

# Non-Invasive Ventilation in the Delivery Room

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# Disclosures

- I have no financial disclosures
- I will not be discussing use of off-label therapies
- I will be discussing various respiratory devices but have no affiliation with the manufacturers and I am not giving my endorsement for any specific device

# Objectives

1. Understand neonatal respiratory physiology
2. Know available neonatal non-invasive ventilation modalities and when to use them

# Outline

- Neonatal respiratory concepts
- Normal respiratory transition at birth
- Neonatal respiratory pathology
- Non-invasive ventilation
- Choosing mode to match potential pathology

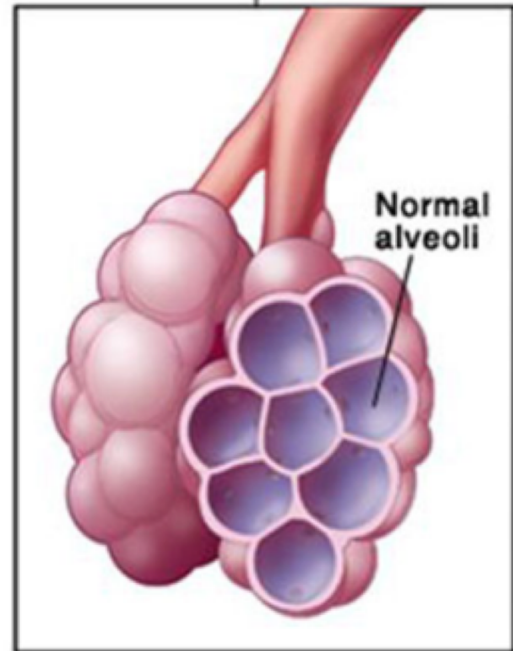
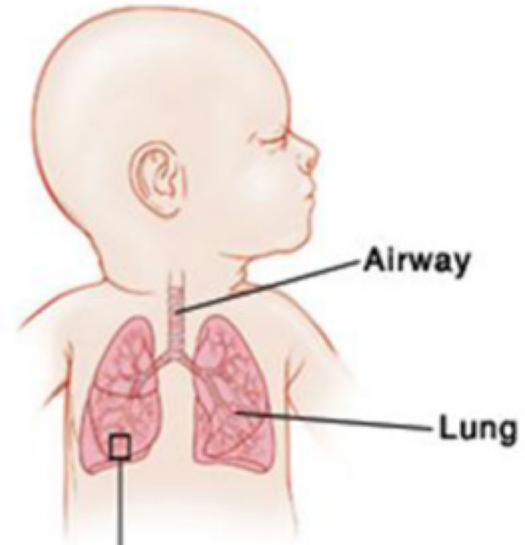
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# Functional Residual Capacity (FRC)

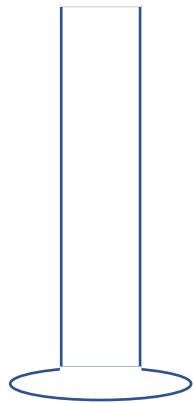
- FRC is essential for proper gas exchange
- First few breaths recruit alveoli
- Alveoli remain open during expiration due to positive end expiratory pressure (PEEP)
  - chest wall rigidity
  - lung recoil
  - surfactant

# FRC



# FRC

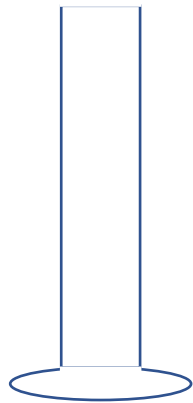
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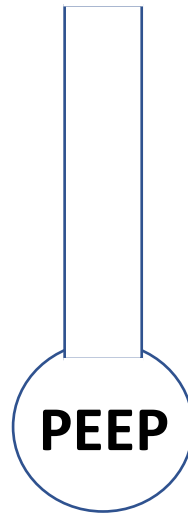


# FRC

No FRC

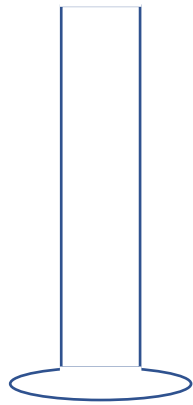


At rest/expiration

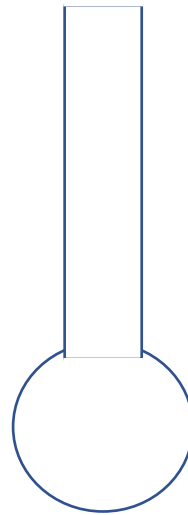


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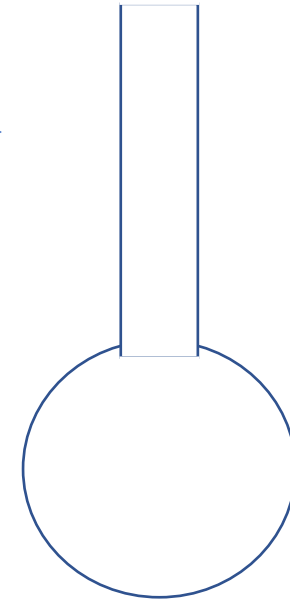
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At rest/expiration



