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Correlational Study for Predictor Variables Affecting Duration on Bubble CPAP

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The Master's Thesis Advisory Committee, as representatives of the faculty, certify that this thesis has met all standards of excellence and scholarship as determined by the faculty.

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CORRELATIONAL STUDY FOR PREDICTOR VARIABLES AFFECTING DURATION ON BUBBLE CPAP

By

ALISON LOUISE STOERI, BS, RRT-NPS

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ABSTRACT

CORRELATIONAL STUDY FOR PREDICTOR VARIABLES AFFECTING DURATION ON BUBBLE CPAP

By

Alison L. Stoeri, BS, RRT-NPS

Bubble CPAP (BCPAP) is used in the neonatal intensive care unit (NICU) as a form of non-invasive ventilation and is commonly employed in neonates demonstrating respiratory distress. BCPAP may be used to avoid the need for intubation and mechanical ventilation thereby reducing lung injury and other morbidities as well as decrease hospital stay. PURPOSE: The purpose of this study is to retrospectively investigate the length of stay on bubble CPAP (BCPAP) considering gestational age, birth weight, and surfactant delivery in the neonatal population born at an urban tertiary high load level three (NICU). METHODS: A retrospective study using existing data from an urban tertiary high load level three NICU was completed. DATA ANALYSIS: Data analysis was performed using SPSS 16.0. Descriptive statistics were run for each variable. Contingency tables were run to determine if gestational age at birth, birth weight, and length of time on BCPAP had significance compared to surfactant delivery. Intercorrelations were run to determine if gestational age at birth, birth weight, and length of time on BCPAP had an effect on each other. Davis conventions were used to analyze the results. RESULTS: Descriptive statistics indicated the mean gestational age at birth to be 32.263 weeks, SD = ±2.978, mean neonatal weight to be 1.899 kg, SD = ±0.728, and mean length of time on BCPAP to be 124.430 hours, SD = ±185.474. Contingency statistics showed a substantial association ($r_{eta} = 0.562$) between the gestational age at birth and surfactant delivery, a very strong association ($r_{eta} = 1.000$) between the birth weight and surfactant delivery, and a very strong association ($r_{eta} = 0.914$) between the length of time the neonate was on BCPAP and surfactant delivery. Pearson product-moment correlation coefficients showed gestational age at birth had a very strong positive association with birth weight ($r = 0.811$, $p < 0.01$) and a moderate negative association with length of time on BCPAP ($r = -0.439$, $p < 0.01$). Intercorrelations also showed birth weight had a moderate negative association with length of time on BCPAP ($r = -0.306$, $p < 0.01$). CONCLUSIONS: The neonate was less likely to receive surfactant if, their gestational age was older at birth, they had a heavier birth weight, and their length of time on BCPCP was shorter. The data also demonstrated that the older the neonate's gestational age at birth and the heavier the neonatal birth weight equated to a shorter length of time on BCPAP. Lastly the data demonstrated that the heavier the neonate's birth weight, the shorter length of time on BCPAP.

TABLE OF CONTENTS

CHAPTER I

Introduction

Oxygen therapy is often used to treat or relieve the effects of respiratory distress in patients who suffer from respiratory disorders. It also increases the oxygen supply to the lungs and to the body tissues of a patient who may have respiratory problems. Oxygenation may also be achieved through mechanical ventilation (Tecklin, 2007).

Mechanical ventilation is defined as the method used to mechanically assist or replace spontaneous breathing in patients who have problems breathing on their own. Mechanical ventilation was first discovered and utilized by Vesalius, who used a reed inserted into the trachea of animals to describe the process (Tecklin, 2007). Modern mechanical ventilation was, however, pioneered by George Poe through his experimentation with oxygen cylinders and tubing connected to suffocated rats (1908).

During mechanical ventilation, a tube is inserted into the mouth or through the nose, bypassing the vocal cords going directly into the trachea but not past the carina. This endotracheal or nasotracheal tube is attached to a breathing circuit that is then connected to a mechanical ventilator for positive pressure ventilation (PPV). During PPV the mechanical ventilator delivers set tidal volumes or pressures at a set rate per minute. This is achieved by setting the parameters of the mechanical ventilator in an appropriate mode to fit each patient’s ventilatory needs.

There are many types of mechanical ventilator modes. Some of the most commonly used modes are: controlled mechanical ventilation (CMV), assist control (A/C), and synchronized intermittent mechanical ventilation (SIMV). Typically, when patients are first placed on the ventilator, the CMV mode is used to allow the patient to rest and get accustomed to the ventilator assuming all the responsibility of breathing for the patient. The CMV mode delivers a set amount of breaths to the patient. A typical disadvantage of the CMV mode, if not correctly set, finds the patient fighting against the ventilator if he/she is not adequately sedated.

The A/C mode also delivers a set number of breaths, but the patient may trigger additional identical breath if he/she feels the need. The A/C mode helps the patient feel more comfortable and lessens fighting against the ventilator as in the CMV mode. One disadvantage of the A/C mode is that it may lead to a respiratory alkalosis if the patient begins to take too many additional breathes.

If respiratory alkalosis occurs, this is an indication to switch the patient to SIMV mode of ventilation which is often used to wean the patient. In SIMV mode the patient also receives a set number of breathes. However, the difference between A/C and SIMV is that in A/C the additional breathes the patient triggers are all at the set volume or pressure, which is much higher than the patient would spontaneously breathe. This process may lead to too much carbon dioxide removal. In SIMV, the patient only receives the set number of breaths. Any additional breaths they want to take are done so spontaneously, so the patient does not get another identical breath as in AC mode. That breath will often be accompanied by pressure support, but it allows the patient to assume some of the work of breathing.

