EXPERIENCE OF NASAL CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP) BY INFANT FLOW DRIVER IN A NEONATAL UNIT OF A DEVELOPING COUNTRY

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ABSTRACT

Objective: To study the safety and efficacy of nasal continuous positive airways pressure by infant flow driver in neonates admitted with respiratory problems.

Study Design: Quasi-experimental study.

Place and Duration of Study: This study was conducted at CMH Lahore from April 2012 to March 2013.

Subjects and Methods: All infants who were treated with nasal continuous positive airway pressure (nCPAP) for various indications at neonatal intensive care unit (NICU) of CMH Lahore were evaluated for gestational age, weight, gender, indications and duration on nCPAP, pre-defined outcomes, complications and length of hospital stay. Efficacy was defined as the ability to manage an infant on nCPAP alone thus avoiding the need for mechanical ventilation.

Results: During the study period, 343 neonates were admitted in NICU. Forty five neonates were placed on nCPAP. Mean gestational age was 33.85 ± 3 weeks. Mean weight was 2043 ± 770 grams. Main indications for applying nCPAP were respiratory distress syndrome (48.9%) and neonatal pneumonia (17.8%). Most common complication was abdominal distension (6.7%). Out of 45 infants placed on nCPAP, 32 (71.1%) were managed on nCPAP alone while 13 (28.9%) needed mechanical ventilation after nCPAP failure.

Conclusion: Nasal CPAP by an infant flow driver is a useful method to manage respiratory distress in neonates. It reduces the need for mechanical ventilation and can be used as first line respiratory support before mechanical ventilation.

Keywords: Mechanical ventilation, nCPAP ventilation, Neonates, Respiratory Distress syndrome.

INTRODUCTION

Continuous positive airway pressure (CPAP) refers to the application of positive airway pressure to a spontaneously breathing infant throughout the respiratory cycle. CPAP was first used as a method of supporting breathing of preterm infants in 1971[1]. Over the past four decades, it has evolved into a well-established modality to treat respiratory distress syndrome (RDS) and a variety of neonatal respiratory conditions including apnea of prematurity, transient tachypnea of newborn (TTN) and neonatal pneumonia[2]. It is also an effective method for preventing extubation failure in neonates with RDS[3]. The physiological effects of CPAP include decreasing work of breathing, improving oxygenation, maintaining lung volume by recruitment of alveoli, lowering upper airway resistance, and reducing obstructive apnea[4].

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CPAP can be delivered by nasal route (non invasive) with the help of bubble CPAP or an infant flow driver. Alternatively, it can be given after endotracheal intubation (invasive) with the help of mechanical ventilators[5]. Nasal CPAP (nCPAP) via an infant flow driver is technically superior to bubble CPAP as it has ability to vary its flow and allows infant to exhale passively thus reducing asynchrony. In contrast, bubble CPAP exerts a continuous descending pressure (CDP) and infant has to exhale against this pressure resulting in increased work of breathing during expiration[6]. Nasal CPAP using an infant flow driver has potential advantages over CPAP given by a mechanical ventilator in the form of non-invasiveness, lower cost, application by nursing staff (it is easy to teach and no intubation is required) and lower risk of complications[7].

Multiple studies have shown that nCPAP reduces the need for mechanical ventilation and a variety of neonatal respiratory conditions can be managed on nCPAP alone[7,8]. This is particularly relevant in resource-limited countries like Pakistan where neonatal

mortality rate is alarmingly high in infants with respiratory difficulties. In Pakistan, we have limited facilities for newborn care and skilled doctors and nursing staff for mechanical ventilation is available only in much selected centers. Even in these centers there a high incidence of ventilator - associated complications. These complications range from acute pharyngeal and laryngeal injury, tube blockage and displacement, vagal stimulation, apnea and bradycardia, laryngeal edema, pneumothorax, atelectasis, introduction of nosocomial infection to late complications like stricture and subglottic stenosis[9].