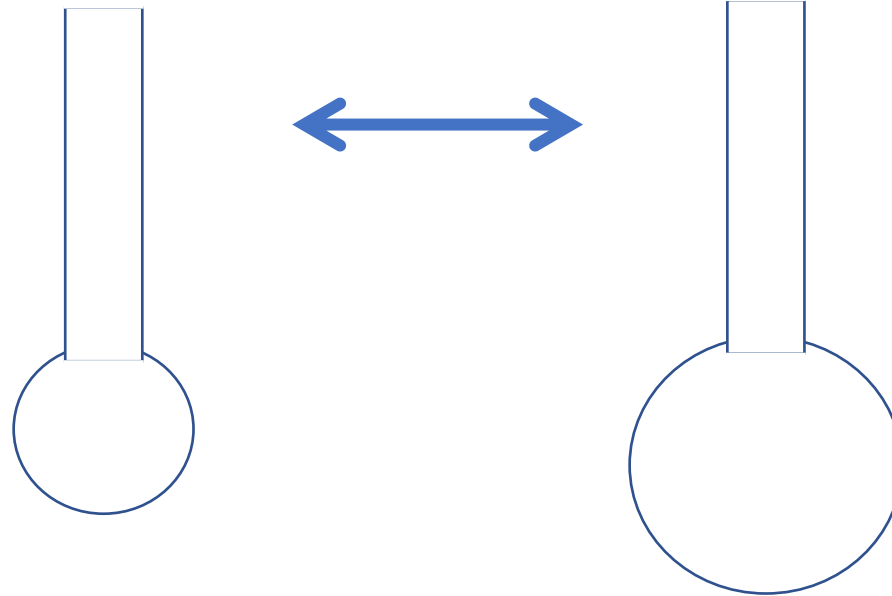
Inspiration



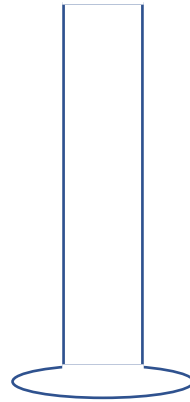
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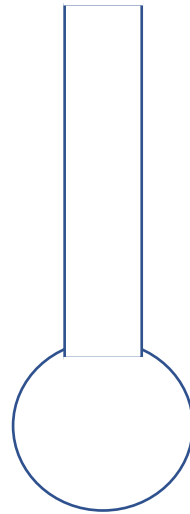
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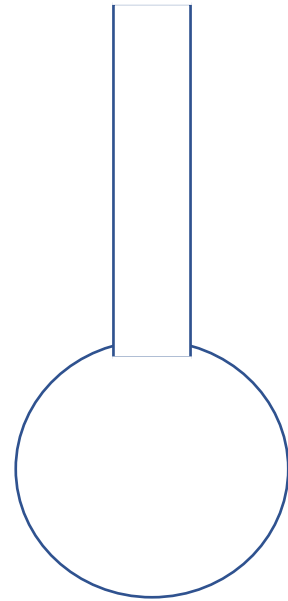
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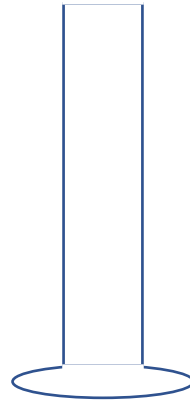
# FRC



# FRC



# FRC



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- Neonatal respiratory concepts
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# Lung Fluid Clearance

- During labor, fetal lung fluid reduced to 35%
  - Lung epithelium: changes from active chloride secretion to active sodium absorption (ENaC)
  - Starts days prior to labor



# Lung Fluid Clearance

- Remaining 35% cleared with breathing at birth

- Air-fluid interface established

Alveolar fluid



Interstitium



Lymphatics



# Lung Fluid Clearance

Disruption of fluid clearance at birth:

**Transient Tachypnea of the Newborn  
(TTN)**

# Surfactant Production

- Lipid and protein component produced starting around 22 wks of gestation
- By term, type 2 cells in lungs contain more surfactant than adult lungs (5-20 times)
- Decreases alveolar surface tension
  - Alveoli open more easily with inspiration and do not collapse with expiration

