

## Management of Neonatal Patients

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This Presentation is Approved for  
1.5 CRCE Credit Hours

## Learning Objectives

- State the indications for supplemental oxygen therapy applied to neonates.
- Explain the complications of supplemental oxygen therapy applied to neonates.
- Select devices and settings of supplemental oxygen therapy applied to neonates.
- Apply subambient oxygen therapy to neonates.
- Select medications and devices for aerosol delivery to neonates.
- Describe the rationale and goals for environmental therapy for neonates.
- Apply environmental devices to neonates.
- Explain the goals and strategies of developmental care for neonates.

## Learning Objectives

- Select artificial airways for neonates
- Explain special considerations pertaining to intubation of neonates
- Explain the role of chest physiotherapy for neonates, as determined by research findings
- Explain the physiologic & adverse effects of continuous positive airway pressure (CPAP) for neonates
- Identify the indications & contraindications of CPAP for neonates
- Select CPAP generators & interfaces for neonates

## Learning Objectives

- Explain special considerations & technical issues for continuous mechanical ventilation (CMV) applied to neonates
- Compare CMV modes applied to neonates
- Outline procedures & ventilator control settings for application of CMV to neonates
- Implement liberation from CMV for neonates

## Oxygen Therapy

- Indication for newborn
  - ❖  $\text{PaO}_2 < 60$  mm Hg
  - ❖  $\text{SaO}_2 < 90\%$
  - ❖ Except in the presence of
    - Ductal dependent cardiac anomaly
    - Left-to-right anatomic shunt

## Oxygen Therapy

- Associated complications
  - ❖ Bronchopulmonary dysplasia (BPD)
  - ❖ Retinopathy of prematurity
  - ❖ Oxygen-induced hypoventilation
  - ❖ Closure of DA with ductal-dependent anomaly → sudden death

## Oxygen Therapy

- Requirements for newborns
  - ❖ Precise, low-flow delivery - term newborn inspiratory flow = 3 - 6 L/min
  - ❖ Appliances small enough to fit
  - ❖ Minimal deadspace
  - ❖ Minimal noise production
  - ❖ Oxygenation monitoring
    - PaO<sub>2</sub> < 80 torr
    - SpO<sub>2</sub> low 90s%

FYI see links below for an abstract about target SpO<sub>2</sub>

## Infant Oxygen Hood



## Oxygen Hood

- Infants
- FiO<sub>2</sub> up to 1.0
- Minimum flow = 7 L/min for CO<sub>2</sub> washout

## Oxygen Hood

- Equipment
  - ❖ Hood
    - Sized for infant
    - Disposable vs. non-disposable
  - ❖ Blender
  - ❖ Heated humidifier (NOT nebulizer) - maintain 32 - 34C
  - ❖ Thermometer
  - ❖ O<sub>2</sub> analyzer

## Oxygen Hood

- Nebulizer should be avoided due to
  - ❖ Infection
  - ❖ Noise
  - ❖ Bronchospasm
  - ❖ Reduced viscosity of secretions
  - ❖ Fluid overload

FYI see links below for AARC clinical practice guideline on O<sub>2</sub> for neonatal & pediatric patients

## Nasal Oxygen

- Cannula or catheter
  - ❖ 0.25 L/min →  $FiO_2 = 0.24 - 0.35$
  - ❖ Increments of 0.10 or 0.125 L/min
  - ❖ Never use adult range flowmeters

FYI see links below for infant Low Flow  $O_2$   $FiO_2$  calculator (see menu on left). Includes NICUTOOLS for mobile device.

