Early initiation also reduced the requirement for mechanical ventilation and attendant complications in this set of population. For bigger neonate first few hours will be crucial in determining the success or failure of CPAP. During this period neonate is learning to adjust and should be allowed to settled in by minimal handling and by different comfort measures like swaddling, nesting or sucrose/ glucose (0.5-1 mL) via pacifier. We use small dose of oral/ IV sedation for very agitated large neonate.

The rate of culture proven sepsis and the duration of antibiotic therapy required were reduced in this study during CPAP era. The reasons for this is not clear but may be lower rates of ventilator associated pneumonia and reduction in the use of indwelling catheters with CPAP therapy. The targeted oxygen saturation used during CPAP era result in substantial decrease in incidence of ROP. Recently published study showed that the targeted saturations are associated with decreased rate of ROP [13]. There was no documented neonate with necrotising enterocolitis during the CPAP era.

The incidence of air leaks was increased in this study, as found in earlier studies [3,10], but similar to their studies, there was no change in the associated morbidity like intraventricular haemorrhage. Interesting to note that, out of the 13 neonates with air leaks in the CPAP era, six had the air leak at the time of admission (as compared to one out of the three in the MV era). Furthermore, in the CPAP era, out of the 13 with air leaks, seven neonates were never on CPAP. Three neonates developed pneumothorax while on MV while another three developed while on CPAP. One neonate had a spontaneous pneumothorax, when not on any respiratory support. Three pneumothoraces followed administration of surfactant while another three were associated with meconium aspiration syndrome. Three neonates with air leaks were managed with needle aspiration alone while 10 neonates required intercostal chest tube drainage. Only one neonate required intubation and mechanical ventilation for the management of pneumothorax. So the actual incidence of air leak while on CPAP comes down to 3 (3.19%) and incidence while on respiratory support

(CPAP and/or MV) is 6.38%. In the MV era, out of the two air leaks developed during the stay in NICU, one was post operative (PDA ligation).There was no mortality associated with air leaks in both the era.

Success and failure of CPAP therapy is the end results of multiple factors. In addition to SVR adequate preparation and acceptance from all the health professionals before implementation is essential. We have found in our unit that the initial resistance by health professionals particularly nursing staffs was replaced by over enthusiasm of acceptance within few months of implementation of CPAP therapy. Treating paediatrician should understand that there is a learning curve attached to the CPAP therapy, and therefore nursing acceptance and familiarity with the CPAP process will improve with time. Ongoing knowledge and skill training for new staff is essential.

Validating CPAP therapy for acute respiratory failure as a primary modality of respiratory support is more relevant in Indian context. CPAP is very cost effective compared to mechanical ventilation, given the fact that equipment is cheaper and less expenditure will be incurred in establishment of the infrastructure required. We have not performed formal cost benefit analysis for this study, but the decrease in duration of respiratory support, length of hospital stay, duration of antibiotic therapy and lesser incidence of nosocomial infections found in this study, translates into lesser expenditure. Bubble CPAP is also very simple technically and can be mastered with common sense. The equipment is not cumbersome nor is it space occupying. It can be accommodated even in small intensive care units without much congestion. The nursing staff can be easily trained in managing the infants on CPAP, as not much of technical expertise like endotracheal intubation is required. This study showed that CPAP therapy decreases intubation rate by nearly 23%. This perfectly suits the requirement in developing countries where still the doctor patient ratio is very low and where there is a paucity of specialists. In most of the developing countries, the intensive care units are also small and congested.

This study is limited by the retrospective nature of the data and the lack of long-term developmental outcomes. Some biological data on admission, particularly severity scores, are lacking. The study was performed in the same NICU with the same nursing staff over two successive study periods so that one can assume that unit culture and other habits did not change over the study except introduction of lung protective strategies and Bubble CPAP as a primary mode for neonates with acute respiratory failure. This strategy is associated with decreased morbidities. Prospective controlled trial validating CPAP therapy in different scenario (tertiary or non tertiary centers or transport) in different populations (term neonates or preterm or SGA) against (mechanical ventilation or head box oxygen or high flow oxygen) in Indian context is urgently required and will be of immense utility.

CONCLUSION

CPAP can be used safely as a primary modality for both term and preterm neonates with acute respiratory failure and in combination with SVR resulted in decrease in need for MV, hospital stay, sepsis, NEC and ROP.

What is already known

CPAP can be used as a primary ventilator modality in the management of respiratory failure in premature infant.

What this study adds

A standardised ventilator regimen with bubble CPAP is associated with reduced need for MV, decreased in hospital stay, sepsis, NEC and ROP and can be extremely important in the context of developing economy of third world countries like India.

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