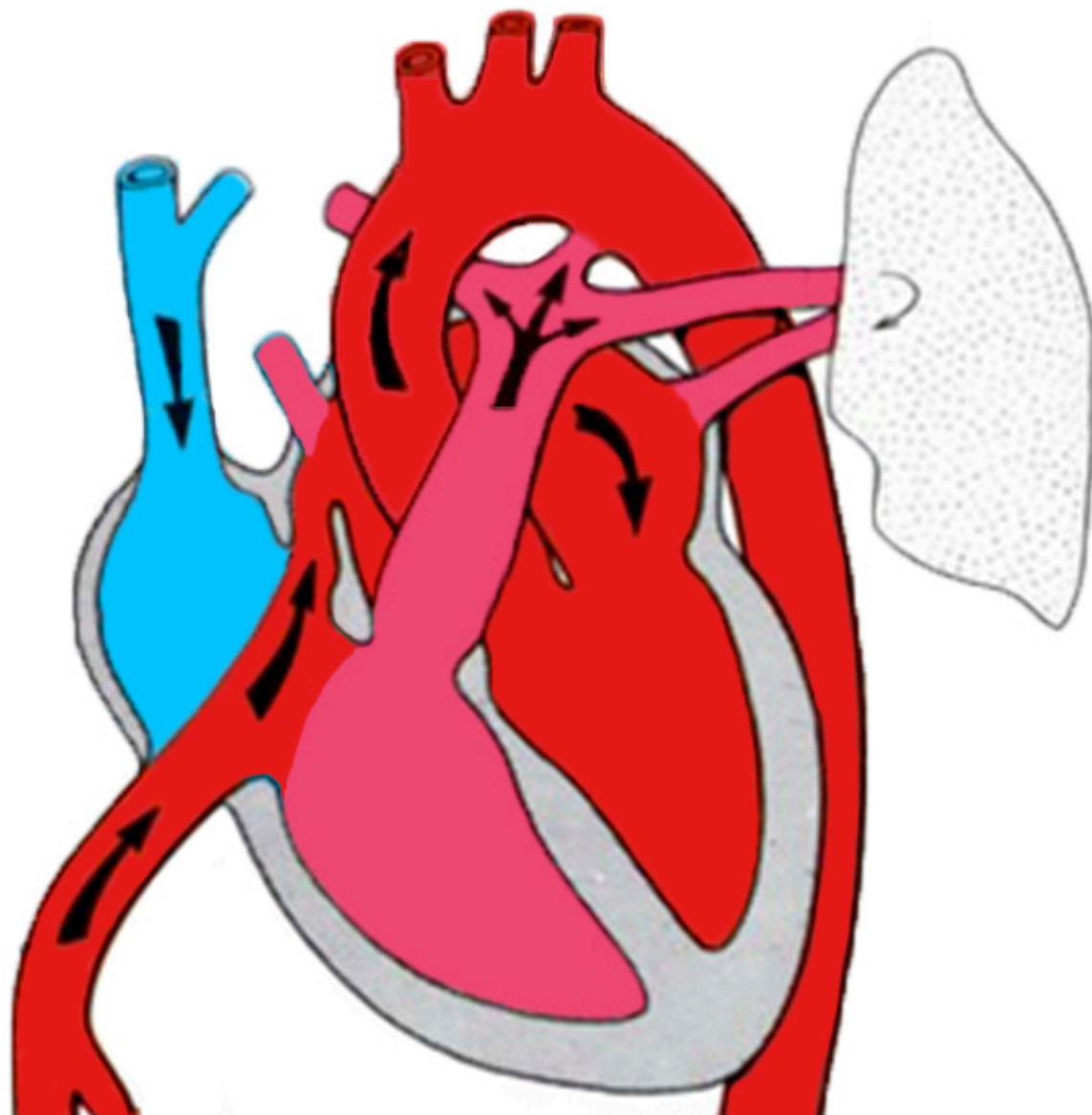
# Surfactant Production

Disruption of surfactant activity at birth:

