Neonatal Respiratory Support:
Who Needs What and When?

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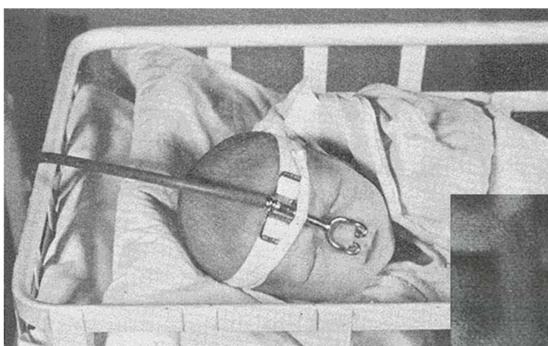
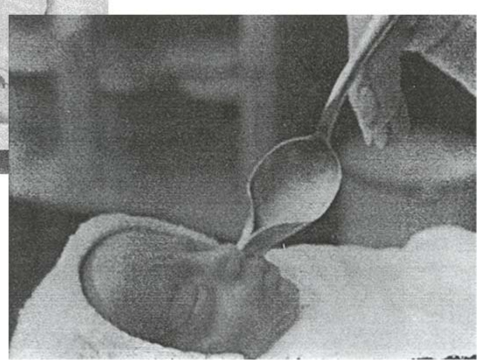
We've Come A Long Way…





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Changes

- Room air resuscitations with targeted O2 sats
- Permissive hypercapnia
- High flow nasal cannula (HFNC)
- Ventilatory modes
- Ventilator acquired pneumonia prevention (VAP)
- Suctioning techniques/frequency
- Prophylactic vs Rescue Surfactant

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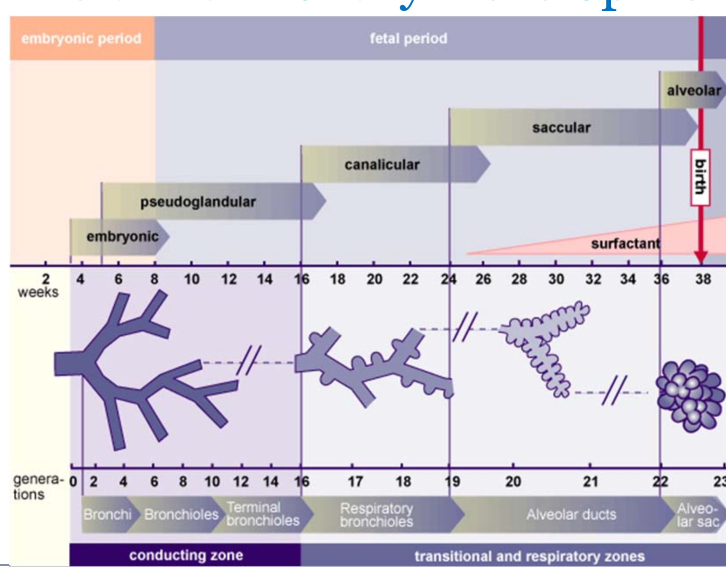
Fetal Pulmonary Development



http://www.embryology.ch/anglais/rrespiratory/phasen01.html

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Embryology of the Respiratory System

- Embryonic phase: (1 to 5 wks gestation)
  - Primitive lung bud appears by 24 days postconception
- Pseudoglandular phase: (6 to 16 wks)
  - Branching from main bronchus continues
  - Cartilage forms in trachea

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Embryology of the Respiratory System

- Late Pseudoglandular phase: (8 to10 wks)
  - Guts into abdomen
  - Pleuroperitoneal canal closes (diaphragm)

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Embryology of the Respiratory System

- Canalicular phase: (17 to 28 wks)
  - Critical period in lung development
  - Framework for gas exchange portion of lung is set
  - Type II endothelial cells appear. Major role in surfactant production
  - Surfactant not excreted into alveoli until 10 weeks later

Embryology of the Respiratory System

- Terminal sac phase: (26 to birth)
  - Mature, vascularized gas exchange sites form
  - Thinning interstitial tissue, capillaries move closer to saccules
  - Saccules can function for gas exchange
  - Type II cells begin to produce surfactant

Embryology of the Respiratory System

- Alveolar phase: (36 wks to 8 yrs)
  - All airway branching is complete
  - Epithelial tissue continues to thin out, bringing capillaries in closer contact with respiratory saccules
  - After birth, terminal airspaces increase in number from about 20 million to about 300 million total by age 8
  - Lung volume increases from about 200cc at birth to about 5.5 liters by age 25.
  - Good potential for lung growth postnatally

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Embryology of the Respiratory System

- No firm boundaries separating phases
- Gas exchange is possible fairly early in gestation, inefficient
- Pulmonary vascular development follows tissue development
  - Tissue differentiation into veins and arteries
  - Formation of capillary networks
  - Thinning of interstitium
  - Muscle layers increase in artery walls, control pulmonary vascular resistance
  - Later growth and development includes remodeling of arteries, changes in wall thickness and distribution of muscle within walls

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Fetal Pulmonary Vessels and Musculature

- Greater amount of smooth muscle compared to adults
  - Increases tone of vessels, increases resistance to flow
  - Muscle amounts decrease rapidly after birth, especially in first weeks of life. At adult amounts by 4 to 8 weeks.
  - Decrease in muscle aids in fall of pulmonary vascular resistance after birth

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Fetal Pulmonary Vessels and Musculature

- Constrictor response (reactivity) of smooth muscle is great
  - Hypoxemia triggers greatest response. Causes high PVR
  - Vessels are "twitchy": respond to small changes in paO_2 with marked vasoconstriction
  - Reactivity continues after birth, especially in term neonates

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Fetal Pulmonary Vessels and Musculature

- PVR increases with gestational age
- Vascular tone increases in late gestation
- In utero, pulmonary pressures are equivalent to systemic pressures

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Principles of Pulmonary Function

- Newborn susceptible to respiratory distress due to limits on respiratory system:
  - Ribcage not well ossified
  - Respiratory muscles have low endurance and strength
  - Floppy chest wall offers little resistance to collapse

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Weak Chest Wall

Principles of Pulmonary Function

- Surface tension
  - Opposes lung inflation, supports lung deflation
  - Depends on alveolar diameter
  - Smaller diameter requires higher pressures for inflation
  - Surfactant is phospholipid