A person on AC, for example, will be set at 12 breaths per minute and each breath whether part of the 12 or triggered by the patient is set to a tidal volume of 600 mL. This means, for each additional breath the patient takes, he/she still receives 600 mL. A patient in SIMV with the same set 12 breathes per minute and a 600 mL tidal volume may take another breath, but the patient will not be guaranteed 600 mL in the additional breaths; instead he/she may only get 400 mL or whatever his/her respiratory muscles can handle. If the patient has week respiratory muscles (i.e. diaphragm) his/her spontaneous breath will be lower than someone with stronger respiratory muscles. Pressure support may be added to the spontaneous breaths to help the patient reach a target tidal volume and not to overly exhaust his/her muscles.

The addition of pressure support in the SIMV mode helps the patient overcome the resistance of the endotracheal tube, thereby decreasing the work of breathing, and also allowing the patient to assume some degree of responsibility. Pressure support is different from other modes in that it is used during spontaneous breathing only. Pressure support is often instituted during mechanical ventilation to enhance spontaneous breathing during SIMV or may be used alone to facilitate weaning from the ventilator. Each of the previous approaches are then achieved by setting parameters on the ventilator for each mode.

The parameters that can be applied to each mode are either volume control (VC) or pressure control (PC). During VC there is a set volume the patient must receive allowing the pressure it takes to get to that volume to vary. This can be dangerous when the patient's compliance decreases and the pressures go above a certain level. In these circumstances it is generally good practice to switch over to PC. During pressure control, a set pressure is delivered to the patient's lungs, resulting in varying volume delivery. This helps in patients with decreased lung compliance such as those with acute respiratory distress syndrome (ARDS) or infants with respiratory distress syndrome (RDS). In these patients the low volumes help prevent barotraumas, an adverse effect of controlled mechanical ventilation from dangerously high pressures. Each patient's ideal pressures and volumes must be taken into consideration.

There are still many considerations and discrepancies as to what the ideal volumes and pressures are for each of the adult, pediatric, and neonatal populations. Adult and pediatric patients are often ventilated at 8-10 ml/kg of ideal body weight. It is essential to use ideal body weight since the size of the lungs does not change with an overweight or underweight person. For example, if a patient's ideal body weight is 70kg; he/she would receive a set tidal volume (Vt) of 560-700ml per breath. A neonate may be ventilated anywhere from 4-10ml/kg as there is much variability in ventilator settings in this population driven by a number of considerations. How a neonate is ventilated depends on the underlying pathology. Additional considerations for mechanically ventilated neonates include barotraumas or volutraumas, particularly in patients with extremely non-compliant or underdeveloped/hypoplastic lungs. It is important not to cause more damage since this population goes through several developmental stages in utero and if born prematurely, complete development has not occurred.

The stages of human lung development cause a number of factors to be considered when treating or ventilating a neonate. Human lung development goes through several stages including the pseudoglandular stage (5-17 weeks) where the diaphragm, conduction airways, mucus glands and goblet cells, columnar and cuboidal epithelia develop and the nasal cavity separates from the nasopharynx. The canalicular stage (16-26 weeks) where there is enlargement of the airways, circulation, and gas exchange unit's takes place. Meconium is present in the bowel in this stage as well as breathing movements with elastic lung tissue develop. Type one and two pneumocytes develop into immature surfactant and cuboidal and squamous epithelia continue to develop. The saccular (24-36 weeks) and alveolar (36 weeks to 2 years) stages are where primitive alveoli form and the fetal lungs take up approximately 2-3% of total weight. Surfactant matures and capillaries grow closer to the alveoli. This is important since surfactant lowers the surface tension in the alveoli allowing them to open more easily and to stay open. The closer the capillaries, the better the oxygen exchange between the alveoli and the bloodstream, thus improving oxygen delivery to the tissues. There are 25-75 million alveoli at birth, and they continue to multiply to 800 million in early adolescence (Whitaker, 2001). If any of these stages do not take place, severe underdevelopment occurs. For example, a neonate born at 26 weeks gestation will not have developed alveoli or mature surfactant.

Neonates that are born prematurely have underdeveloped lungs and lack sufficient surfactant, which often leads to respiratory distress syndrome (RDS). RDS is the leading cause of morbidity and mortality in this premature population where the incidence and severity of RDS is inversely proportional to gestational age (Sinha et al., 2008). The chief pathology is a deficiency of surfactant, which leads to higher surface tension at the alveolar surface and interferes with normal exchange of respiratory gases. Due to this pathology , a number of anatomical abnormalities may occur including, increased alveolar-capillary membrane permeability and thickness, decreased lung compliance, increased resistance, increased work of breathing, ventilation/perfusion mismatch, and impaired gas exchange (Sinha and Donn, 2006). The symptoms include tachypnea, grunting, nasal flaring, retractions, and an increased work of breathing, distinguished by the use of accessory muscles.

If RDS is not treated, or if the neonate does not respond acceptably and needs mechanical ventilation and oxygen therapy for extended periods, bronchopulmonary dysplasia may occur. Bronchopulmonary dysplasia (BPD) is a complex pulmonary disorder characterized by lung inflammation and injury leading to abnormal repair mechanisms and arrested lung development or decreased alveolarization (Polin and Sahni, 2002). Many times these neonates develop ventilator-induced lung injury, frequently as a result of high pressures. BPD and chronic lung disease (CLD) often result from mechanical ventilation and the need for extended oxygen therapy greater than 28-30 days. Thirty to forty percent develop one of these disorders, sometimes severe enough to interfere with normal growth and development (Sinha and Donn, 2006).