## Subambient $O_2$ Therapy

- Goals
  - ❖ Increase pulmonary vascular resistance
  - ❖ Prevent closure of ductus arteriosus
- Indication: ductal dependent cardiac anomaly, e.g.
  - ❖ Transposition of great arteries
  - ❖ Tricuspid, mitral atresia

## Subambient $O_2$ Therapy

- Methods
  - ❖ Bleed-in nitrogen to ventilator circuit
  - ❖ Obtain premixed subambient mixture in cylinder
  - ❖ Titrate  $FiO_2$  to  $SaO_2$  80 - 85%
- Problem: some  $O_2$  analyzers may not measure subambient  $FO_2$

## Subambient $O_2$ Therapy

- $O_2$  analyzers that accurately measure  $FiO_2$  between 0.0 & 0.21
  - ❖ The Mini-OX III
  - ❖ Teledyne TED-190

## Aerosol Therapy

## Aerosolized Medications

- Bronchodilators - for reversible obstruction, e.g. BPD
  - ❖ Albuterol
  - ❖ Ipratropium
- Furosemide (Lasix)
  - ❖ Improves lung mechanics
  - ❖ No data on outcomes - trials are needed

## Aerosolized Medications

- Inhaled corticosteroids
  - ❖ Do not treat or prevent BPD
  - ❖ May benefit patients with meconium aspiration
  - ❖ Parenteral dexamethasone (Decadron) after week one may reduce risk for BPD
- Agents
  - ❖ Fluticasone (Flovent)
  - ❖ Budesonide (Pulmicort)

## Aerosolized Medications

- Surfactant
  - ❖ Lucinactant (Surfaxin)
  - ❖ FDA-approved in 2012
- Pulmonary vasodilators - replace nitric oxide for pulmonary hypertension
  - ❖ Epoprostenol (Flolan) - continuous administration
  - ❖ Iloprost (Ventavis) - longer acting, intermittent administration

## Aerosol Generators

- Nebulizer vs. metered dose inhaler (MDI)
  - ❖ Equal effectiveness for all patient groups
  - ❖ MDI more efficient, less expensive
  - ❖ Nebulizer necessary for medications that are not available as MDI
  - ❖ Infants cannot use dry-powder inhalers (DPI)

## Aerosol Generators

- Wire mesh nebulizer (Aeroneb™) - best for nebulization in ventilator circuits
- Metered dose inhaler
  - ❖ Valved holding chamber, e.g. Aerochamber
  - ❖ Tightly fitting mask

## Aerosol Delivery Interfaces

- Ventilator circuit
- Mask with valved spacer
- Hood - effective, efficient with nebulized medications
- Nasal prongs, mask? - needs study
- Blow-by - ineffective

## Environments

## Rationale for Environmental Control

- Birth is a traumatic event → post-traumatic stress disorder
- Immature organ systems
  - ❖ Thermoregulatory apparatus
  - ❖ Auditory, visual organs
  - ❖ Olfactory - odors are new experience
  - ❖ Central nervous system
  - ❖ Immune system
  - ❖ Epithelium - never been touched

## Rationale for Environmental Control

- Threats
  - ❖ Thermal stress
  - ❖ Light
  - ❖ Sound
  - ❖ Touch
  - ❖ Odors
  - ❖ Infection
  - ❖ Painful procedures - neonates are more sensitive to pain

## Goals for Environmental Control

- Foster physiologic & neurologic development
  - ❖ Protection from threats
  - ❖ Nutrition - weight gain

## Heat Exchange Mechanisms

- Conduction - surface contact
- Convection - fluid current
- Evaporation - water evaporation from skin
- Radiation - heat waves to or from distant object (hard to detect)

## Preventing Heat Exchange

- Neutral thermal environment
- Keep infant dry - first resuscitation step
- Insulate contact surfaces
- Keep covered, including the head
- Isolate from air currents
- High ambient humidity (swamp)

## Environmental Equipment

- Incubator functions
  - ❖ Isolate from infection, except when contaminated toys are present
  - ❖ Isolate from noise
  - ❖ Isolate from light (if covered)
  - ❖ Provide neutral thermal environment
  - ❖ Provide ambient humidity - prevents evaporative heat loss