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Principles of Pulmonary Function

- Compliance
  - Refers to elasticity or distensibility of lung
  - Expressed as change in volume caused by change in pressure
  - Higher compliance allows for larger volume to be delivered to alveoli per unit of pressure

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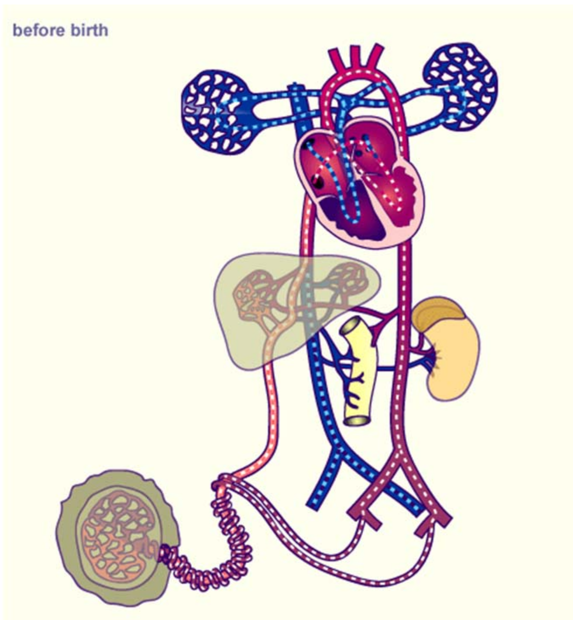
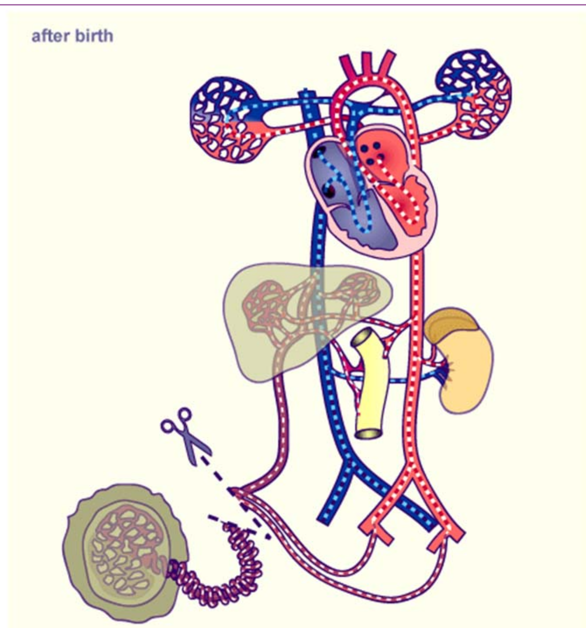


http://www.embryology.ch/anglais/pcardio/umstellung01.html

Fetal Circulation Review

- Characteristics of fetal circulation:
  - Gas exchange is liquid to liquid
  - Organ of respiration is placenta
    - High flow, low resistance
  - Fetal lungs
    - Low flow, high resistance
  - PA's constricted
  - High right heart and lung pressures
  - Low left heart pressures
  - Open fetal shunts



http://www.embryology.ch/anglais/pcardio/umstellung01.html

Transition Review

- At birth, infant must start using lungs for gas exchange
  - Respiratory movements initiated
    - Cold, chemoreceptors
  - Entry of air into lungs and expansion of alveoli
    - High opening pressures required
  - Establish FRC
    - Surfactant
  - Increase pulmonary blood flow and redistribute cardiac output
    - Clamping cord, removing low resistance placenta
    - Pulmonary blood flow goes from 10% to 100%

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Ventilatory Equipment in DR

- Mask
- Flow inflating bag
- T piece resuscitator
- Self inflating bag
- LMA

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Ventilatory Strategies in DR

- Sustained inflation
- Pressure and volume
- Oxygen
- CPAP
- Intubation
- Surfactant

- What does the literature show?
- Vaucher, Y. E., Peralta-Carcelen, M., Finer, N. N., Carlo, W. A., Gantz, M. G., Walsh, M. C., et al. (2012). Neurodevelopmental outcomes in the early CPAP and pulse oximetry trial. *The New England Journal of Medicine*,*367*(26), 2495-2504

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CPQCC: Optimizing Delivery Room Management

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CPQCC Initiative for Neonatal Resuscitation - Best Recommended Practices

- Use a Checklist to prepare for all High Risk Deliveries
- Improve Teamwork and communication in the delivery room using pre-briefings, looped communication, and debriefings
- Have a functioning pulse oximeter on and working by 2 minutes

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CPQCC Initiative for Neonatal Resuscitation

- Maintain normal temperatures – especially for the ELBW infant
- Optimize initial respiratory support using early CPAP, in an attempt to avoid early intubation and prophylactic surfactant

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Pulse Ox for Evaluation of Oxygenation

- Use as a tool to optimize oxygenation
- Should be on and functioning by 2 minutes of Life
- Necessary for managing SpO2 and FiO2
- Not as easy as it looks!

- Where should the pulse ox be placed?

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NRP Targeted O2 Sat Parameters

1 min	60-65%
2 min	65-70%
3 min	70-75%
4 min	75-80%
5 min	80-85%

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Room Air Resuscitation

- Not for all…
- Term vs VLBW
- Room Air vs 100% Oxygen for the VLBW Infant (Wang et al, Pediatrics 2008;121:1083-9)
- 30% vs 90% oxygen in DR for VLBW (Vento et al Pediatrics. 2009; 124(3):E439-E449)
- Vaucher, Y. E., Peralta-Carcelen, M., Finer, N. N., Carlo, W. A., Gantz, M. G., Walsh, M. C., et al. (2012). Neurodevelopmental outcomes in the early CPAP and pulse oximetry trial. *The New England Journal of Medicine*, *367*(26), 2495-2504.
- Where does the jury stand?