Mechanical ventilation in neonates was first conducted in 1959. Since its inception, it has been noted that infant mortality due to respiratory problems such as RDS has been greatly reduced. However, the use of mechanical ventilation has been discredited with being responsible (in part) for the development of morbidity in neonates, in particular BPD (Tecklin, 2007). Van Marter et al. (2000) showed intubation and mechanical ventilation to be the single most important predictor of BPD.

Since mechanical ventilation is thought to be the most important predictor of BPD, other treatment avenues should be explored. Developed by Professor Colin Sullivan in Royal Prince Alfred Hospital, Sydney (1971), the Continuous Positive

Airway Pressure (CPAP) system was specifically meant to treat sleep apnea. The goal of CPAP is to prevent atelectasis and airway closure. CPAP may also help reduce ventilator-induced injury and other morbidities, as well as decrease hospital stay (Polin and Sahni, 2002). In neonates, it is sometimes used to treat apnea due to prematurity. Initially, continuous positive airway pressure machines were developed to help treat apnea in patients at home but are now used in many hospitals. More specifically CPAP is used in intensive care and high dependency units as a form of respiratory ventilation that increases functional residual capacity (Paoli, 2008).

Physiological beneficial effects of CPAP include the following: increased functional residual capacity and transpulmonary pressure, decreased pulmonary vascular resistance and intrapulmonary shunt, increased static compliance and PaO2, and decreased work of breathing and splinting of airway opening. Physiological risks include air leak syndromes such as pneumothorax, pneumomediastinum, or pulmonary interstitial emphysema. High CPAP levels may decrease compliance, increase work of breathing, decrease venous return and consequently cause a decrease in cardiac output. Urine output and renal clearance could also be decreased due to reflex secretion of antidiuretic hormone (ADH) and increased levels of aldosterone (Polin and Sahni 2002).

An ideal CPAP delivery system should include a patient-system that is easily and rapidly applicable, readily removable, re-connectable, non-traumatic, capable of producing stable pressures at the desired levels, has the capacity to be connected to humidification and supplementary oxygen systems, has low resistance to breathing, minimal dead space, easily understood and maintained, readily sterilizable, safe, and cost effective (Polin and Sahni, 2002). There are several types of CPAP systems, including those that are ventilator-derived. In ventilator initiated CPAP, an infant flow driver is utilized where gas flows into the CPAP device directly, as a result, changing the pressure. Underwater bubble CPAP is where a tube is placed underwater to create a back-pressure and oscillatory effect in the lungs. Several different methods are used to deliver CPAP with various advantages and disadvantages. The most commonly used methods are the endotracheal tube, nasal prongs (one or two), nasopharyngeal tube (one or two), mask, or head box. Appropriately fitting nasal prongs are the most common method of CPAP delivery.

Underwater bubble CPAP (BCPAP) is emerging as one of the safest ways to employ CPAP. During bubble CPAP, the expiratory limb of the CPAP circuit vents through an underwater seal resulting in bubbles that create pressure oscillations similar to those produced by high-frequency ventilation. These vibrations are then transmitted back to the airway opening (Pillow, 2007). BCPAP has a strong advantage in that it is relatively simple and inexpensive. Another advantage is that if there is inadequate pressure owing to a large leak, the bubbling will stop (Paoli, Morley, and Davis 2003).

Avery et al. (1987) found a significantly lower incidence of BPD at Columbia University compared to other American centers, because they use CPAP, thus avoiding intubation. Studies by De Klerk and De Klerk (2001) show that animal and neonates who receive early nasal continuous positive airway pressure (NCPAP) have shown promising results in terms of reduction of lung injury, need for mechanical ventilation, and incidence of BPD. However, Plumm et al. (2006) and Lagercrantz (2007) have shown that the use of NCPAP as an alternative mode of mechanical ventilation has similar risks in terms of development of BPD. These discrepancies may be due to staff knowledge of CPAP implementation at each institution.

Purpose of the Study

The purpose of this study was to retrospectively investigate the length of stay on bubble CPAP (BCPAP) considering gestational age, birth weight, and surfactant delivery in the neonatal population born at an urban tertiary high load level three neonatal intensive care unit. Bubble CPAP is often used as a means to avoid mechanical ventilation, however, guidelines as to the most optimal variables are to predict length on BCPAP have yet to be determined. The desired outcome of this study is to increase awareness of these parameters and to aid in determining the ideal neonatal populations that are successful with the implementation of BCPAP.

The following research questions were addressed to guide the acquisition of data required to satisfy the requirements of the purpose/statement of the problem.

1. What was the neonate's gestational age?
2. What was the neonate's birth weight?
3. What was the neonate's length of stay on bubble CPAP?
4. Does gestational age at birth have an effect on whether or not the neonate receives surfactant?
5. Does birth weight have an effect on whether or not the neonate receives surfactant?

6. Does the length of time on BCPAP have an effect on whether or not the neonate receives surfactant?

7. Does gestational age have an effect on length on bubble CPAP?

8. Does birth weight have an effect on length on bubble CPAP?

9. Does gestational age have an effect on birth weight?

Significance of study

This study is significant in that it may identify the types of neonates that are most likely to have success on bubble CPAP. This study may also identify certain variables that may be predictors of failure or success and optimize patient value. These results can be generalized to the neonatal population who receive bubble CPAP at the institution studied.

Definition of words and terms

Length of stay: The duration of stay at the same hospital from birth to discharge.

Length on BCPAP: The length of time the neonate is on BCPAP, whether continual duration or split into different times.