## Infant Incubator



## Environmental Equipment

- Incubator precautions
  - ❖ Manipulation can generate serious noise
  - ❖ Always close the doors
  - ❖ Drawback: reduced access to infant
  - ❖ Temperature sensor for servo-controlled humidifier heaters must be outside the incubator

## Environmental Equipment

- Radiant warmers
  - ❖ Radiant heat
  - ❖ Good access to infant
  - ❖ Drawback: increased exposure
  - ❖ Need plastic cover

## Radiant Warmer



See links below to view GE Giraffe™ Omnibed

## Environmental Equipment

- Plastic wrap/bags
  - ❖ Effective, inexpensive
  - ❖ Prevent H<sub>2</sub>O & caloric loss from convection, evaporation
  - ❖ Should apply in delivery room so they are in place during transport

## Servo - Control

- Available for warmers & incubators
- Advantage: adjusts warming to skin temperature
- Precaution: improper placement of probe results in over-warming or under-warming

## Developmental Care

- Rationale: reduce external stimuli that cause
  - ❖ Intraventricular hemorrhage (IVH)
  - ❖ Abnormal neurologic development

## Developmental Care

- Components
  - ❖ Noise reduction
  - ❖ Light reduction
  - ❖ Minimal physical stimulation
  - ❖ Uninterrupted sleep
  - ❖ Behavior-based care: use cues from neonate guide timing of routine care

## Developmental Care

- Stimulation of infant avoided during
  - ❖ Sleep
  - ❖ Poor oxygenation
  - ❖ Inapproachability: gaze aversion, grimace
- Many premature newborns do not like to be touched

## But... Some Do



## Kangaroo Care

- Maternal-infant skin contact
  - ❖ For medically stable infants
  - ❖ Reduces crying in response to heel stick (pain reduction?)
  - ❖ Stabilizes temperature

See links below to view abstract on kangaroo care

## Developmental Care

- Music therapy
  - ❖ White noise to protect from NICU sounds
  - ❖ May reduce stress

## Developmental Care

- Music with kangaroo care reduces maternal anxiety (one small study)
- Aromatherapy - pleasant odor may decrease apneic episodes
- Research does not find consistent favorable outcomes for developmental care

## Airway Management

## Airways & Intubation

- Considerations for infants
  - ❖ Delicate mucosa - easily injured
  - ❖ Short, narrow trachea
  - ❖ Cords are anterior & cephalad
  - ❖ Reduced bronchial angle - left mainstem intubation likely

## Airways & Intubation

- Considerations for infants
  - ❖ Germinal teeth under gums - destroyed by trauma
  - ❖ Dominant vagal tone - strong response to airway stimulation - bradycardia

## Airways & Intubation

- Orotracheal, nasotracheal tubes-uncuffed
- Tube sizes
  - ❖ 2.0 - 2.5 < 1 kg
  - ❖ 3.0 for 1 - 2 kg
  - ❖ 3.5 for 2 - 3 kg
  - ❖ 3.5 - 4.0 term, appropriate weight for gestational age (AGA)

## Airways & Intubation

- Laryngoscope blades
  - ❖ 00 Miller for extremely low birthweight (ELBW) infants
  - ❖ 0 Miller for premies
  - ❖ 1 Miller for term newborns



## Airways & Intubation

- Strict caution if stylet is used with infants
- Do not hyperextend neck
- May require anticholinergic to block vagal reflex
- Little margin for error → secure tube firmly
- Small air leak is desirable → minimal pressure damage

## Suctioning Guidelines

- Suction only when needed
- Do not use saline routinely
- Do not turn head to suction
- Do not hyperventilate
- Preoxygenate only 10% - 15% above ventilator setting, unless severely hypoxemic, then use 100%

## Suctioning Guidelines

- Insert catheter only 1 cm beyond ETT tip
- Limit total suction time to 10 sec
- Limit vacuum levels: 50 - 75 mm Hg for infants
- Observe for
  - ❖ Bradycardia
  - ❖ Cyanosis