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2011 CPQCC Goals for Surfactant Replacement

- Measure: Infants receiving surfactant in the delivery room
- Goal: 0
- Why?
  - Attempt trial of CPAP
  - Have verification of ETT placement before instillation
  - Potential side effects of surfactant

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Surfactant: For Those Who Need It, The Earlier the Better

- Escobedo MB, Gunkel JH, Kennedy KA, et al. Early surfactant for neonates with mild to moderate respiratory distress syndrome: a multicenter, randomized trial. *J Pediatr. 2004;144(6):804-808.*
- Engle WA and the Committee on Fetus and Newborn. Surfactant-replacement therapy for respiratory distress in the preterm and term neonate. *Pediatrics*. 2008;121(2):419-432.

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Surfactant Dosing

- Infasurf 3 mL/kg
- Survanta 4 mL/kg
- Curosurf 2.5mL/kg

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Surfactant Therapy: Acute Complications

- Sudden deterioration of condition related to:
  - Pneumothorax
  - ETT-extubation, disconnection, plugging
  - Mechanical malfunction
  - Severe hypoxia

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Surfactant Therapy: Acute Complications

- Sudden deterioration of condition related to:
  - Increased intracranial pressure
  - Changes in cerebral blood flow if $PaCO_2$ decreases rapidly
  - Intraventricular hemorrhage and periventricular leukomalacia
  - Hypoxic-ischemic brain injury
  - Decreased cardiac output/hypotension

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Post Resuscitation Treatment Options

- Watch and wait
- Oxygen
- HFNC
- CPAP
- Intubation

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Oxygen

- Indications for
- Delivery options
- Special considerations
- Troubleshooting
- Weaning

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Why We Like Cannulas…

Oxygen-A Potent Drug

- Establish SpO2/PaO2 range
  - What is optimal? 88-92? 88-95?
  - What does the evidence show?

- Desaturation orders
- Avoid titrate orders
- Alarms

Oxygen Delivery Options

- BBO2
- Hood
- Nasal Cannula
- High Flow Nasal Cannula

- Weaning…

High Flow Nasal Cannula

- About
- Indications for
- Best candidates
- Special considerations
- Troubleshooting
- Weaning

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HFNC: About

- Nasal cannula that delivers heated and humidified "high flow" (>1 L/minute) with or without oxygen
- Used extensively for older children with viral respiratory infections
- Use in NICUs increasing due to:
  - Relative ease of use
  - Easier access to the baby's face
  - Less bulky
  - Less skin trauma than CPAP

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Heated High Flow Nasal Cannula (HHFNC)

- Pros:
  - Less skin and mucosal damage
  - Patients tend to tolerate better
  - Can start feeds on HFNC
- Cons:
  - Lack of randomized controlled trial to support use*
  - Inability to measure distending pressure

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(HHFNC) The Evidence

- Kubicka ZJ, Limauro J, Darnall RA. Heated, humidified high-flow nasal cannula therapy: yet another way to deliver continuous positive airway pressure? Pediatrics. 2008 Jan; 121(1):82-8.
- Shoemaker MT, Pierce MR, DiGeronimo RJ. High flow nasal cannula versus nasal CPAP for neonatal respiratory disease: a retrospective study. J Perinatol, 2007 Feb; 27 (2) : 85-91.
- University of Utah ongoing study comparing HHFNC to NCPAP with study completion summer 2013

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HFNC: Indications for

- RDS
- Apnea of prematurity
- Post extubation support
- To decrease WOB
- Weaning after CPAP

Special Considerations

- Circuit temperature
- Skin and mucosa
- Factors affecting delivered pressure:
  - Flow
  - Cannula size
  - Infant age
  - Any lung diseases present

Troubleshooting

- Hot circuit/ temperature alarms
- Increased respiratory distress/WOB
- Loss of flow
  - Nasal secretions
  - Obstruction
  - Disconnections/kinks

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Initial Settings @ UCSF

- Start 2-3 L
- Max of 5-6L
- Always start low and titrate up
- Consider CPAP when you get to 5 L

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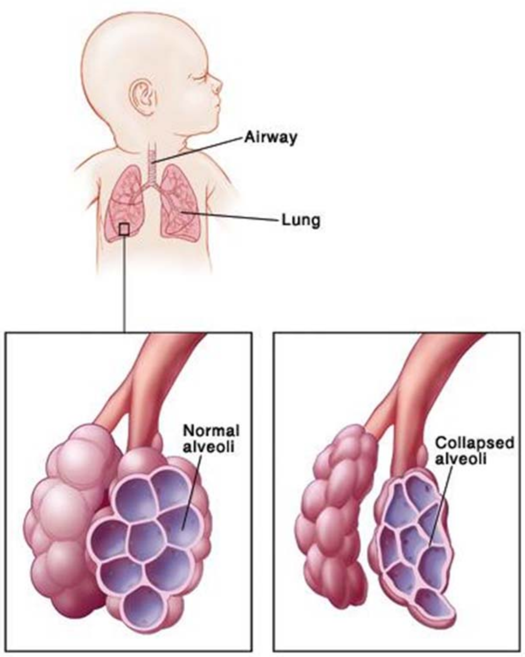
CPAP


Airway
Lung
Normal alveoli
Collapsed alveoli

CPAP History

- Positive Pressure Therapy was first used by Poultan and Oxan in 1936[1]
- Harrison[2] is credited to first recognize it in infants with RDS.
- In 1971, Gregory[3] used CPAP for the first time in neonates with RDS.
- Over the last 3 decades, several methods of applying CPAP have become routinely available

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CPAP Indications

- RDS
- Apnea of prematurity
- Treatment of hypoxemia
- Generalized Atelectasis
- Recent Extubation
- Pulmonary Edema
- Transient tachypnea
- Increased WOB
- Upper Airway Obstructions

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Why CPAP Works

- Increase FRC
- Reduce Work of Breathing
- Increase PaO2 with lower FIO2

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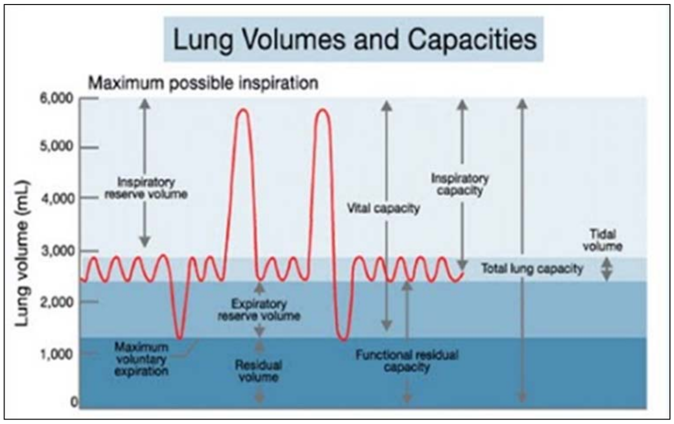
Balloons