Failure rates: If the neonate is put on bubble CPAP and must then be intubated and put on mechanical ventilation, or death. Reasons to intubate and start mechanical ventilation are often a $PaCO_2 \geq 60$ mmHg, a $FiO_2 \geq 0.6$ to maintain acceptable oxygen saturation, and persistent serious apneic episodes.

Weight ranges:

Extremely low birth weight defined as less than 1000g at birth

Very low birth weight defined as less than 1500g at birth

Low birth weight defined as less than 2500g at birth

Delimitations

This study includes a population of neonates between October 1, 2007 and April 1, 2009. The results of this study can only be generalized to this group of neonates.

Although these limiting factors are considered outside the control of the researcher, it is important to recognize each one in order to effectively evaluate the significance of this study. These limitations are not only present in the research setting, but are also limiting factors in the clinical setting.

Assumptions

The intention of this study is to prove that the older the neonatal gestational age, the shorter the time on BCPAP. This is assumed due to further development and lung maturity of the lungs in this population. Heavier neonates may also have a shorter time on BCPAP, because this type of neonate has more body fat and is usually farther along in gestational age and maturity. Two neonates at the same gestational age but different weights will have varying outcomes; where as the heavier neonate may have a shorter duration on BCPAP compared to a smaller or lighter neonate. Two neonates that weigh the same but have different gestational ages will have different outcomes in that the older neonate will have shorter durations on BCPAP compared to the younger neonate at the same weight due to lung maturity.

It is also assumed that neonates that were intubated and given surfactant will have a lower surface tension leading to shorter durations on BCPAP. In these populations the neonates are generally smaller and less mature, so the time on bubble CPAP may be just as long as older and heavier neonates, however, the length of intervention may be longer than the older or heavier neonate.

CHAPTER II

Review of Literature

Continuous positive airway pressure (CPAP) is commonly used to prevent intubation and mechanical ventilation. The beneficial effects of CPAP result from splinting the airways, enhancing lung expansion, promoting increased residual lung volume, preventing alveolar collapse, preserving endogenous surfactant, reducing ventilation/perfusion mismatch, improving oxygenation, improving lung compliance, reducing airway resistance, reducing the work of breathing, and stabilizing the respiratory pattern (Morley, 1999). At present, CPAP is commonly employed on patients with mild to chronic respiratory failure. Its function has been effective in neonates early after birth. For neonates with respiratory disorders, CPAP has been known to have an almost instant effect in managing symptoms, sometimes symptoms are alleviated after a single days use. If a response is not prompt, further use of CPAP may be required (Paoli, 2008).

Avery et al. (1987) conducted research to determine if there are differences between medical centers regarding the occurrence of chronic lung disease due to prematurity when birth weight, race, and sex are evaluated. Caucasian male infants with birth weights between 700 and 1500 grams were used in the survey with the hypothesis that chronic lung disease in these infants would be more common in certain institutions than others. The results showed there was little discrepancy in survival rates between centers, but there was a large difference in chronic lung disease at Columbia University. This was possibly due to the institution of CPAP immediately after birth in all infants showing respiratory distress instead of intubation. Researchers believe the use of CPAP lessened injuries to the lungs of neonates such as barotraumas or volutraumas, which often leads to further complications. Successes and positive outcomes were directly related to the experiences of professional staff members in delivering this therapy appropriately.

Pillow et al. (2007) evaluated differences in gas exchange and lung injury from respiratory distress with either bubble CPAP (BCPAP) or constant pressure CPAP (CP-CPAP) in intubated newborn, preterm lambs. Two groups in each category were evaluated; one receiving the CPAP at 8 LPM and the other at 12 LPM, there was a total of 4 groups. The authors hypothesized that in the newborn lung lacking surfactant, the BCPAP would increase alveolar recruitment leading to increased volume compared to the CP-CPAP. The results showed that BCPAP encouraged progressive arterial oxygen levels and increased oxygen extraction which showed lower $PaCO_2$ levels. Furthermore, premature lung volumes were promptly stabilized at lower pressures used with BCPAP while also reducing alveolar protein levels compared with CP-CPAP. Researchers contemplated this may decrease the likelihood of chronic lung disease (CLD) or lung injury but needs to be further examined. One limitation of this study was in using a cuffed tracheal tube to deliver the CPAP instead of the usual nasal prong; however, they still believe the findings were relevant.

In addition, Koyamaibole et al. (2005) studied all neonates admitted to the NICU 18 months before and 18 months after the implementation of bubble-CPAP use in that hospital. The first period before bubble-CPAP use was from September 1, 2001 to May 14, 2003, while the second period after bubble-CPAP introduction was from May 15, 2003 to August 30, 2004. There were a total of 1,152 infants in the study. The hypotheses were that bubble-CPAP would decrease the need for mechanical ventilation, create fewer complications and be less costly. Bubble-CPAP produced a 50% reduction in the need for mechanical ventilation; however, there was no change in mortality rate. There were several limiting factors since this study was not a randomized trial; nevertheless, the researchers noted that bubble-CPAP is an efficacious intervention that should be implemented in developing countries due to the significant cost effectiveness.

This literature review will offer a subjective comparison of this mode of mechanical ventilation, specifically continuous positive airway pressure, and more specifically bubble CPAP in treating neonatal respiratory disorders. It will focus on distinguishing gestational age, and weight differences among neonates. This review will focus on outcomes such as length of stay, need for extended oxygen therapy such as CPAP, and failure rates leading to intubation and mechanical ventilation.