## Chest Physiotherapy

- Not indicated for routine care of neonates
  - ❖ There is no evidence of benefit
  - ❖ There is evidence that it harms neonates, e.g. intraventricular hemorrhage

## Continuous Positive Airway Pressure (CPAP)

## Definition & Rationale

- CPAP: application of positive pressure throughout ventilatory cycle during spontaneous breathing
- Rationale: maintain the patient's functional residual capacity & prevent airway closure, while avoiding adverse effects of invasive ventilation
- Note: continuous negative extrathoracic pressure is equally effective

See links below to view infant negative pressure ventilator

## Physiologic Effects

- Increases FRC
- Improves V/Q matching → reduces shunt
- Increases collateral ventilation
- Increases lung compliance (C<sub>L</sub>)
- Decreases work of breathing (WOB)
- May enhance surfactant production

## Adverse Effects

- Air leaks, e.g. pneumothorax
- May increase intracranial pressure (ICP)
- May increase right-to-left blood flow across persistent fetal shunts
- Does NOT decrease cardiac output (nCPAP)
- Skin, mucosa breakdown from interface

## Indications

- Respiratory distress syndrome (RDS)
- Apnea of prematurity
- Transient tachypnea of the newborn (TTN)
- Atelectasis
- Meconium aspiration
- Bronchopulmonary dysplasia
- Cardiogenic pulmonary edema
- Discontinuation of invasive ventilation

## Contraindications

- Cardiovascular instability
- Frequent apneic episodes, with desaturation & bradycardia
- Frank ventilatory failure
- Upper airway anomalies, e.g. cleft palate

## Outcomes

- Reduces ventilator days
- There are mixed results pertaining to CPAP and
  - ❖ The rate of BPD
  - ❖ Mortality
- Increased incidence of pneumothoraces compared to ventilation

## CPAP Generators

- Ventilator
- Bubble device
- Humidified high flow generator for nasal cannula (HHFNC)
- Dedicated CPAP device

## CPAP Generators

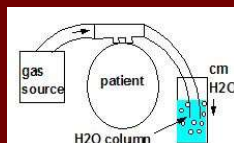
- > Ventilator
  - ❖ Advantages
    - Monitors
    - Graphics
    - Alarms
    - Measurement of lung mechanics
    - Capability of other modes - easy switchover

## CPAP Generators

- > Ventilator
  - ❖ Disadvantage: current ventilators are expensive
  - ❖ Administration of CPAP is a good reason to hang on to the old, time-cycled pressure ventilators

## CPAP Generators

- > Bubble CPAP device - exhalation directed through column of water



See links below to view Fisher-Paykel bubble CPAP

## CPAP Generators

- > Bubble CPAP device
  - ❖ Advantages
    - Device simplicity
    - Inexpensive
    - Bubbling may enhance gas exchange
  - ❖ Disadvantages
    - Increased WOB
    - Infection?

## CPAP Generators

- > Humidified high flow nasal cannula (HHFNC) - CPAP produced by flow
  - ❖ High flow = 4 - 6 L/min
  - ❖ Level of CPAP is determined by
    - Liter flow
    - Size of prongs
    - Size of the infant

## CPAP Generators

- > HHFNC
  - ❖ Advantages
    - Device simplicity
    - Less damage to nasal tissues
    - Cannulae are easier keep in position
  - ❖ Disadvantages
    - Inconsistent level of CPAP
    - Mixed data on effectiveness
  - ❖ Need randomized clinical trials

## CPAP Generators

- Dedicated CPAP device, e.g. Infant Flow™ NCPAP & SiPAP™
  - ❖ Fluidic controls
  - ❖ Advantages
    - Capable of CPAP & bilevel support
    - Less expensive than current ventilators
    - Compared favorably with Babylog™
    - Transportable
  - ❖ Disadvantage: availability of SiPAP?