Functional Residual Capacity (FRC)



PEEP helps…

- Establish FRC
  - Conserve Surfactant
- Thus reducing frequency and severity of RDS

Milner, A. (2001). The importance of ventilation to effective resuscitation in the term and preterm infant. Seminars In Neonatology, 6(3), 219-224. http://dx.doi.org/10.1053/siny.2001.0057

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Why NCPAP Works

- Airway and alveoli are splinted open in the premature infant. This improves FRC, V/Q matching, and prevents collapsing of the surfactant deficient alveoli
- Large internal diameter of the nasal prongs reduces flow resistance and WOB

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Why NCPAP Works

Reduces the need of intubation

- Facilitates normal mucociliary flow
- Lessen the possibility of airway injury due to secondary infections and aspiration
- Avoids ETT triggering of inflammatory response found in early stages of CLD

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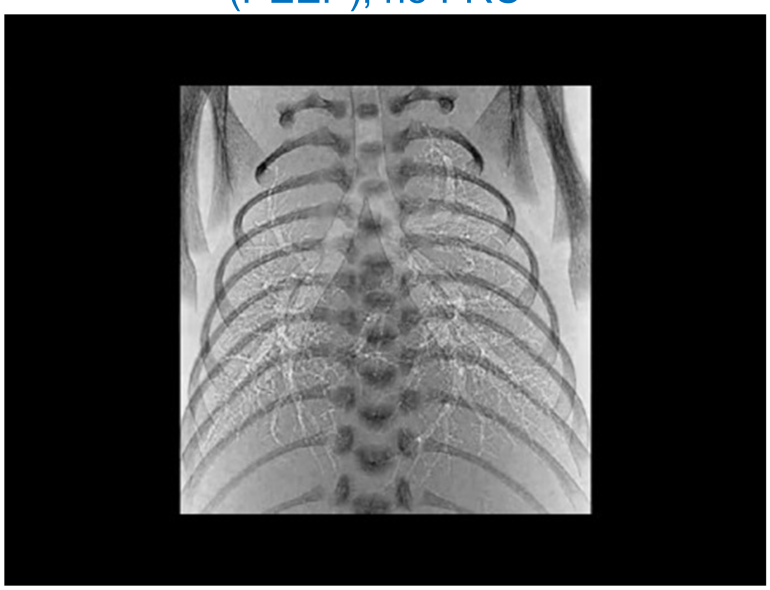
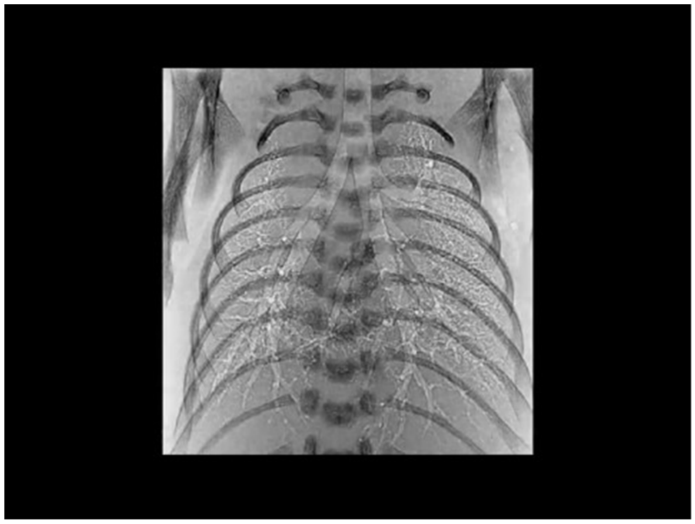
PPV with no Peak end expiratory pressure (PEEP), no FRC



PPV with PEEP & FRC maintenance



Cardiovascular Effects

- Giving optimal CPAP pressures should improve metabolic acidosis and cardiac output
- Relieves signs of cardiac decompensation associated with left-to right shunt

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Contraindications

- Upper airway abnormalities
- Inadequate spontaneous respirations
- Untreated CDH or T-E Fistula
- Untreated pneumothorax
- Bronchiolitis
- Severe cardiac instability

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NCPAP Monitoring

- Work of breathing
- Clinical assessment
- Nares/Skin
- Equipment and alarms
- Weaning
- CXR

- Patient Considerations?

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Adverse Effects

- Lung-over distension
- Gastric insufflation
- Nasal breakdown
- Obstruction
- CO_2 retention

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Procedure

- Obtain appropriate orders from medical staff for CPAP
- Proper sizing for bonnet and mask or prongs
- Don't forget to get your head circumference first!
- Apply Nasal CPAP separately after proper hat is placed

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Equipment

- Monitoring Gas blender
- Universal Generator with prongs or masks
- Delivery Circuit
- Caps/Bonnets
- Humidified Device

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Nasal CPAP Applications

- Parameters
  - FiO_2
  - CPAP Level
  - Flow
  - Temperature
  - Alarm Settings

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Alarms

- Set +3cmH_2O above and +2cmH_2O below desired peep level
- Oxygen plus/minus .5 desired FIO_2
- 30 second alarm button
- Safety limit valves terminates flow if pressure >12cmH_2O

Monitoring

- Work of Breathing
- Respiratory rate
- Chest excursions
- Chest retractions

What to Look for on Chest X-ray

- Expansion
- Atelectasis
- RDS

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RDS

Weaning

- Patient's condition will guide the weaning
- Weaned peep accordingly:
  - CXR
  - ABG
  - WOB

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Nursing Care of Baby on CPAP

- Full assessment of nares and skin q 6
- Keeping nasal mask or prongs in place with minimal pressure
- Orogastric tube should be placed to vent
- Gentle suction to clear mucus Q4-6PRN
- Massage nare to increase circulation**
- Regular change in position Q3-4hours