Research studies dedicated to this review on neonates were limited due to the rather sensitive nature of human bodies at this life stage, hence most of the literature as referenced relates to a pediatric setting. Resources for the review were derived from *Public/Publisher MEDLINE (PubMed), CINHAL, Official Journal of the American Academy of Pediatrics* and independent sources and texts.

Continuous Positive Airway Pressure (CPAP)

Gestational age and weight differences

A study conducted by Plumm et al. (2001) indicated that there was no major difference in the baseline characteristics of neonatal groups with respect to gestational age and weight. About 6 % of neonates with birth weights below 1500 g who were treated early with continuous positive airway pressure needed mechanical ventilation within the first two hours of life.

Aly, Patel and El-Mohandes (2005) conducted a retrospective stratified cohort study involving 234 very low birth weight (VLBW) preterm, hospital born neonates. Results showed neonates who were briefly intubated and then extubated to CPAP were at an increased risk for extended oxygen requirement, while those who failed CPAP were at an increased risk for developing necrotizing enterocolitis.

Ammari et al. (2005) carried out a retrospective analysis of 261 neonates weighing ≤ 1250 grams (VLBW) between June, 1999 , and July, 2002, to determine which variables differentiate those who succeeded versus failed on CPAP, and whether it can be predicted which neonates were likely to fail CPAP. Of the 229 neonates started on CPAP, 174 (76%) were successful and 55 (24%) required intubation after 72 hours. Only 32 (12%) were started on mechanical ventilation. Post menstrual age (PMA) and neonate's small for their gestational age (SGA) had significantly increased risk for CPAP failure. Although, none had a positive predicted value above 55%, meaning they were poor predictors of CPAP failure. Overall, successful neonates on CPAP were on average 3 gestational weeks older and weighed 300 grams more. The researchers agreed that part of the difficulty in predicting failure was due to the difficulty in diagnosing severity of RDS at birth.

Polin and Sahni (2002) compared CPAP delivery devices from several studies and multiple different centers throughout the world while contrasting them to the original Columbia University formative studies. The writers concluded neonates weighing more than 1000g had significant improvement using just CPAP while 75% of infants under 750g needed mechanical ventilation.

Morley et al. (2008) performed a randomized trial to test whether nasal CPAP was superior to intubation and ventilation directly after birth in 610 preterm neonates of 25-28 gestational weeks of age. After 28 days, the results showed there was little variation in the general mortality of the neonates. However, of the survivors, those on CPAP required less need for oxygen and had fewer days of overall ventilation.

Sinha, Gupta, and Donn (2007) evaluated several different studies using CPAP, intubation and mechanical ventilation, and surfactant. The authors stated the frequency and severity of RDS was inversely proportional to the gestational age of the neonate. Many were put on mechanical ventilation and of those, 30-40% developed chronic lung disease (CLD). The authors noted that neonates born after 28 weeks did well on CPAP and surfactant if needed, however those under 28 weeks required mechanical ventilation. In addition, the authors felt early use of CPAP and surfactant may have a synergistic effect when used together, because CPAP seems to conserve the existing surfactant. This in turn reduces morbidities, with the exception of BPD.

BUBBLE CPAP

Gestational age and weight differences

Chan and Chan (2007) studied short term outcomes of 80 premature neonates supported on CPAP with a birth weight of less than 1500g. Neonates born between October, 2000, and March, 2002, (period 1) were compared to neonates born between October, 2002, and March, 2004, (period 2). The neonates in period 1 were treated with ventilator CPAP, while the neonates in period 2 were treated with bubble CPAP. The aim of the study was to evaluate respiratory outcomes with the hypothesis that bubble CPAP would create less apnea post extubation and improved non-respiratory outcomes. The results were separated into two birth weights of <1499g VLBW and <1000g extremely low birth weight (ELBW). There was no increased incidence of intraventricular hemorrhage (IVH) or CLD on BCPAP with less apnea as well, although these neonates were on BCPAP longer than ventilator CPAP. There was also no increase in non-respiratory morbidities with BCPAP, and 33% of the VLBW neonates were successful with BCPAP alone. Most were initially intubated before receiving CPAP which could have skewed results, so the scientists agreed a study with more samples would be needed to determine long term effects.

Lee et al. (1998) performed a prospective randomized crossover study on ten neonates weighing between 750-2000g at a gestational age between 28-34 weeks. The neonates were diagnosed with wet lung or RDS and were put on either bubble CPAP or ventilator-derived CPAP to determine differential outcomes. The hypothesis was that the bubbles from the bubble CPAP would create vibrations similar to high-frequency ventilation, thus improving gas exchange. The results showed all neonates on bubble CPAP had a lower minute volume and respiratory rate when compared to ventilator-derived CPAP, although there was no difference in transcutaneous partial pressure of CO_2 (alveolar ventilation) or O_2 saturation. It was suspected the decrease in the minute volume and respiratory rate lead to a decreased work of breathing and fatigue for the neonate to keep the same degree of gas exchange. However, the researchers were not able to measure the tidal volumes, compliance or resistance accurately, thus, not allowing for valid conclusions about the effects on the work of breathing.

Narendran et al. (2003) compared the outcomes of all neonates between 401 and 1000g (ELBW) splitting them into two groups of which period 1 were historic controls and period 2 neonates which were placed on bubble CPAP in the delivery room. The researcher's hypothesized that the early introduction of bubble CPAP would result in improved respiratory outcomes. The hypotheses verified that days on mechanical ventilation, delivery room intubations, and use of postnatal steroids were all significantly decreased, while days on CPAP and weight of neonates after 36 weeks increased. There was also no increase in complications and no neonate in period 2 developed a pneumothorax. The researchers speculated that since CPAP is not invasive, there was a much lower risk of infection which may contribute to the lower incidence of CLD.