In view of these limitations, nCPAP ventilation was introduced in our NICU, with structured training of nurses and resident doctors. It was found to be a simple and efficient method of treating neonates with respiratory distress. The objective of this study is to evaluate the safety and efficacy of nasal Continuous Positive Airways Pressure (nCPAP) by infant flow driver in terms of reducing need for mechanical ventilation in neonates.

MATERIAL AND METHODS

This quasi-experimental study was performed from April 2012 to March 2013 at the NICU of CMH Lahore. All infants who were < 1 week old and a gestational age of > 28 weeks, infants with respiratory distress (clinically manifested by one or more of the following: grunting, tachypnea, sternal retraction, intercostal and subcostal recession) having arterial pCO_2 < 60 mm Hg and O_2 saturation below 88 % measured with the help of pulse oximeter on 2 l/min nasal oxygen, infants with radiological findings consistent with RDS, TTN or pneumonia if fulfilling the above criteria and infants with idiopathic apnea of prematurity (< 3 apnoeic episodes per hour and not requiring bag-mask ventilation) were included in the study. Babies with major congenital malformations, neuromuscular disease, severe birth asphyxia (Apgar score at five minutes of less than 4, serum bicarbonate < 12 mmol/l in the first hour) or overwhelming infection were excluded from the study.

Forty five (n=45) infants who were admitted in NICU and fulfilled the inclusion criteria were included in the study by non-probability consecutive sampling. The data of all babies treated with nCPAP including gestational age, weight, gender, indication of nCPAP, length of hospital stay, complications while on nCPAP, need for mechanical ventilation was recorded.

Successful outcome (efficacy) was defined as the ability to manage a case on nCPAP alone without the need for mechanical ventilation with successful weaning off the nCPAP to achieve following criteria: blood gases having arterial pCO_2 < 60 mm Hg, O_2 saturation > 88 % without supplementary O_2 requirement for four hours consecutively.

Patients were shifted from nCPAP to mechanical ventilation (failure of nCPAP) if: arterial blood gas revealed an increase in pCO_2 above 60 mm Hg and /or pH < 7.20, O_2 requirement > 60% at CPAP pressure of 6 cm H_2O, three or more apnoeic episodes / hour requiring stimulation or one apnoeic episode requiring bag and mask ventilation.

SPSS version 20 was used to analyze the data. Mean and standard deviation (SD) were calculated for quantitative variables like gestational age, weight of the baby, length of stay in hospital and duration on nCPAP. Frequencies and percentages were calculated for qualitative variables like indication and complications of nCPAP, need for mechanical ventilation, weight and gestational age category and whether the baby survived or died.

RESULTS

Twenty-four babies (53.3%) were males and 21 (46.7%) were females. Mean gestational age was 33.85 ± 3 weeks. Mean weight was 2043 ±770 grams. Mean duration of nCPAP was 63.4 ± 29 hours. Mean length of stay in hospital was 8.90 ± 4 days. Fifteen neonates (33.3%) were between 28-32 weeks of gestation, 20 (44.4%) were between 32 to 36 weeks, 9 (20.0%) were between 36 - 40 weeks and one (2.2 %) was > 40 weeks of gestation. Fourteen (31.1%) babies were between 1000-1500 grams, 21 (46.7%) were between 1501-2500 grams, 7 (15.6%) were between 2501-3500 grams. Two babies (4.4%)

were more than 3500 grams while one baby (2.2%) was less than 1000 grams.

Our main indication of nCPAP was RDS. Twenty-eight (62.2%) babies with RDS were given nCPAP. Twenty two (48.9%) neonates were placed on nCPAP without surfactant administration while 6 (13.3 %) were given surfactant and then placed on nCPAP. Out of 45 babies, 32 (71.1%) were managed on nCPAP alone while 13 (28.9%) required mechanical ventilation after nCPAP failure. Out of 13 babies requiring mechanical ventilation, eight babies had severe RDS (Figure). Complications were observed in 10 (22.2%) babies while thirty-five (77.8%) babies remained free of complications (Table). Thirty-nine (86.7%) babies were successfully treated and discharged while 6 (13.3%) babies died.