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Skin Care-Do's and Don't's

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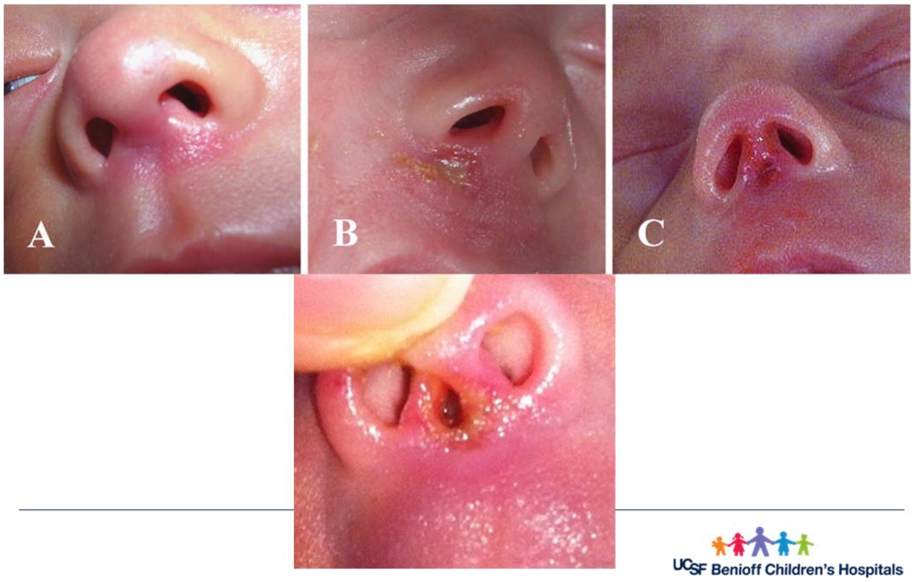
CPAP and Skin Considerations



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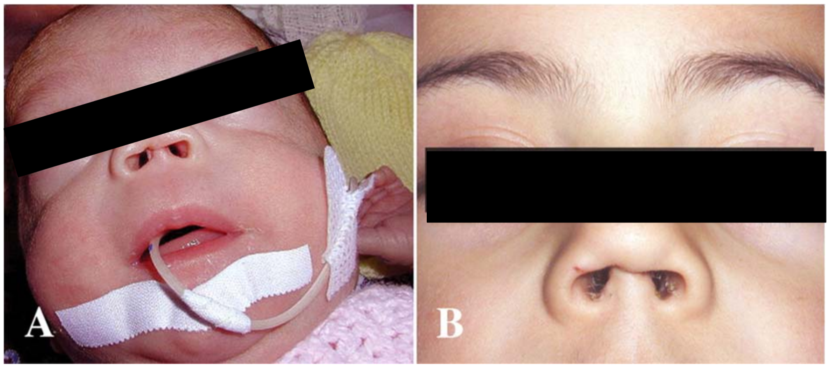
"Snubbing"

Stage III nasal trauma.



Fischer C et al. Arch Dis Child Fetal Neonatal Ed
doi:10.1136/adc.2009.179416

Positioning Techniques

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Loss of PEEP

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The Intubated Patient

- Why intubate?
- Monitoring
- Nursing care
- Comfort considerations
- Trouble shooting

Indications for Intubation

- **Gasping**
- Inadequate respiratory drive
- Continued need for PPV
- Airway obstruction
- Congenital anomalies
- Worsening apnea and bradycardia
- Bradycardia unresponsive to effective ventilation

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Indications for Intubation

- Signs of respiratory failure
  - Rapidly increasing O2 requirement
  - Worsening retractions
  - Hypercarbia
  - Respiratory Acidosis
  - Signs of exhaustion

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Respiratory Assessment of Ventilated Patient

- Ventilator breaths vs. patient breaths
  - Spontaneous respirations can be abdominal
  - Ventilator breaths will have even chest rise and fall
- Ventilator settings
  - Check ventilator to confirm that ordered vent settings are being delivered
  - Check alarms

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Respiratory Assessment

- Chest movement
  - Observe for good chest rise with each breath
  - Symmetrical movement of chest
- Tube position
  - ETT securely attached to face
  - Lip to tip measurement
  - No kinks or pulling of ETT
  - Tubing always positioned lower than patient to avoid moisture rainout into ETT

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What's missing?

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Nursing Care of the Intubated Patient

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VAP Prevention

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Ventilator Circuits:

- Keep capped if not on patient. (Hand ventilation or on transport)
- Do not put open (uncapped) circuit on bed
- Do not "tap" open circuit on bed to clear water
- Drain water into 4x4, glove, or cloth diaper and dispose.
- Drain water away from patient (Also important with CPAP and HFNC)

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Elevating the Head of the Bed:

Intubated:

- Elevate the head of the isolette or radiant warmer 15-30 degrees
- This has been shown to reduce work of breathing and decrease the risk of aspiration of oral secretions

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How do we know when to suction?

- Are we suctioning simply because a certain amount of time has passed?
- Is the patient desaturating due to other factors, such as pain?
- Can we time suctioning after giving pain or sedation meds to help the baby tolerate it better?
- Are we providing enough time between suction passes for the patient to recover adequately?

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Indications for suctioning:

- Decreased oxygen saturations and/or frequent desaturations
- Coarse breath sounds
- Coughing and/or agitation
- Increased work of breathing

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Methods of Suction

- Open
- Closed

Minimize use of Saline:

- **Mucus and water/saline do not mix, even when shaken**
- One study showed that suctioning retrieves only 11–19% of instilled saline. The un-retrieved saline could interfere with gas exchange and worsen your patient's condition.
- Saline is associated with increased desaturation and slower recovery after suctioning.
- Saline instillation moves bacteria from the lining of the endotracheal tube into the lungs. In a laboratory study, it was shown that instilling saline during suctioning moved five times more bacteria from the endotracheal tube into the airway, compared to suctioning without saline.

Minimize use of Saline:

- It is important to clear your suction catheter with saline after each pass. You will see that you are actually removing secretions without instilling saline to the patient.
- If judged necessary in cases where suctioning without saline has failed to clear the ETT, use the smallest amount of saline possible.
- Suctioning without saline has not been shown to increase the incidence of plugged endotracheal tubes.