See links below to view Infant Flow™ devices

## CPAP Interfaces

- Nasopharyngeal tube - least desirable
- Nasal prongs - most common
- Nasal cannula - for HHFNC
- Nasal mask - may reduce tissue damage
- Helmet

FYI see links below to download AARC  
Clinical Practice Guideline on CPAP for neonates

## CPAP Interfaces

- Helmet
  - ❖ Currently under study
  - ❖ Not FDA-approved
  - ❖ Reduces tissue damage
  - ❖ Decreases cerebral blood flow
  - ❖ Will not function with patient-triggered modes

See links below to view CPAP helmet

## Nasal Injuries

- Injuries can lead to significant physical abnormalities
- Injury types
  - ❖ Compressed nasal bridge
  - ❖ Asymmetric nares
  - ❖ Septal erosion
  - ❖ Keloid scarring

## Prevention of Nasal Injuries

- Remove Q4H to check skin
- Continually monitor positioning
- Alternate prongs with nasal mask
- Apply Duoderm™ over nose & philtrum
- Choose appropriate interface, size & hat

## CPAP Bottom Lines

- Strategy for RDS
  - ❖ Intubate
  - ❖ Surfactant
  - ❖ Extubate to nCPAP
- Favored interface - short nasal prongs
- Pacifier may help by reducing mouth-breathing
- Room air nasal cannula ineffective

FYI see links below to view abstract on room air cannula

## Mechanical Ventilation Basics

## Special Considerations

- Tracheal tubes
  - ❖ Uncuffed → leaks are likely
  - ❖ Small diameter → high resistance to flow

## Special Considerations

- Lung volumes (TV low as 0.005L)
  - ❖  $VD_{th}$  (dead space) not tolerated
  - ❖ Compressible gas volume is critical
  - ❖ Small leaks more critical (volume)

## Special Considerations

- Lung & chest wall mechanics
  - ❖ Low, rapidly changing  $C_L$
  - ❖ Small diameter of airways → high  $R_{AW}$  → low inspiratory flows ( $V_I$ )
  - ❖ High  $C_{TH}$  → lack of skeletal support in face of low  $C_L$  → retractions

## Complications of CMV

- Oxygen-related
  - ❖ Retinopathy of prematurity
  - ❖ Pulmonary oxygen toxicity → RDS
- Pressure-related (PIP, Ppt)
  - ❖ Pneumothorax, etc.
  - ❖ Pulmonary interstitial emphysema

## Complications of CMV

- Mean airway pressure - related
  - ❖ Reduced cardiac output
  - ❖ Reduced urinary output
  - ❖ Intraventricular hemorrhage
  - ❖ Necrotizing enterocolitis (NEC)
- Pressure-oxygen-time related - BPD

## Special Issues for Ventilators

- Triggering inspiration
  - ❖ Rapid rate → shorter  $T_{I}$ ,  $T_E$
  - ❖ Ventilator response time may exceed patient's inspiratory time
  - ❖ Late response to effort → asynchrony with ventilator

## Special Issues for Ventilators

- Complications of asynchrony
  - ❖ Barotrauma
  - ❖ Increased WOB
  - ❖ Maldistribution of ventilation → V/Q mismatch → hypoxemia
  - ❖ Increased ICP → IVH

## Special Issues for Ventilators

- Triggering mechanisms for selected ventilators
  - ❖ Pressure (obsolete)
  - ❖ Flow - all current ventilators
  - ❖ Motion-sensing (obsolete?)
    - Infant Star - abdominal motion
    - Sechrist IV 200 (SAVI) - thoracic impedance

## Special Issues for Ventilators

- Triggering mechanisms for selected ventilators
  - ❖ Diaphragmatic neurologic stimulation - Maquet Servo with neurally adjusted ventilatory assist (NAVA™)

## Pressure Targeted Ventilation

- Used in time-cycled, pressure-limited ventilation
- Most common because of
  - ❖ Cuffless tube
  - ❖ Lack of volume monitors
  - ❖ Simple, inexpensive ventilators