DISCUSSION

Respiratory distress is one of the commonest conditions in preterm infants (3-7% of all live births). Almost 1 out of every 4 admitted neonates to NICU requires some form of assisted ventilation[10]. Respiratory distress in newborns present with tachypnea, inspiratory recessions and expiratory grunting. CPAP has gained immense popularity and[5] being technically simple, effective and inexpensive it has become the primary approach of respiratory support in NICU[11].

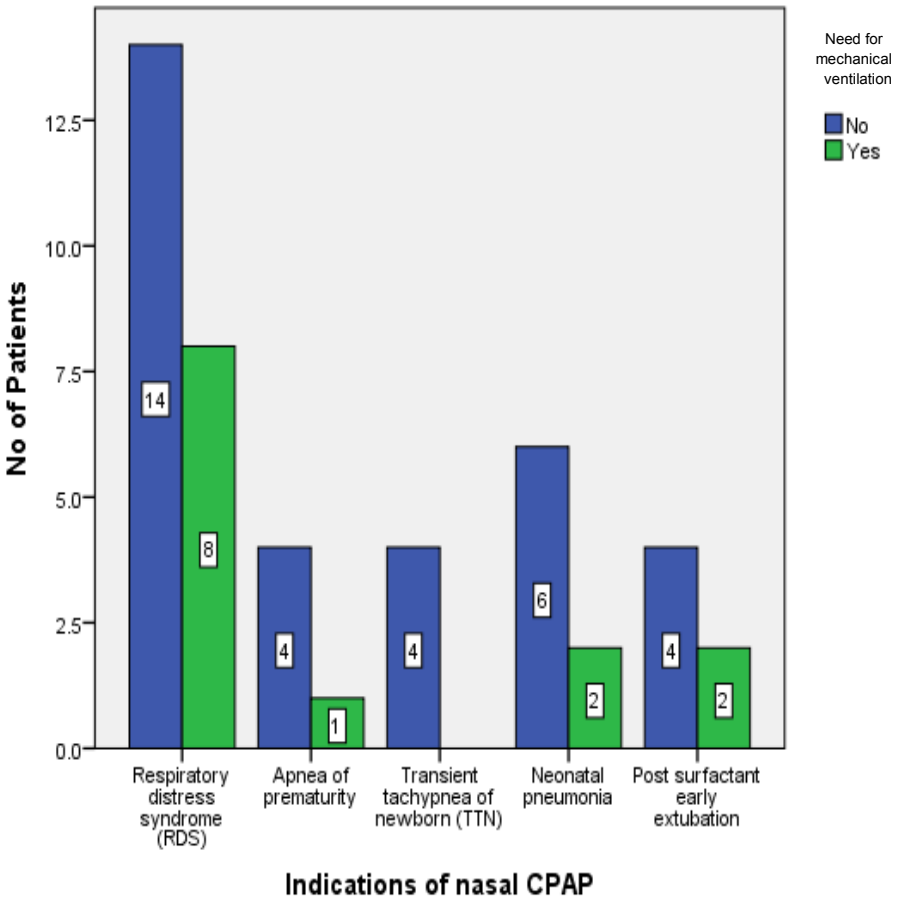

Figure-1: Indications of nasal CPAP and need for mechanical ventilation (n=45).

Infant flow driver has long been used as a system for administering CPAP in newborn infants in industrialized countries[7]. It uses the "Bernoulli effect" via dual injector jets directed towards each nasal prong to maintain a constant pressure. If the infant requires more

inspiratory flow, the venture action of the injector jets entrains additional flow. When the infant expires there is a "fluidic flip" that causes the flow to flip around and to leave the generator chamber via the expiratory limb (Coanda effect). Unlike other methods of CPAP where the infant has to exhale against the incoming gas flow, the "fluidic flip" of the infant flow driver assists exhalation thus reducing the work of breathing[6,7].