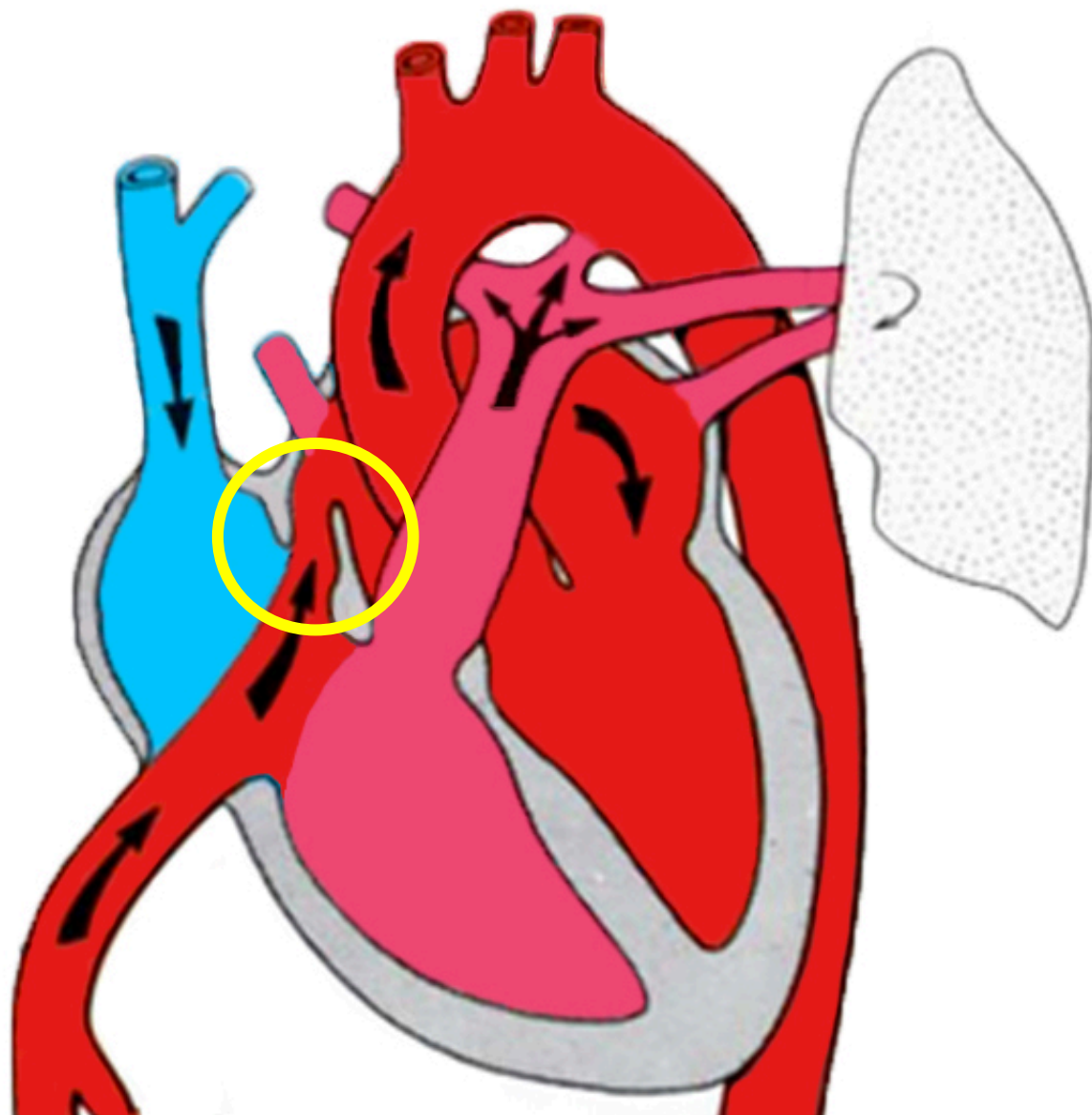
**Respiratory Distress Syndrome (RDS)**

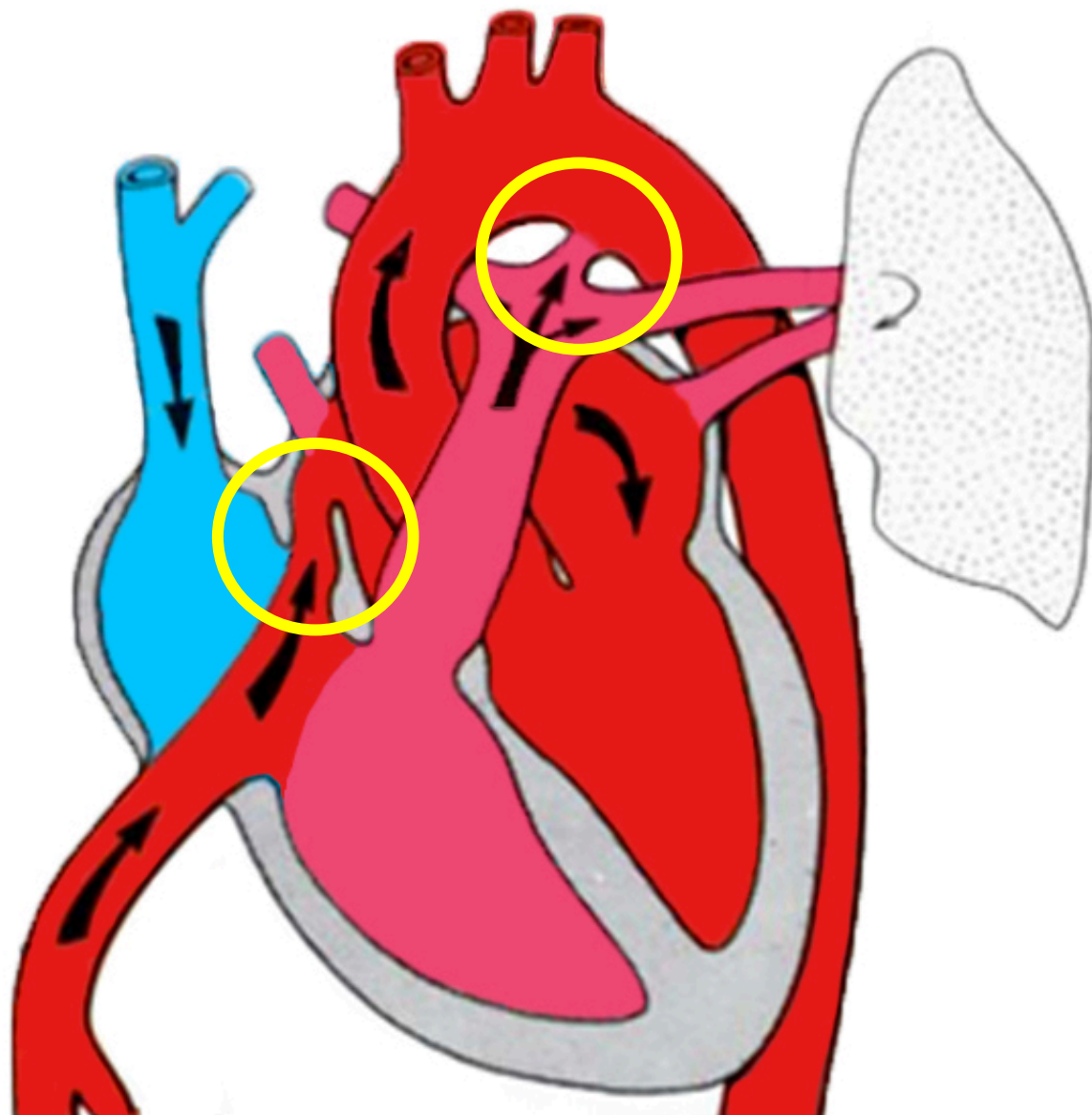
# Pulmonary Blood Flow

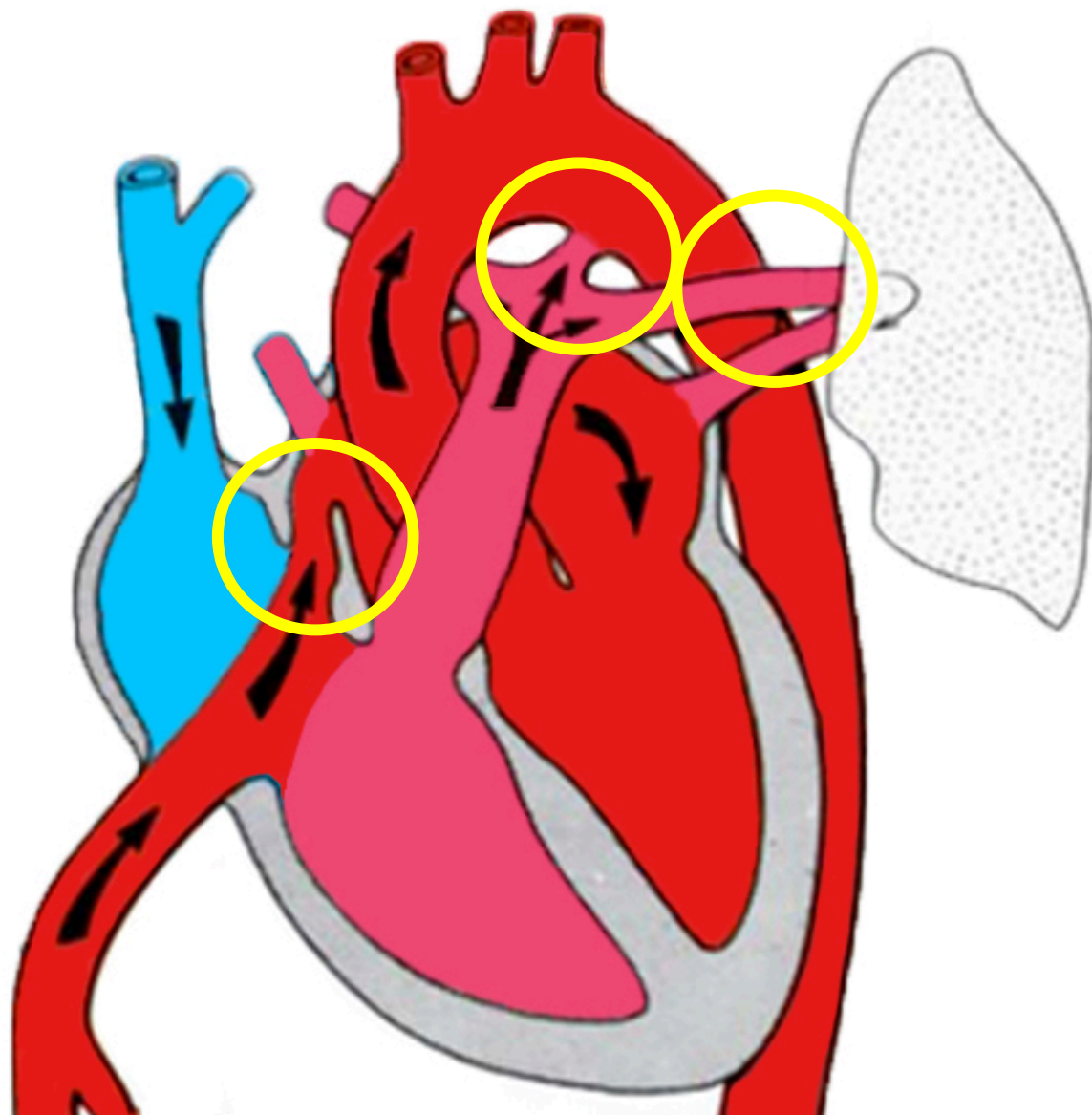
- Fetal lung receives  $< 3-8\%$  of combined ventricular output
  - most RV output crosses ductus arteriosus (DA)
- Transition to 100% of blood flow after delivery