Conclusion

Much research has been done on continuous positive airway pressure in helping prevent intubation and mechanical ventilation. This has been mostly achieved by increasing the neonates FRC, thus improving the work of breathing and oxygenation. It is known that prevalence and severity of RDS was inversely proportional to the gestational age, implying the lower the gestational age, the more severe the syndrome and the more likely neonatal failure. Research also established that the lower the birth weight and/or gestational age, the higher the failure rate and the longer the need for supplemental therapies such as CPAP, surfactant delivery, oxygen therapy, and perhaps mechanical ventilation. Research revealed that the earlier the initiation of CPAP the less likely the neonate was to be intubated and mechanically ventilated, however this population was on CPAP longer. When the neonate is put on CPAP instead of mechanical ventilation, there is less potential for introduction of bacteria into the lungs; therefore those on CPAP had a lower incidence of infection. Research also suggests there is no increase in likelihood of BPD or CLD, and in fact the rates might be decreased, although more research needed to be conducted in this area. Lastly some research showed there was no difference in mortality of neonates on CPAP versus those on mechanical ventilation, but of the survivors, those on CPAP required supplemental therapies for shorter periods than those on mechanical ventilation.

The introduction of continuous positive airway pressure in 1981 improved the treatment of neonatal respiratory distress syndrome. CPAP is a less invasive technique that if employed early has many beneficial outcomes. There are many types of CPAP and different ways of producing the required pressure; however, bubble CPAP is a valuable way of employing continuous positive airway pressure, because it is relatively simple and inexpensive. Many hospitals can benefit from the use of BCPAP due to the simplicity and ease of training personnel to correctly apply it. Hospitals will also benefit because it is cost effective, thereby benefiting the institution financially.

CHAPTER III

Methodology

The study performed is a retrospective study using existing data from an urban tertiary high load level three neonatal intensive care unit (NICU). The data will be used to answer the preset research questions.

Population

The subjects used were neonates from an urban tertiary high load level three neonatal intensive care unit between October 5, 2007, and March 28, 2009. The patients for this study will be a cross section of different weights and ages that will be utilized to compute statistics and answer preset research question. Data was collected from 1256 patient's charts from the above dates and 180 met the inclusion criterion. The inclusion criterions were as follows: Neonates born at the hospital where research was being conducted and placement on bubble CPAP at some point in time during their stay at that hospital. Neonates that were excluded were those that left the hospital for surgeries and then returned and those that were intubated and mechanically ventilated.

Instrumentation

The researcher performed all data collection for this project. The researcher collected the data from computer charts at the urban tertiary high load level three NICU. Data was collected as part of documentation files in the computerized charting database utilized by the hospital and all identifiable markers were removed. Approval was granted by the Institutional Review Board and a data agreement was received from the hospital where research was done.

The researcher met with the major professor and discussed what they wanted to look at based on past research. All possible variables were discussed and critiqued. Each was listed as a final product in Appendix A. Variables used included birth weight, gestational age, actual age at time of intervention, surfactant use, and length of time on BCPAP. It was assumed that surfactant use meant the neonate was first intubated to instill the treatment. An instrument was developed to collect information from the computerized charting database where as the medical record number was replaced with a code that could not be traced back to any specific individual. The research instrument included the following variables: birth weight, actual weight at time of intervention, gestational age, actual age at time of intervention, surfactant use, and mechanical ventilation use.

Once the instrument was developed, it was checked for variability by a major professor in the Respiratory Care Program. To ensure reliability of measure, the instrument was used on a selected group of patients. This patient group was checked again by the director of the Respiratory Care Department at the urban tertiary high load level three NICU to make sure that what was recorded on each instrument matched that in the patient files. After the researcher met with the director, he ran a formula to gather the data in the computerized charting database to extract the information for 25% of the data, make sure it would be reliable, and answer what we wanted. Once we were able to do that, 18 months of this data were run. A report was generated from Puritan Bennett's Clinivision mobile patient charting software, identifiable markers were blacked-out for the researcher, and a copy was kept at the urban tertiary high load level three NICU. The patients were selected by chart review from April 1, 2009, backwards to October 1, 2007.

There were a total of 1,256 patients used, and 180 were included in this study. Inclusion criterion was specifically bubble CPAP where the patient was placed on bubble CPAP at some point in time during his/her stay in the NICU. Exclusion criterion included those that were intubated and mechanically ventilated, those that were not born at that hospital, and those that were transported out for surgeries and perhaps later returned. The patient's variables were recorded and placed into the instrument for further evaluation and analysis.

Data Analysis

All statistical analyses were run using SPSS 16.0 statistical software. Descriptive statistics were calculated for each variable. The magnitude of correlations between variables was interpreted using the Davis conventions (Davis, 1971).

Coefficient	**Description**
.70 or higher	Very strong association
.50 to .69	Substantial association
.30 to .49	Moderate association
.10 to .29	Low association
.01 to .09	Negligible association

Person Product Moment correlation coefficients were calculated for all ratio data. Eta correlation coefficients were used for calculations made between ratio and nominal data. There data were placed into the tables by a brief narrative.

CHAPTER IV

Results

The purpose of this study was to retrospectively investigate the length of stay on bubble CPAP (BCPAP) considering gestational age, birth weight, and surfactant delivery in the neonatal population born at an urban tertiary high load level three neonatal intensive care unit between October 1, 2007, and April 1, 2009. This research study explored correlations between each variable to increase awareness of these parameters and to aid in determining the ideal neonatal populations that are successful with the implementation of BCPAP.