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Pain and Sedation for Intubation

- Premedication
  - Kumar, P., Denson, S. E., Mancuso, T. J., & Committee on Fetus and Newborn, Section on Anesthesiology and Pain Medicine. (2010). Premedication for nonemergency endotracheal intubation in the neonate.*Pediatrics*, *125*(3), 608-615
- Ongoing care
  - Comfort measures
  - Pharmacologic measures

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Blood Gases

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Blood Gases

	Arterial	Capillary
pH*	**7.30 - 7.45**	**Same**
PCO_2 *	**35 - 45 mmHg**	**35 - 50 mmHg**
PO_2 (on room air)	**60 – 80 mmHg**	**--- (not useful)**
HCO_3 Bicarb	**19 – 26 mEq/L**	**19 – 26 mEq/L**
Base Excess	**-4 to +4**	**-4 to +4**

*preterm infants have lower acceptable pH, and higher CO_2

Health.vic.gov.au,. (2015). *Blood gas interpretation for neonates: Neonatal ehandbook - Department of Health and Human Services, Victoria, Australia*. Retrieved 13 October 2015, from http://www.health.vic.gov.au/neonatalhandbook/pathology/blood-gas-interpretation.htm

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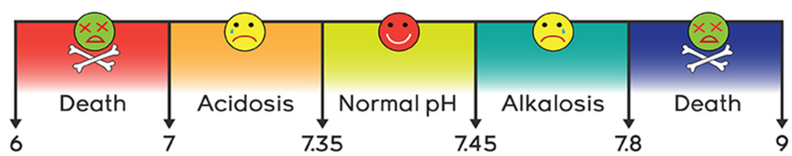
CO_2 = ACID
↑H+

HCO_3 = BASE
↓H+

Blood pH Levels



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ACIDOSIS
pH <7.35

↑ CO_2 Respiratory

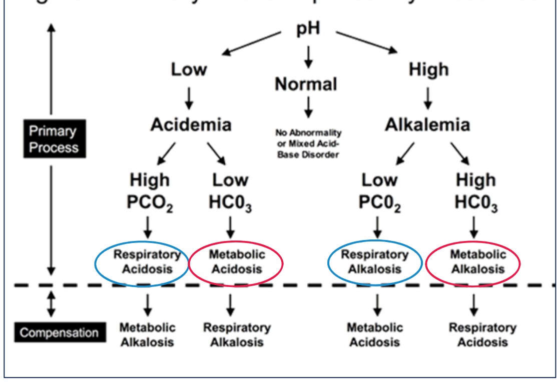
↓ HCO_3 Metabolic

ALKALOSIS
pH >7.45

↑ HCO_3 Metabolic

↓ CO_2 Respiratory

Figure 2: Primary And Compensatory Processes



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Blood Gases

1. Where did the gas come from?
2. Is the pH: low, normal or high?
3. If pH low: ↑ $CO_{2,}$ ↓ HCO_3, or mixed
4. If pH high: ↑ $HCO_{3,}$ ↓ CO_2, or mixed

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Respiratory Acidosis

pCO_2 >=45mmHg, pH <7.35

Causes…

Loss of tidal volume
- Lung disease
- Pneumothorax
- Airway obstruction
- "Mechanical" interference

Loss of respiratory drive
- Poor effort
- Neurologic injury
- Apnea

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Respiratory Acidosis

pCO_2 >=45mmHg, pH <7.35

Treatment-

- Renal compensation
- CPAP
- Positive Pressure Ventilation
- Intubation
  - ↑ tidal volume and/or rate

Chronic Respiratory acidosis will see a rise in HCO_3

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Metabolic Acidosis

HCO_3<=18 mEq/L, pH <7.35

Causes…

- ↑ Lactic acid production
  - Shock
  - Sepsis
  - Cardiac disease
  - Hypothermia
  - Hypoglycemia
- Excessive loss of HCO3
- Inborn error of metabolism

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Metabolic Acidosis

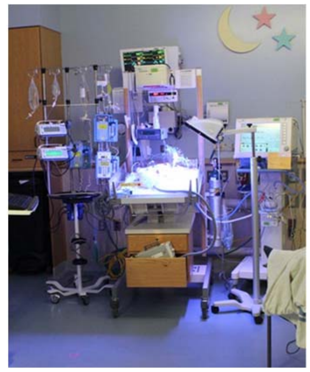
HCO_3<=18 mmol/L, pH <7.35

Identify and treat underlying causes!

- Hypoxia
- Hypotension
- Infection
- Hypoglycemia
- Hypothermia

Medications…

- NS bolus, Bicarb



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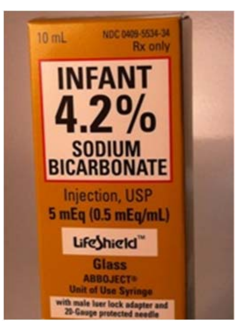
Sodium Bicarbonate… useless therapy?



- Efficacy and safety of sodium bicarbonate replacement therapy unproven
- Still used in severe acidosis
- Not recommended in resuscitation
  - Lack of efficacy
  - Potential for harm
- Not recommended for preterm infants
  - Increased mortality
  - Increased IVH

Never to be given if patient not ventilating well

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Respiratory Alkalosis

pCO_2 <= 35mmHg, pH >7.45

Causes…

Too much ventilation!!

