Neonatal Nursing Education Brief: Bubble CPAP - Continuous Positive Airway Pressure
https://www.seattlechildrens.org/healthcare-professionals/education/continuing-medical-nursing-education/neonatal-nursing-education-briefs/
Bubble CPAP is a gentle, non-invasive form of respiratory support. It has been shown to be safe and effective. When used immediately after birth, it can help avoid intubation and mechanical ventilation. There are several benefits of Bubble CPAP, including the production of wave like oscillations that can mitigate surfactant deficiency and respiratory distress syndrome.
NICU, CPAP, Bubble CPAP, continuous positive airway pressure, RDS

Bubble CPAP - Continuous Positive Airway Pressure

Purpose and Goal: CNEP # 2117

- Learn about CPAP use in the NICU
- Learn about the benefits of Bubble CPAP use in preterm infants

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Requirements for successful completion:

- Successfully complete the post-test
- Complete the evaluation form

Date

- November 2019 – November 2021

Learning Objectives

- Describe the risks of surfactant deficiency in the neonate
- Describe the advantages of using Bubble CPAP in the NICU
- Describe 2 strategies to avoid nasal trauma from CPAP

Introduction

- Nasal CPAP is commonly used in the NICU
- CPAP is a mode of mechanical ventilation
    - It can minimize neonatal lung injury
    - While promoting physiologic stability
- CPAP works by delivering continuous
    - Air and oxygen
    - Distending pressures
- It is increasingly used for respiratory support
    - CPAP stents open the airways
    - And reduces work of breathing

Development of the Respiratory System

- Fetal lung development is divided into 5 stages
    - The embryonic stage
        - 0 - 7 weeks gestation
    - The pseudoglandular stage
        - 7 - 17 weeks gestation
    - The canalicular stage

        - 17 - 27 weeks gestation
    - The saccular stage
        - 28 - 36 weeks gestation
    - The alveolar stage
        - 36 weeks gestation - 2 years
- The embryonic stage is characterized by:
    - Formation of the trachea
    - Development of mainstem bronchi
    - Development of pulmonary arteries
- The pseudoglandular stage is characterized by:
    - Differentiation of airways
        - Into conducting bronchioles
        - Into terminal bronchioles
    - Proliferation of pulmonary vasculature
- The canalicular stage is characterized by:
    - Formation of distal airways
    - Secretion of surfactant into alveoli
        - At 24 weeks gestation
- The saccular stage is characterized by:
    - Increasing surface area for gas exchange
    - Formation of capillary air-blood interface
- The alveolar stage is characterized by:
    - Formation of alveoli
    - Maturation of alveoli
    - Multiplication of alveoli
- Functional immaturity of the lungs
    - Is dependent on gestational age at birth
    - Because surfactant production
        - Is often not initiated
        - And generally not mature enough
        - To support extrauterine life
            - Without mechanical support
            - Until 32-36 weeks gestation

- Surfactant is a mixture of several substances
    - Protein
    - Phopho-lipids
    - Neutral lipids
- Surfactant lowers the surface tension
    - At the air-liquid alveoli interface
    - And prevents alveolar collapse
- Therefore, infants <32 weeks gestation
    - Have the highest risk of surfactant deficiency
    - Have the highest risk of respiratory distress
    - Have the highest risk of developing co-morbidities
        - BPD
        - ROP
        - IVH

Transition to Extrauterine Life

- Transition from fetal to neonatal life
    - Is a complex process
    - That involves physiologic changes
- Most term infants have a smooth transition
- Most premature infants are at a disadvantage
- Premature infants <32 weeks gestation
    - Are generally unprepared to handle
    - The physiologic demands of extrauterine life
- Alveolar instability and collapse are common
- Instability and collapse can cause
    - Impaired oxygenation
    - Decreased functional residual capacity
    - Hypoxemia
    - Respiratory distress
- Globally, over 13 million preterm infants

    - <37 weeks gestation
    - Are born each year
- In the USA, preterm birth rates remain high
    - Over 400,000 infants
    - Are born <37 weeks every year
- Preterm infant mortality and morbidity
    - Are directly proportional
    - To gestational age at birth
- Efforts to reduce mortality and morbidity
    - Begin immediately after birth
    - And start with respiratory support
- Supportive respiratory measures are indicated
    - To support immature lungs
    - To establish physiologic stability
- Supportive measures may include
    - CPAP
    - Endotracheal intubation
    - Mechanical ventilation
- CPAP is a mode of ventilation that is
    - Gentle
    - Non-invasive
    - Well studied
- It can help mitigate the effects of lung immaturity
    - By minimizing lung injury
    - And improving long-term outcomes