In our cohort, the most common indication of nCPAP was RDS (n=28, 62.2%). Twenty-two (48.9%) babies were placed on nCPAP without surfactant therapy. Six (13.3%) neonates with RDS were intubated, given surfactant therapy, extubated and then placed on nCPAP. This is universal practice worldwide and RDS remains the major indication of nCPAP[12,13]. In a local study by Hameed et al, RDS was the commonest etiological indication (39.2%) for starting nCPAP and was also associated with best survival rate (60.6%) in Pakistan[10].

Although nCPAP is non-invasive but various minor and major complications have been reported in the literature[14]. In our study most common complication was abdominal distension occurring in 6.7% of babies. This commonly occurring side effect of nCPAP is called CPAP belly syndrome. Jaile et al described this complication in 14% of babies who weighed more than 1000 grams[15]. It can be managed by intermittent decompression with the help of a nasogastric tube[13]. Pneumothorax and hypotension are life-threatening complications of nCPAP. Pneumothorax occurs when CPAP pressure is kept high or when pressures are not lowered during recovery phase of RDS. The incidence of pneumothorax has been variously reported from 1.4% to 10.3% in different studies[16,17]. In our study, pneumothorax and hypotension each occurred in 4.4% of patients. Hypotension occurs secondarily to decreased venous return, decreased right ventricle stroke volume and decreased distensibility of left ventricle when high CPAP pressure is used. Hypotension can be managed by reducing the nCPAP pressure and use of ionotrpic support.

Swietliński et al described erosion of nares in 12% of babies but in our study only mild redness was observed in 4.4% of neonates. This was because we used Hudson nasal prongs which are especially designed to reduce nasal trauma[17]. Over all in our study 77.8% babies remained complication free while 22.2% babies suffered from some form of complications. This percentage is relatively high as compared to other studies in the region[10,17,18]. This could be because we included abdominal distension which was not included in the studies quoted above. Another factor could be the deficiency of NICU trained doctors and nursing staff with less than ideal nurse-patient ratio.

In our study, the need for mechanical ventilation was reduced by 71.1%, thus saving them being exposed to this invasive therapeutic modality. Koyamaibole L et al described a 50% reduction in the need for mechanical ventilation in their study conducted in 2005[18]. In a study conducted in Poland need for mechanical ventilation was reduced by 78%[17]. In an Indian study, 61.24% babies were managed with CPAP alone[19]. Although need for mechanical ventilation was reduced but in our study 28.9% babies needed rescue mechanical ventilation after nCPAP failure.

Table-1: Complications of nasal CPAP (n = 45).

Complications	No of patients	percentage
Redness of nares or nasal septum	2	4.4
Hypotension	2	4.4
Dislodgement of nasal prongs	1	2.2
Pneumothorax	2	4.4
Distention of abdomen	3	6.7
No complication	35	77.8

In our cohort mortality rate on nCPAP was 13.3% which is comparable to the Indian study where mortality rate was 12.2%[19]. Most of our deaths were among premature babies with RDS. Kamath et al highlighted the same facts in

their study published in 2011 where nCPAP failure was most commonly seen in babies who were premature and had severe RDS especially when they were not given surfactant[20]. In our cohort, one patient died while being on nCPAP while other five died after they were placed on mechanical ventilation. Mortality rate on mechanical ventilation after nCPAP failure was high in our study. In our study, 13 patients got mechanical ventilation and out of them 5 patients died resulting in a mortality rate of 38.46% among ventilated patients. Koyamaibole et al[18] described mortality rate as high as 66.7% in patients placed on mechanical ventilation after nCPAP failure. Saxena et al[19] described a mortality rate of 18.75% among neonates who were ventilated after nCPAP failure. Saxena et al gave surfactant to 39.76% of their neonates before placing them on ventilator resulting in better survival as compared to our study. We were able to provide surfactant to 21.42% of patients.

CONCLUSION

Nasal CPAP is effective in reducing the need for mechanical ventilation in neonates with respiratory distress and can be used as first line respiratory support between nasal oxygen and mechanical ventilation. However, it also has its own complications and it is preferable to have back up mechanical ventilation for patients who fail nCPAP trial.

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