Descriptive Data

Gestational age at birth, birth weight, and length of time on BCPAP data was presented in Table 1. One hundred eighty neonatal charts were included in this study. The mean gestational age of these neonates was 32.263 weeks at birth, with a standard deviation of 2.978. The mean birth weight of these neonates was 1.899 kg with a standard deviation of 0.728. The mean length of time on BCPAP of 124.43 hours with a standard deviation of 185.474 hours showing large variances in length of time in this study.

Table I. Gestational age at birth, birth weight, and length of time on BCPAP (n=180)

	Minimum	Maximum	Mean	Std. Deviation
Gestational age at birth (weeks)	25.714	40.000	32.263	2.978
Birth weight (kg)	.670	4.340	1.899	.728

Length of time on BCPAP (hours)	2	1018	124.430	185.474

Correlations

Intercorrelations were presented in table II. According to the Davis conventions, gestational age at birth had a very strong positive association with birth weight ($r = 0.811$, $p < 0.01$) and a moderate negative association with length of time on BCPAP ($r = -0.439$,

Table II. Intercorrelations (n = 180)

		Gestational age at birth	Birth weight	Length of time on BCPAP
Gestational age at birth	Pearson Correlation	1	$.811^{**}$	$-.439^{**}$
	Sig. (2-tailed)		.000	.000
Birth weight	Pearson Correlation	$.811^{**}$	1	$-.306^{**}$
	Sig. (2-tailed)	.000		.000
Length of time on BCPAP	Pearson Correlation	$-.439^{**}$	$-.306^{**}$	1
	Sig. (2-tailed)	.000	.000	

Note: All coefficients were Pearson product-moment correlations. **. Correlation was significant at the 0.01 level (2-tailed).	

$p < 0.01$). The older the neonate's gestational age at birth, the heavier the neonatal birth weight. The older the neonate's gestational age at birth the shorter the length of time on BCPAP. Using the Davis conventions, birth weight had a moderate negative association with length of time on BCPAP ($r = -0.306$, $p < 0.01$), meaning the heavier the neonate's birth weight, the shorter length of time on BCPAP.

According to the Davis conventions, there was a substantial association ($r_{eta} = 0.562$) between the gestational age at birth and surfactant delivery. As indicated, the further along or older the gestational age at birth, the less likely that neonate was to receive surfactant delivery.

According to the Davis conventions, there was a very strong association ($r_{eta} = 1.000$) between the birth weight and surfactant delivery. As indicated, the heavier the neonate at birth, the less likely that neonate was to receive surfactant delivery.

According to the Davis conventions, there was a very strong association ($r_{eta} = 0.914$) between the length of time the neonate was on BCPAP and surfactant delivery. As indicated, the shorter the duration on BCPAP, the less likely that neonate was to receive surfactant delivery.

CHAPTER V

Discussion

Respiratory distress syndrome (RDS) is the leading cause of morbidity and mortality in the premature neonatal population. Therefore it is crucial to find the most effective and efficient techniques to treat this population suffering from RDS and other forms of respiratory distress. Bubble CPAP has often been employed as a safe, efficient and effective way of applying non-invasive ventilation. It is used to avoid the need for intubation and mechanical ventilation thereby reducing lung injury and other morbidities as well as decreasing hospital stays.

The focus of this study was to investigate the length of stay on bubble CPAP (BCPAP) considering gestational age, birth weight, and surfactant delivery in the neonatal population. The mean neonatal gestational age was slightly over 32 weeks. This demonstrated that the population of neonates that were most often put on BCPAP were premature, however, not extremely premature. This indicated that the younger gestational age neonates either failed BCPAP or were not even candidates and had to be intubated and mechanically ventilated directly or soon after birth. This also indicated that the term neonates have little to no problem with respiratory distress and may simply require oxygen therapy without positive pressure. The mean birth weight was just shy of 2 kg indicating smaller neonates benefited from BCPAP without being considered very low or extremely low birth weight. Those neonates had little if any fat on their body and were generally less developed internally, meaning they needed more advanced interventions than BCPAP. The mean length of time on BCPAP was about 125 hours or 5 days. This indicated the neonate needed several days to recruit enough alveoli to keep his/her oxygenation levels satisfactory before being well enough to wean off. The standard deviation was large however signifying some neonates responded right away, while others took much longer, maybe even weeks.

Determination of surfactant delivery was evaluated by looking at several different variables and how each affected whether or not the neonate received this therapy. Interestingly, only about 10% of the neonates in this study received surfactant. This indicates BCPAP as being a possible alternative method of increasing the neonatal oxygenation status therefore decreasing respiratory distress. Since BCPAP increases FRC, surfactant may not always be necessary if successful on BCPAP, however if the response is questionable, surfactant may then be considered. The results displayed that the older the gestational age at birth, the less likely the neonate was to receive surfactant delivery. This was most likely due to a more maturely developed neonate which means that neonate had the time in utero to develop enough natural surfactant. The results also demonstrated that the heavier the neonate, the less likely he/she was to receive surfactant delivery. This was most likely due to the neonate being older therefore having more natural surfactant in his/her body. They also show that the shorter length of time spent on BCPAP, the less likely that neonate was to receive surfactant delivery. It can be assumed that the neonates that appear to be failing BCPAP may receive the surfactant delivery as another attempt to keep him/her off the mechanical ventilator. Neonates that only spend a short time on the BCPAP would probably not get surfactant delivery, because they may respond positively to the BCPAP alone and not need further intervention.