Continuous Positive Airway Pressure

- Historically, mechanical ventilation
- Was used to oxygenate and ventilate infants
- Over time, it was discovered that ventilation
    - Caused volutrauma in infants

        - Caused barotrauma in infants
        - Increased morbidity and mortality
- Respiratory support strategies shifted
    - From invasive strategies
    - To non-invasive strategies
- CPAP was first recognized in 1971
- An initial CPAP trial met with success
    - Administered via endotracheal tube
    - Outcome: 16 out of 20 infants survived
- CPAP is a form of continuous distending pressure
- There are two main types of CPAP in use:
    - Continuous Flow
        - Conventional CPAP
        - Bubble CPAP
    - Variable Flow
        - Infant Flow Driven
        - Nasal-Jet Driven
- Continuous Flow CPAP
    - The flow of gas is fixed
    - The flow of gas is constant
    - In Conventional CPAP
        - Gas flows into the circuit
        - And into an exhalation valve
        - Which opens alternatively
        - To a set ventilator pressure
    - In Bubble CPAP
        - Gas flows into the circuit
        - And into a submerged expiratory limb
        - To a set water pressure
- Variable Flow CPAP
    - The flow of gas is inconsistent
    - In Infant Flow Driven CPAP
        - An infant flow driver

        - Adjusts to the gas flow
        - During the respiratory cycle
        - While the gas flow is altered
        - The set pressure is constant
    - In Nasal-Jet CPAP
        - The system tubing
        - Is attached to a generator
        - That adjusts the gas flow
            - Based on sensed pressure
            - Based on airway resistance
- Multiple benefits of Bubble CPAP have been shown

Bubble Continuous Positive Airway Pressure

- Bubble CPAP was first introduced in 1975
- Bubble CPAP is a gas flow mixture
    - That is warmed and humidified
    - And flows from a wall to the infant
- It is administered via mask or nasal prongs
- The expiratory limb of the system
    - Is submerged in a sterile water chamber
    - At the desired depth in centimeters
    - That produces positive end expiratory pressure
- The oxygen flow rate ranges from 5-10 L/minute
    - And adjusted until gaseous bubbling is seen
    - The higher the flow → the more bubbling
    - The higher the flow → the higher the pressure
- The gas flow rate is an important variable
    - Fixed CPAP flow rates
    - Provide more effective pressures
- The bubbling provides a unique oscillation
    - Via the submersion in sterile water

        - Of the expiratory limb of the system
- The oscillations have been found to:
    - Produce vibrations
    - That simulate waveforms
        - That improve gas exchange
        - That improve CO2 elimination
        - That work via facilitated diffusion
- The oscillations are an important feature
    - That distinguish Bubble CPAP
    - From other forms of CPAP
- Multiple Bubble CPAP studies have shown:
    - Lower oxygen requirements
    - Minimal respiratory decompensation
    - Less need for mechanical ventilation
    - Fewer infants with chronic lung disease
    - And decreased length of NICU stays
- Bubble CPAP has also been shown to:
    - Be non-invasive
    - Be inexpensive
    - Be easy to use
- Several comparison studies have been done
    - That show improved outcomes
    - Using continuous Bubble CPAP
    - Versus mechanical ventilation
- In comparison to other forms of respiratory support
    - Bubble CPAP has been shown to:
        - Reduce alveolar structural damage
        - Reduce pulmonary edema
        - Reduce pulmonary inflammation
        - Reduce pulmonary fibrosis
- These benefits are achieved by the oscillation
- Over time, Bubble CPAP results in:
    - Higher fluctuations of pressure

        - Higher fluctuations of frequency
        - Higher recruitment of atelectasis
        - Equitable distribution of gas transport
- Of note: the noise from Bubble CPAP
    - Has been shown to ↑ surfactant production