- Reduce rate/TV

Abnormal control of breathing

- During HIE

Hypocarbia & long-term effects

- Cerebral vasoconstriction
- ↑ poor outcomes, ↑ death, ↑ disability
  ↑ PVL, ↑ CP, ↑ neuro deficits

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Metabolic Alkalosis

HCO_3 > 25mmol/L, pH >7.45

Causes…

Hypochloremia

- Diuretics, GI obstruction

Too much Bicarbonate

Treatment

Treat underlying cause

- Chloride replacement

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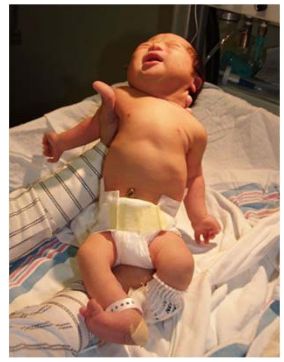
Case 1: Noah

- Term baby
- Delivered by emergent c/s due to fetal distress
- RR 26, HR 124, weak respiratory effort
- SpO_2 90% on 0.50 FiO2 via NC
- Hypotonic
- Capillary blood gas
  - pH 7.16, PCO_2 70, HCO_3 21, BE -7



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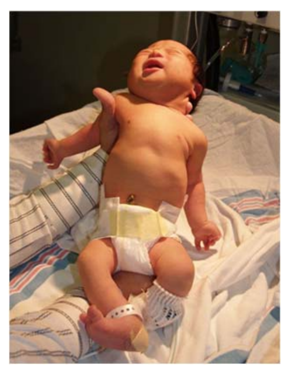
Case 1: Noah

- Had an asphyxial insult
- Inadequate respirations → high PCO_2 (respiratory acidosis)
- Tissue hypoxia → metabolic acidosis
- What to do now?



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Case 2: Mia

- 28 weeks' gestation
- Developed RDS
- Now intubated and ventilated
- Blood gas:
- pH 7.47, PCO_2 28, HCO_3 22, BD 4
  - What does Mia have?

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Case 2: Mia

- Respiratory alkalosis
- Excessive ventilation
- Correct by
  - Decreasing ventilator rate
  - Decreasing tidal volume or
  - Decreasing inspiratory pressure

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Extra questions

- Arterial blood gas result: pH 7.35, PCO2 23, HCO3 (bicarbonate) 12. The correct interpretation of this blood gas is:
  a) compensated metabolic acidosis.
  b) compensated mixed metabolic and respiratory acidosis.
  c) compensated respiratory acidosis.

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Extra questions

- Arterial blood gas result: pH 7.18, PCO2 63, HCO3 (bicarbonate) 23. The correct interpretation of this blood gas is
  a) uncompensated metabolic acidosis.
  b) uncompensated mixed metabolic and respiratory acidosis.
  c) uncompensated respiratory acidosis.

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Extra questions

- A term infant has suspected pneumonia and is on a ventilator. The blood gas reveals a severe metabolic and respiratory acidosis and low arterial oxygen tension. Which one of the following statements is FALSE?
  a) Blended oxygen should be administered and oxygen saturation should be monitored
  b) Sodium bicarbonate should be given immediately to treat the acidosis
  c) Tissue hypoxia may lead to cellular necrosis and subsequent organ damage

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Extra questions

- Arterial blood gas result: pH 7.25, PCO2 36, HCO3 (bicarbonate) 15. The correct interpretation of this blood gas is

a) compensated respiratory acidosis.
b) uncompensated metabolic acidosis.
c) uncompensated mixed metabolic and respiratory acidosis.

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Extra questions

Arterial blood gas result: pH 7.03, PCO_2 55, HCO_3 (bicarbonate) 14.
The correct interpretation of
this blood gas is

a) uncompensated metabolic acidosis.
b) uncompensated mixed metabolic and respiratory acidosis.
c) uncompensated respiratory acidosis.

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Case Studies-Case 1

- You attend a cesarean section for a 38 week infant. Mom is a G1 P0-1. Maternal history is significant for a planned home birth with arrest of labor. The midwife briefs the team that they are expecting a big baby. Ultrasound done in triage reveals polyhydramnios. No other risk factors. Membranes are intact.
- When uterine incision is made there is a gush of amniotic fluid. The OB suctions 2 canisters of amniotic fluid from the uterus

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Case Study 1 Continued

- Infant is placed on the warmer and you note frothy oral secretions and respiratory distress. Preductal sat reading is 68% at one minute. The mouth is suctioned for copious secretions and you attempt to suction more deeply* but the suction catheter only advances 5 cm.
- Respiratory distress worsens with grunting, retractions and tachypnea and an O2 sat reading of 68% at 5 mins of life in 40% FiO2
- Baby receives Mask CPAP and FiO2 is increased
- You take baby to the NICU

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Your Chest Xray …

- What are we seeing?
- What is our differential diagnosis?
- What is the best approach to respiratory support for this baby?

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Case Study 2

- A 32 year old G2-P1 carrying twins at 30 weeks gestation presents to labor and delivery with a bulging amniotic sac and delivery is imminent
- She receives one dose of Betamethasone prior to delivery
- The team is assembled. Twin A is delivered vaginally.
- How would you support this baby?
- What do you base your decision making on?
- When would you escalate respiratory support?

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Case Study 2

- You are notified that twin B is a breech extraction
- How do you prepare your team?
- What risk factors are present that may complicate care?

- Baby B is delivered, limp and apneic -how would support for this twin differ from Twin A's resuscitation?

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Case Study 3

- A woman presents to your unit at 36 weeks gestation and delivery is imminent. She has been followed at UCSF by Fetal Treatment with the diagnosis of severe left sided congenital diaphragmatic hernia where she was supposed to deliver. She is too unstable to transport.
- How do you prepare for this delivery?
- What are the immediate steps that need to be taken when the baby is delivered?
- How do we ventilate this baby?

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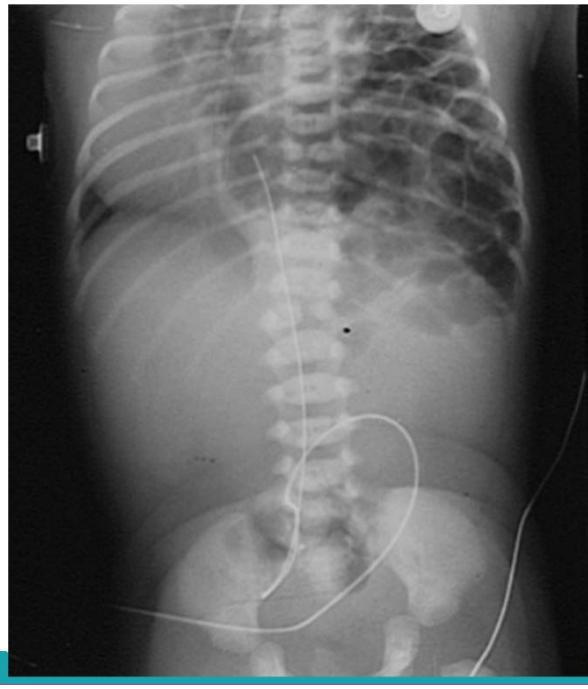

Case Study 3

- What can be done to optimize ventilation based on the x-ray?