## Volume-Targeted Ventilation

- Requires precise  $TV_E$  monitoring
- Maintains  $V_E$  despite changing  $C_L$ ,  $R_{AW}$
- Trial (2008) - favorable long-term effects for VCV
- Trial (2009) -  $TV = 6$  mL/kg to reduce WOB
- Problems
  - ❖ Uncuffed tubes → leaks
  - ❖ Greater PIP

## Pressure Support Ventilation

- Overcomes work of breathing due to ETT
- Expiratory trigger adjustment important, due to ETT leak
- Useful in combination with SIMV

## Dual Control Modes

- Pressure control with volume guarantee (various names)
- Available on current ventilators
- Benefits
  - ❖ Volume ventilation
  - ❖ Reduced peak airway pressure
  - ❖ Square pressure wave form - increased mean airway pressure
  - ❖ Decelerating flow wave form

## Initiating & Maintaining Ventilation

- Initiation
  - ❖ Patient hand-bagged (not by a gorilla) to determine PIP, f
  - ❖ Placed on ventilator with same settings

## Initiating & Maintaining Ventilation

- Typical initial settings
  - ❖ PIP = 20 cm H<sub>2</sub>O or 6 mL/kg
  - ❖ TI = 0.3 sec
  - ❖ FiO<sub>2</sub> = for SPO<sub>2</sub> 85 - 90
  - ❖ VI = 5 - 8 L/min
  - ❖ f = 40/min
  - ❖ PEEP = 2 - 3 cm H<sub>2</sub>O (social PEEP)

## Ventilator Adjustments

- Ventilator settings titrated with
  - ❖ SpO<sub>2</sub>
  - ❖ Chest excursion
  - ❖ Lung sounds - air exchange
  - ❖ Visual evidence of increased WOB, e.g. retractions
  - ❖ Blood gases
  - ❖ Vital signs

## Control Over PaO<sub>2</sub>, SpO<sub>2</sub>

- FiO<sub>2</sub>
- P<sub>AW</sub>
  - ❖ EEP
  - ❖ TI → I:E
  - ❖ PIP or TV

## Controlling PaO<sub>2</sub> - VA

- ❖ Frequency (f)
- ❖ Tidal volume
- ❖ Δ P (PIP-EEP)
- ❖ Increasing EEP without increasing PIP → reduced TV → increased PaCO<sub>2</sub>
- ❖ Moderate hypercapnia permitted - permissive hypercapnea

## Weaning

- Protocol implemented by RT reduces ventilation time (2009)
- Controls usually are not weaned to zero before extubation → increased WOB through ETT
- FiO<sub>2</sub> reduced to < 0.4
- PIP reduced to nonhazardous level, e.g. 10 - 12

## Weaning

- Rate reduced to 8 - 12 BPM
- EEP never reduced to 0 before extubation
- Typical settings before extubation
  - ❖ PIP = < 12
  - ❖ EEP = 2 - 4
  - ❖ f = 10

See links below to view abstract on nCPAP levels after extubation

## Summary & Review

- Oxygen therapy
  - ❖ Requirements
  - ❖ Devices
  - ❖ Humidification
  - ❖ Subambient O<sub>2</sub>
- Aerosol therapy
  - ❖ Medications
  - ❖ Devices
  - ❖ Interfaces - no to blowby

## Summary & Review

- Environments
  - ❖ Threats from environment
  - ❖ Incubators
  - ❖ Warmers
  - ❖ Neurologic environment
- Airway management
  - ❖ Special considerations
  - ❖ Airway devices
  - ❖ Suctioning
  - ❖ CPT - NO

## Summary & Review

- CPAP
  - ❖ Indications, complications
  - ❖ Devices - pressure generators & interfaces
- Mechanical ventilation
  - ❖ Special considerations
  - ❖ Ventilation modes
  - ❖ Triggering mechanisms
  - ❖ Ventilator controls
  - ❖ Extubation



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