Physiological Effects of Bubble CPAP

- CPAP works on the continuous flow principle
- CPAP uses blended air and oxygen
    - That is heated and humidified
    - Then delivered via low resistance
    - Via nasal masks and nasal prongs
- The distal end of the expiratory tubing
    - Is submerged underwater
    - The delivered pressure
    - Equals the depth of submersion
- Varying the depth of the submersion
    - Changes the pressure delivered
- Bubbling and pressure will cease whenever
    - The interface is blocked
    - The interface is displaced
    - The infant stops breathing
- There are currently no alarms available
- Frequent intermittent checks are mandatory
- Bubble CPAP pressures depend on
    - The infant breathing through
    - The submerged expiratory tubing
- If the infant's mouth is open
    - Flow can leak
    - Causing a drop in pressure
- The physiologic effects of CPAP include:

        - Decreased upper airway occlusion
        - Decreased upper airway resistance
        - Increased diaphragmatic tone
        - Increased diaphragmatic contractility
        - Increased lung compliance
        - Decreased lower airway resistance
        - Increased tidal volume in stiff lungs
        - Improved ventilation and perfusion
        - Decreased oxygen requirement
        - Conservation of alveolar surfactant
        - Decreased pulmonary edema
- Bubble CPAP may prevent the need for intubation
    - When used immediately at birth
    - In late preterm and tern infants
    - And when used continuously in preterm infants
        - Until 32 weeks gestational age

Respiratory Support of Preterm Infants

- Mechanical ventilation is important
    - In the care of infants
    - With respiratory failure
- The goals of respiratory support are:
    - To maintain adequate gas exchange
    - To minimize the risks of lung injury
- There is a significant association between
    - Prolonged respiratory support
    - And bronchopulmonary dysplasia
    - And poor neurodevelopmental outcomes
- Providing Bubble CPAP at birth can help
- It is an effective non-invasive alternative option
    - In addition to intubation

        - As an alternative to intubation
- Many studies have shown improved oxygenation
- It is an excellent option for post-extubation care
    - It provides critical support
    - For in and out surfactant
    - For early elective extubation

Benefits of CPAP for Premature Infants

- The exact mechanism of how CPAP works
    - Is not entirely clear
    - The mechanism of action
        - Is multifactorial
- CPAP augments the driving pressure
    - Required to overcome
    - The elastic respiratory system
- CPAP changes the intra-pleural pressure
    - That affect respiratory muscles
    - And helps maintain lung volumes
- Several effects are subsequently noted
    - Increased pharyngeal area
    - Decreased airway resistance
    - Enhanced pulmonary compliance
- The end results of CPAP use include:
    - Reduction of work of breathing
    - Conservation of surfactant
        - On the alveolar surfaces
- In short, CPAP provides airway support
    - It stimulates the upper airways
    - It supports functional residual capacity
- Functional Residual Capacity
    - Is also known as FRC

        - FRC is the volume of air
        - Left in the lungs after expiration
- Supporting FRC mitigates surfactant deficiency
- Additionally, CPAP is beneficial for preterm infants
- The immature respiratory system
    - In preterm infants
    - In late preterm infants
    - Is characterized by instability
        - Unstable alveoli
        - Unstable chest wall
- The immature airways are prone to collapse
    - Which decreases FRC
    - Which leads to respiratory failure
- CPAP supports an infant's own efforts
    - To increase FRC
    - By increasing lung volumes
    - And stabilizing the chest wall
- CPAP also avoids side effects of intubation
    - Hemodynamic instability
    - Increased airway resistance
    - Ventilator induced lung injury
    - Acute and chronic airway trauma
    - Increased risk of lung infections
    - Reduced clearance of secretions

Strategies to Reduce Incidence of Injury

- Nasal septal abrasion and erosion
    - Are common side effects of CPAP
- Risk factors for nasal trauma include:
    - CPAP >5 days
    - Gestational age <32 weeks

        - Birthweight <1500 grams
        - Use of incorrect size of interface
- Prevention of nasal septal breakdown
    - Starts with correctly fitting equipment
    - Head size should be measured
        - To ensure correct hat choices
    - Nasal sizing guides should be used
        - To ensure correct prong choice
    - Equipment should be snug but not tight
- There are several strategies that can help
    - Frequent assessment every 3-6 hours
        - Check for decreased perfusion
        - Check nares for pressure areas
        - Check for blanching or excoriation
    - Correct fitting snug equipment
        - Hats
        - Masks
        - Prongs
    - Use Duoderm for protection
        - Or other hydrocolloid dressing
            - Exuderm
            - Replicare
            - Mepilex
        - To provide cushioning
        - To protect nares and philtrum
    - Remove CPAP and check skin every 3-6 hours
        - Brief assessments only
        - Not intended for entire cares
        - Not intended for long periods
    - Rotate between masks and prongs regularly
        - To offload pressure points
        - Around nares and philtrum
    - Choose a size that doesn’t cause blanching