Length of time on BCPAP was evaluated by looking at numerous different variables and how each one influenced the time on BCPAP. The data showed that the older the neonate's gestational age at birth, the heavier the neonatal birth weight and the shorter length of time on BCPAP. This is most likely due to neonatal development. It is indicated that since the neonate was further along in development, he/she should require less intervention. The older the gestational age at birth, the more natural surfactant the neonate should have which should lead to a larger FRC and the easier it should be for the neonate to keep satisfactory oxygenation levels leading to less respiratory distress. Lastly the data demonstrated that the heavier the neonate's birth weight, the shorter length of time on BCPAP which can also be due to a further developed neonate with more natural surfactant and the likelihood of respiratory distress to be smaller.

While this study showed heavier and older neonates spent less time on BCPAP, several other studies found contradicting evidence. Plumm et al. (2001) indicated that there was no major difference in the baseline characteristics of neonatal groups with respect to gestational age and weight while Ammari et al. (2005) showed successful neonates on CPAP were on average 3 gestational weeks older and weighed 300 grams more. Polin and Sahni (2002) concluded neonates weighing more than 1000g showed significant improvement using just CPAP while 75% of infants under 750g needed mechanical ventilation.

Bubble CPAP is commonly employed directly or soon after birth and might or might not have an instant effect in terms of improvement. This may be due to varying apparatus's and interfaces used at each institution, or due to the training of the staff in the use of BCPAP. Avery et al. (1987) found successes and positive outcomes were directly related to the experiences of professional staff members in delivering this therapy appropriately. Positive outcomes could be hindered if the staff doesn't properly fit the interface to the neonates face, or if the most beneficial amount of pressure is not utilized on each neonate. Staff at the hospital where this study was conducted were trained extensively about the use of their BCPAP and how to determine success and failure or if adjustments were needed.

This study was done at a hospital where the only form of non-invasive CPAP is BCPAP. This could be due to the studies showing BCPAP to be more beneficial than other forms of CPAP as well as more cost effective. Pillow et al. (2007) evaluated differences in gas exchange and lung injury from respiratory distress with either bubble CPAP (BCPAP) or constant pressure CPAP (CP-CPAP) in intubated newborn, preterm lambs. The results showed that BCPAP encouraged progressive arterial oxygen levels and increased oxygen extraction which showed lower $PaCO_2$ levels. Furthermore, premature lung volumes were promptly stabilized at lower pressures used with BCPAP while also reducing alveolar protein levels compared with CP-CPAP. In addition, Koyamaibole et al. (2005) studied all neonates admitted to the NICU 18 months before and 18 months after the implementation of bubble-CPAP use in that hospital and results showed BCPAP produced a 50% reduction in the need for mechanical ventilation.

There have been several studies comparing ventilator-derived CPAP and BCPAP although, most of them compared specific weight classes or gestational age ranges. Chan and Chan (2007) showed there was no increase incidence of intraventricular hemorrhage (IVH) or CLD on BCPAP with less apnea as well. There was also no increase in non-respiratory morbidities with BCPAP, and many neonates were successful with BCPAP alone. Lee et al. (1998) showed all neonates on bubble CPAP had a lower minute volume and respiratory rate when compared to ventilator-derived CPAP. Narendran et al. (2003)

showed that the early introduction of bubble CPAP resulted in improved respiratory outcomes. Perhaps all of these were due to the non-invasiveness of BCPAP, and the pressure fluctuations allowed by the BCPAP helped decrease the work of breathing in each neonate therefore leading to fewer incidences of CLD and BPD.

Significant limitations were considered in this current study. Neonates born of different race as well as different genetic make-up might have affected the outcome of this study. Socioeconomic status and access to prenatal care or lack thereof might have affected the care the neonate received before birth. A mother's well being, such as low BMI, maternal/gestational diabetes, or other complications the mother was experiencing might also have affected how the neonate responded to extra-uterine life. Lastly, neonates that failed CPAP or had to be mechanically ventilated as well as those that had surgery were excluded which might have skewed results.

Recommendations for future research

Future research in the area of non-invasive ventilation in the neonatal population should be conducted. Forms of non-invasive ventilation such as BCPAP are very cost-effective and the potential for introducing harmful bacteria into the lungs from intubation is reduced greatly. A controlled, randomized in vivo study should be conducted on all weights and gestational ages taking into account several variables. Variables that should be looked at are: how surfactant or aerosol treatments affect the response to BCPAP, how different ethnicities and genders respond to BCPAP could be beneficial in determining if some are more likely to fail to succeed, and how the neonates of mothers with various health problems such as pregnancy induced hypertension or diabetes respond to BCPAP may be useful to look at too.

BCPAP has several different interfaces that can be applied to the neonate. Evaluation of how each interface affects pressures, oxygen carbon dioxide levels, and work of breathing could be valuable for each institution in determining the most effective device. Lastly, different brands of BCPAP should be evaluated to determine which is readily and easily understood and applied by the practitioner as well as most efficient, and effective.

Conclusion

Current studies on BCPAP are limited and this study along with others should improve the respiratory care in the neonatal population. This study should bring awareness to the need of more research on non-invasive ventilation and the variables affecting outcomes. According to this study, birth weight, gestational age at birth, and surfactant delivery all affect the length of time on BCPAP. It is hoped that further research will be conducted in order to provide clinicians with the comprehensive knowledge needed to provide neonatal patients suffering from respiratory distress with care that is safe and effective.

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Appendix A

INSTRUMENTATION

Code: ________________________

Gestational age at birth: ________________________________

Weight at birth: _______________________________________

Length of time on BCPAP: ____________________________

Given surfactant? Yes No

→ It is assumed the neonate was intubated to receive this treatment