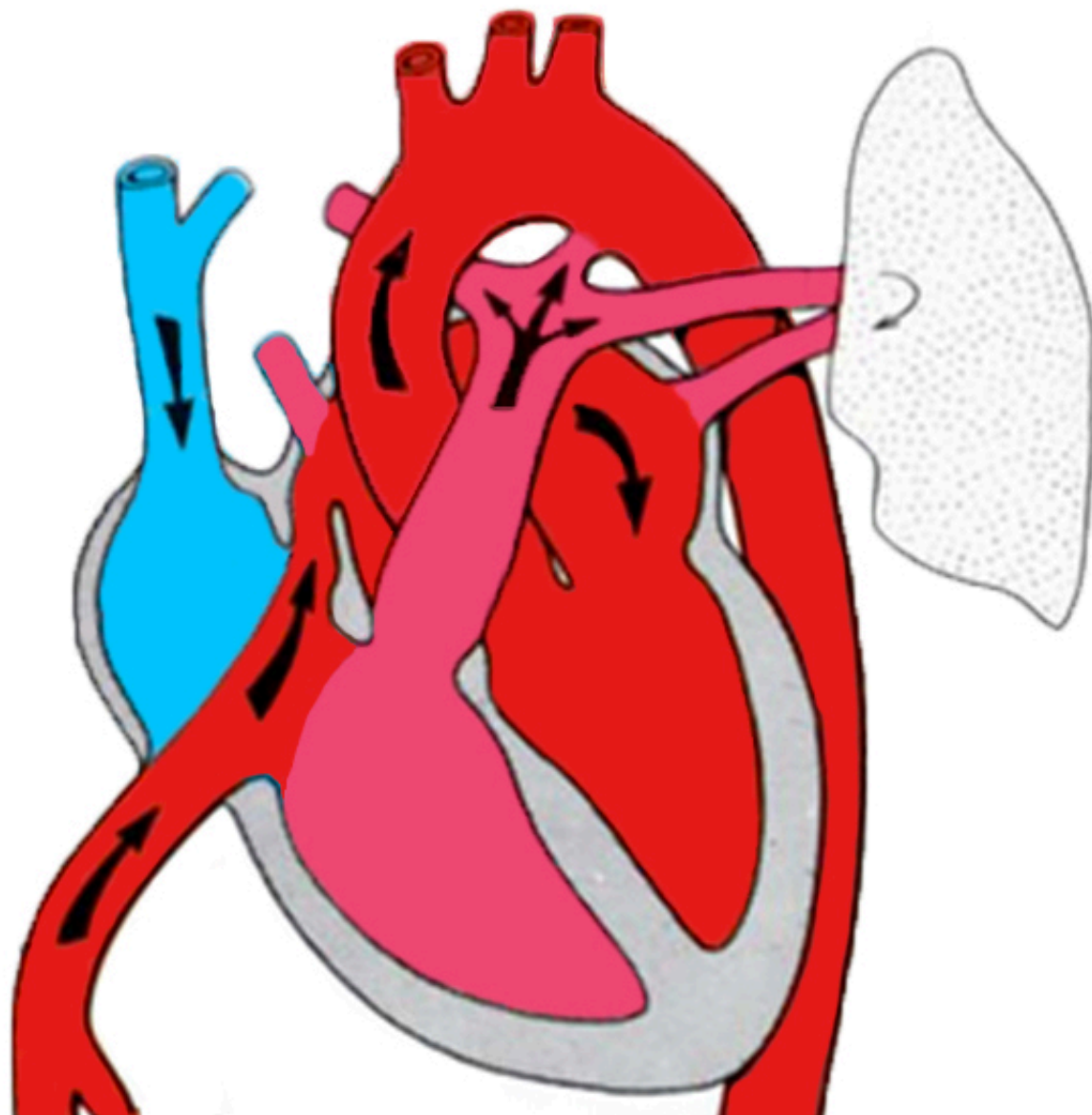


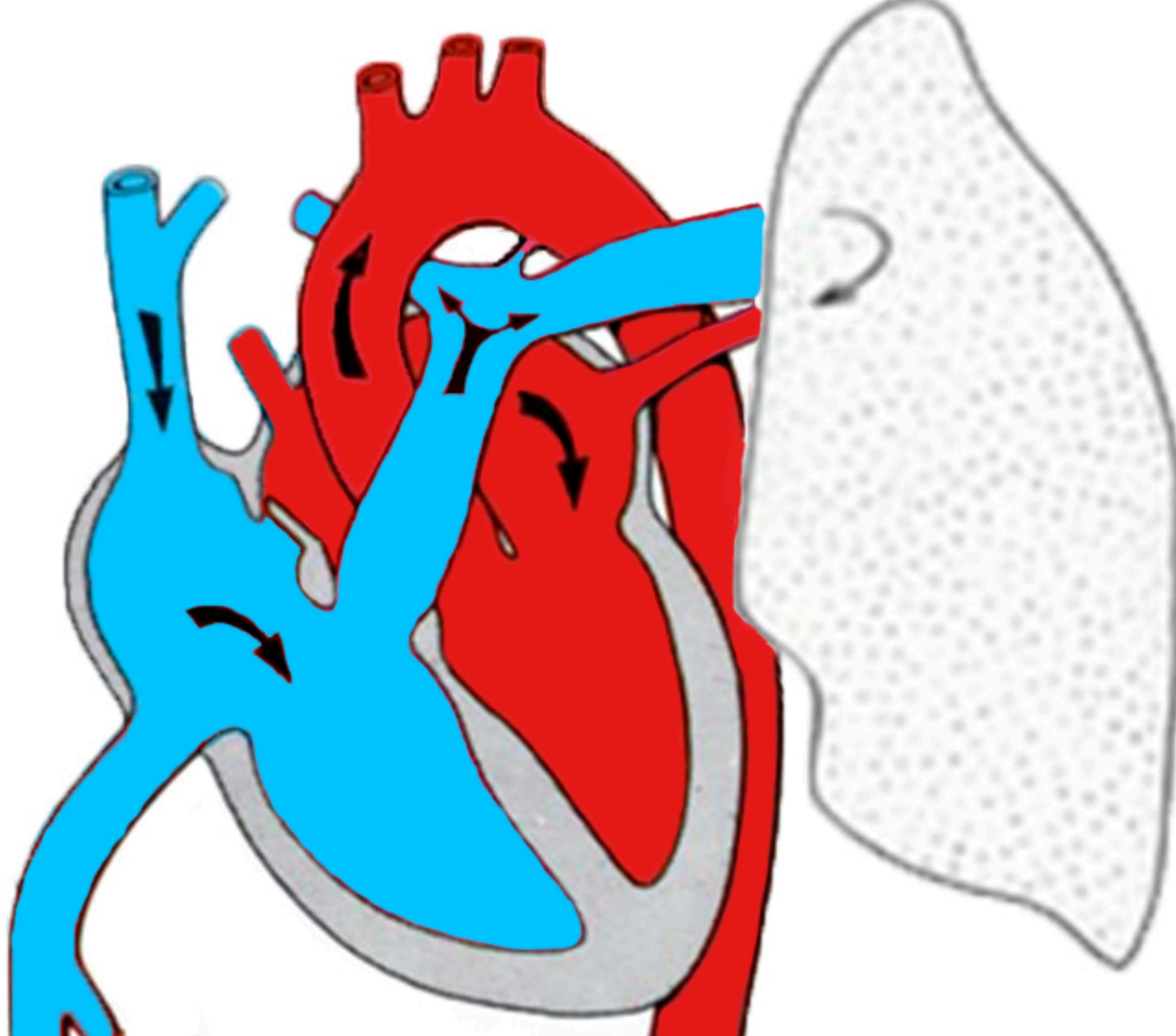




