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
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 term 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