        - Massage nasal septum area during cares
            - To increase blood circulation
        - Use one size larger mask if needed
            - To allow skin to rest
            - To allow tissue healing
        - Maintain a gap of at least 2 mm
            - Between the septum and prongs
            - To avoid blanching, pinching, necrosis
        - Consider using bacitracin ointment
            - To lower WBC counts
            - To improve healing to abrasions
- Infants should be repositioned regularly
    - To avoid pain
    - To avoid discomfort
- Hourly observation is recommended
    - With direct assessments with hands-on cares

Assessing for CPAP Related Nasal Injury

- Routine screening for nasal injury is critical
- There are several main areas of focus
    - Tip of nose
    - Nasal septum
    - Nostrils
    - Nose shape
- All areas should be assessed for injuries
- Tip of nose
    - Normal
    - Reddened
    - Red and indented
    - Red/indented/skin breakdown
    - All above + tissue loss

- Nasal septum
    - Normal
    - Reddened
    - Red and indented
    - Red/indented/skin breakdown
    - All above plus tissue loss
- Nostrils
    - Normal
    - Enlarged
    - Enlarged and prong shaped
    - Red and bleeding
    - As above + tissue loss
- Nose shape
    - Normal
    - Pushed up but normal
    - Pushed up and shortened
        - No return to normal
        - When prongs removed

Summary

- Bubble CPAP is increasingly used in the NICU
    - It has been shown to provide safe
    - It has been shown to provide effective care
- Bubble CPAP provides gentle non-invasive support
- It produces waves similar to oscillation
    - Which facilitate lung recruitment
- Hands on care and familiarity with CPAP
    - Increases the likelihood of success
- It’s effectiveness depends on:
    - Pressure generation
    - Type of nasal interface

- Excellent nursing care

References

Welty, S.E. 2016. Continuous Positive Airway Pressure Strategies with Bubble Nasal Continuous Positive Airway Pressure. Not All Bubbling is the Same: The Seattle Positive Airway System. Clinics in Perinatology, 43, p. 661-671.

Gupta, S. & Donn, S.M. 2016. Contiguous Positive Airway Pressure: To Bubble or Not to Bubble? Clinics in Perinatology, 43, p. 647-659.

Gupta, S. & Donn, S.M. 2016. Continuous Positive Airway Pressure: Physiology and Comparison of Devices. Seminars in Fetal & Neonatal Medicine, 21, p. 204-211.

Casey, J.L., Newberry, D., and Jnah, A., 2016. Early Bubble Continuous Positive Airway Pressure: Investigating Interprofessional Best Practices for the NICU Team. Neonatal Network, 35 (3), p. 133.

Garg, S. & Sinha, S. 2013. Non-Invasive Ventilation in Premature Infants: Based on Evidence or Habit. Journal of Clinical Neonatology, 2 (4), p. 155-159.

Buzzella, B., Claure, N., D'Ugard, C., and Bancalari, E. 2014. A Randomized Controlled Trial of Two Nasal Continuous Positive Airway Pressure Levels after Extubation in Preterm Infants. The Journal of Pediatrics, 164 (1), p. 46-51.

Alessi, S. 2018. Evidence Regarding the Use of Bubble Continuous Positive Airway Pressure in the Extremely Low Birth-Weight Infant. Advances in Neonatal Care, 18 (3), p. 199-207.

Tapia, J.L., Urzua, S., Bancalari, A, et al. 2011. Randomized Trial of Early Bubble Continuous Positive Airway Pressure for Very Low Birth Weight Infants. The Journal of Pediatrics, 161 (1), p. 75-80.

Nowadzky, T., Pantoja, A., and Britton, J.R. 2009. Bubble Continuous Positive Pressure Airway Pressure, A Potentially Better Practice, Reduces the Use of Mechanical Ventilation Among Very Low Birth Weight Infants With Respiratory Distress Syndrome. Pediatrics, 123 (6), p. 1534-1540.