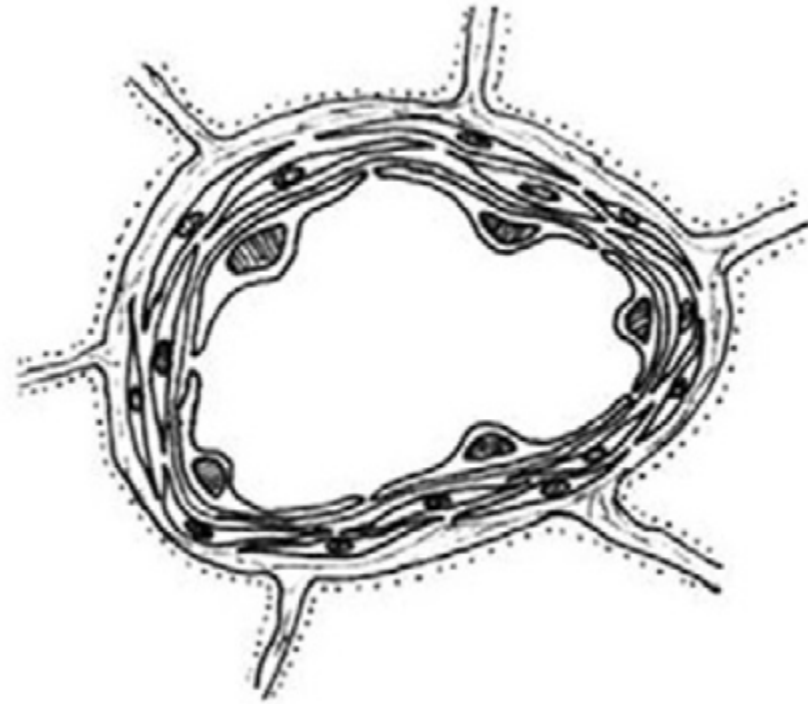
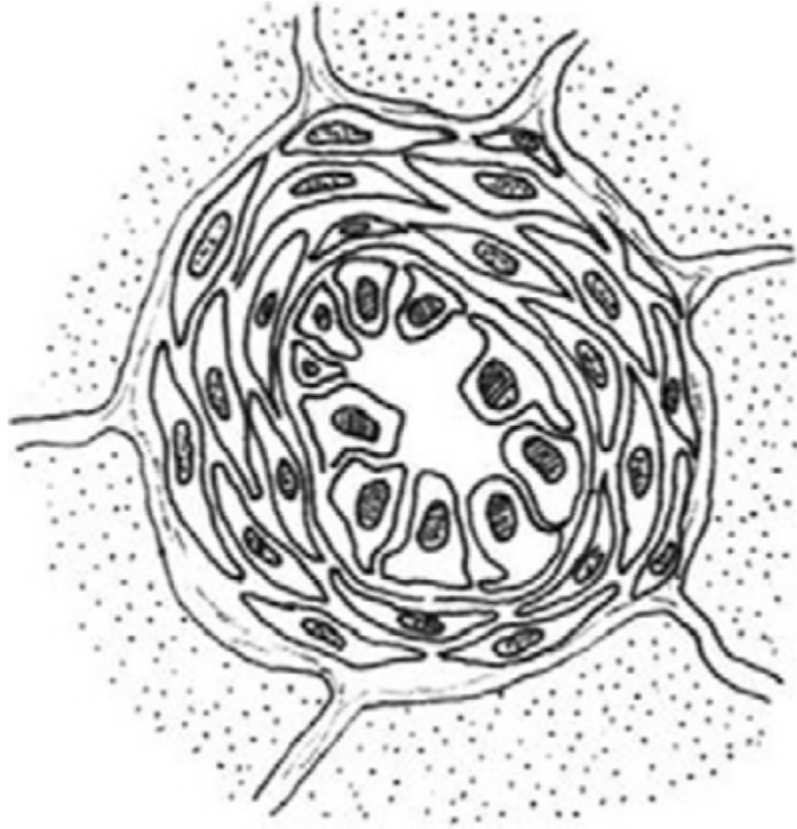