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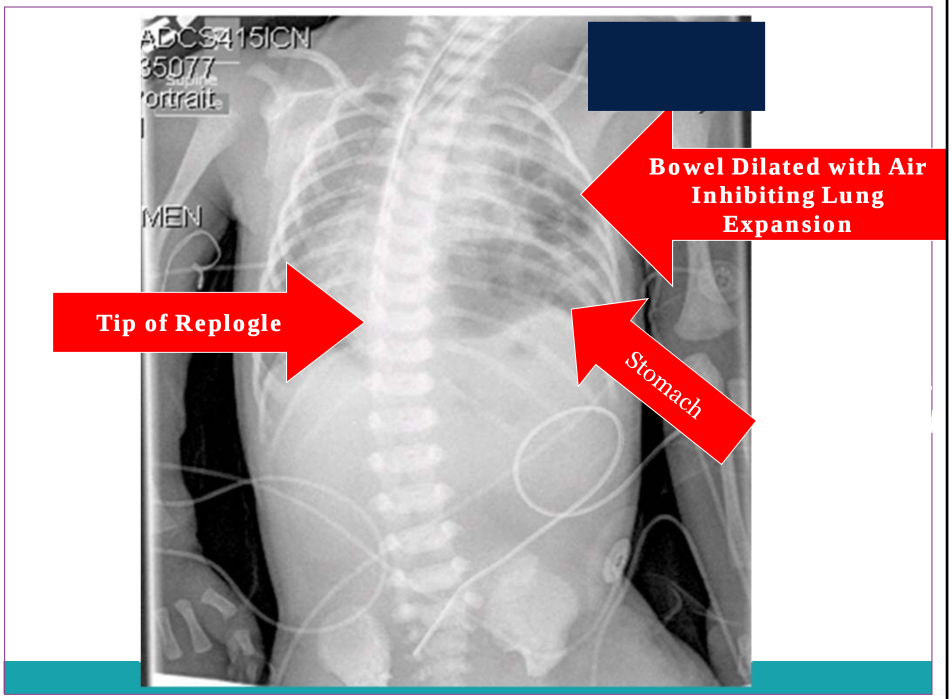
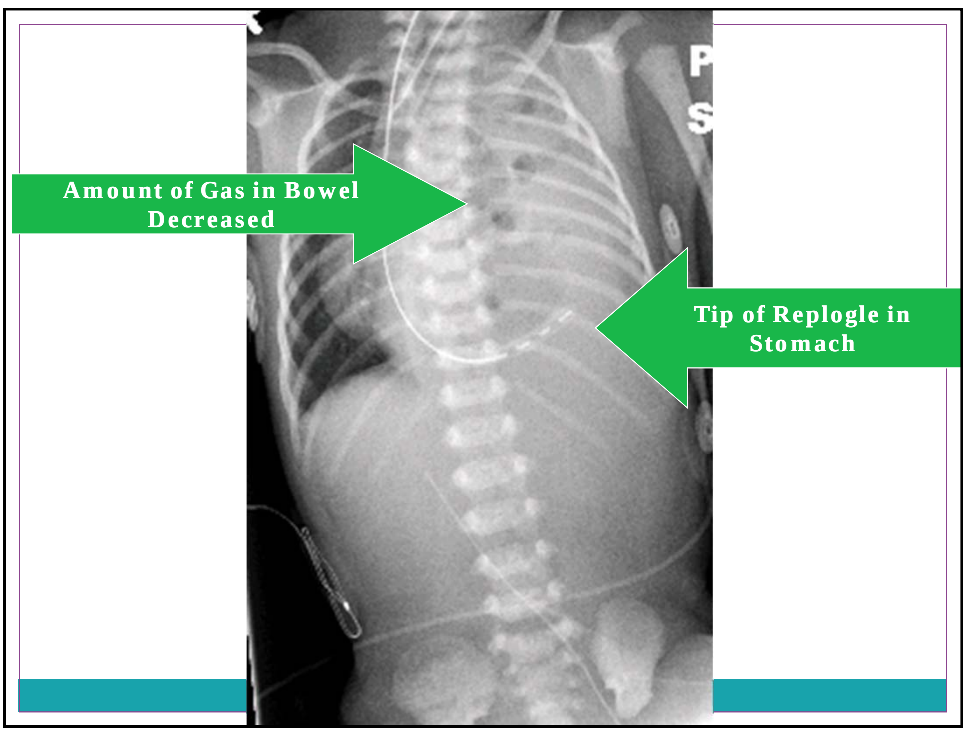

Bowel Dilated with Air Inhibiting Lung Expansion
Tip of Replogle
Stomach


Amount of Gas in Bowel Decreased
Tip of Replogle in Stomach

References

- Finer, N. N., Rich, W., Halamek, L. P., & Leone, T. A. (2012). The delivery room of the future: The fetal and neonatal resuscitation and transition suite. *Clinics in Perinatology, 39*(4), 931-939.
- Kandraju, H., Murki, S., Subramanian, S., Gaddam, P., Deorari, A., & Kumar, P. (2013). Early routine versus late selective surfactant in preterm neonates with respiratory distress syndrome on nasal continuous positive airway pressure: A randomized controlled trial. *Neonatology, 103*(2), 148-154.
- Kumar, P., Denson, S. E., Mancuso, T. J., & Committee on Fetus and Newborn, Section on Anesthesiology and Pain Medicine. (2010). Premedication for nonemergency endotracheal intubation in the neonate. *Pediatrics, 125*(3), 608-615.
- Leone, T. A., Finer, N. N., & Rich, W. (2012). Delivery room respiratory management of the term and preterm infant. *Clinics in Perinatology, 39*(3), 431-440.
- Vaucher, Y. E., Peralta-Carcelen, M., Finer, N. N., Carlo, W. A., Gantz, M. G., Walsh, M. C., et al. (2012). Neurodevelopmental outcomes in the early CPAP and pulse oximetry trial. *The New England Journal of Medicine, 367*(26), 2495-2504.

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Thank You!

Questions?

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