# Vascular Tone Decreases at Birth



# Pulmonary Blood Flow

Disruption of decrease in pulmonary vascular resistance at birth:

## **Persistent Pulmonary Hypertension of the Newborn (PPHN)**

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# Abnormal Transition

- ~10% of neonates will require resuscitative efforts at birth
- Infants born at term via c-section without labor have 2-fold increased risk of respiratory morbidity
  - At 37 wks: 4-fold risk

# Transient Tachypnea of the Newborn (TTN)

- Failure of adequate lung fluid clearance
- 5.7/1000 births at 37-42 wks gestation
- Excess fluid pools in airspaces and interstitium → decreased lung compliance → tachypnea to compensate
- ? Decreased surfactant activity as well?

# TTN

- Clinical presentation
  - Tachypnea with or without increased work of breathing (WOB)
  - May have hypoxemia
  - May have hypercarbia (less common)
  - Onset at birth or within 2 hours

# TTN



# TTN - Management

- Oxygen if hypoxemic
  - Increased oxygen tension enhances activity/expression of ENaC
- CPAP if increased work of breathing
  - Fluid clearance aided by airway distention
- Time
  - Usually resolves in 12-24 hrs

# Respiratory Distress Syndrome (RDS)

- Surfactant deficiency/inactivation leads to:
  - Alveolar collapse
  - Low lung volume/atelectasis
  - Decreased lung compliance
- Pulmonary edema/decreased fluid clearance

# RDS

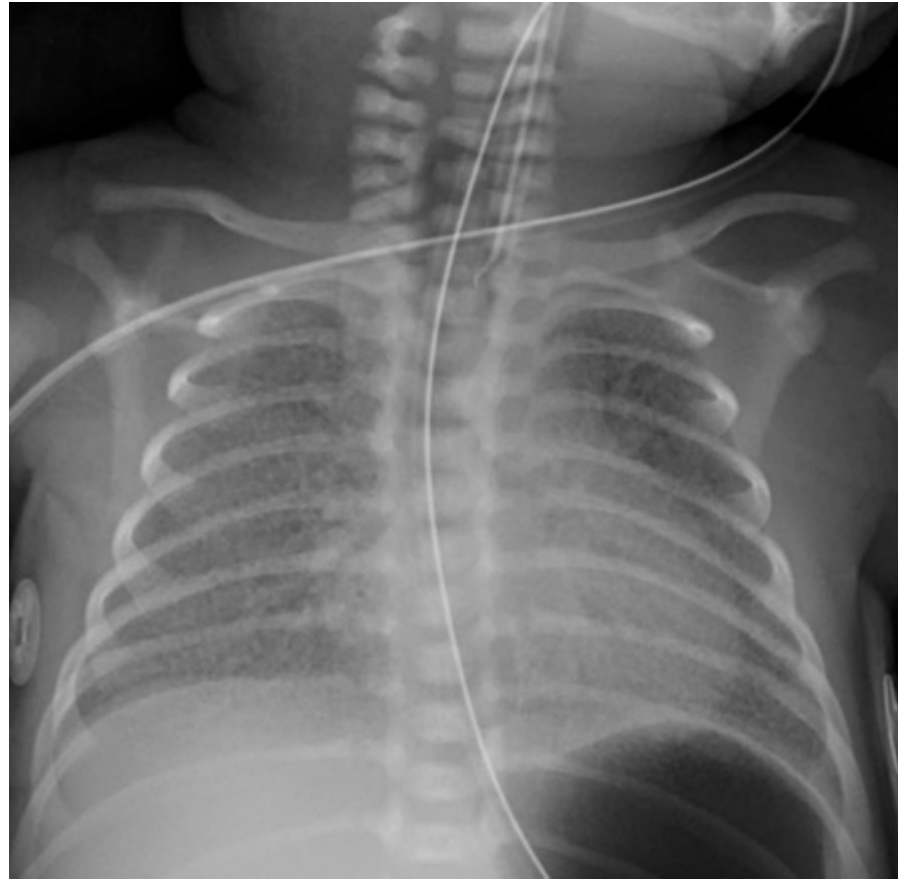
- Most common in preterm infants
  - Incidence increases with decreasing gestational age
- May also occur in term infants especially in presence of:
  - Infant of a diabetic mother
  - Meconium aspiration
  - Pulmonary hemorrhage
  - Pneumonia



# RDS

- Clinical presentation:
  - Increased work of breathing (tachypnea, nasal flaring, grunting, retractions)
  - Hypoxemia
  - Hypercarbia

# RDS

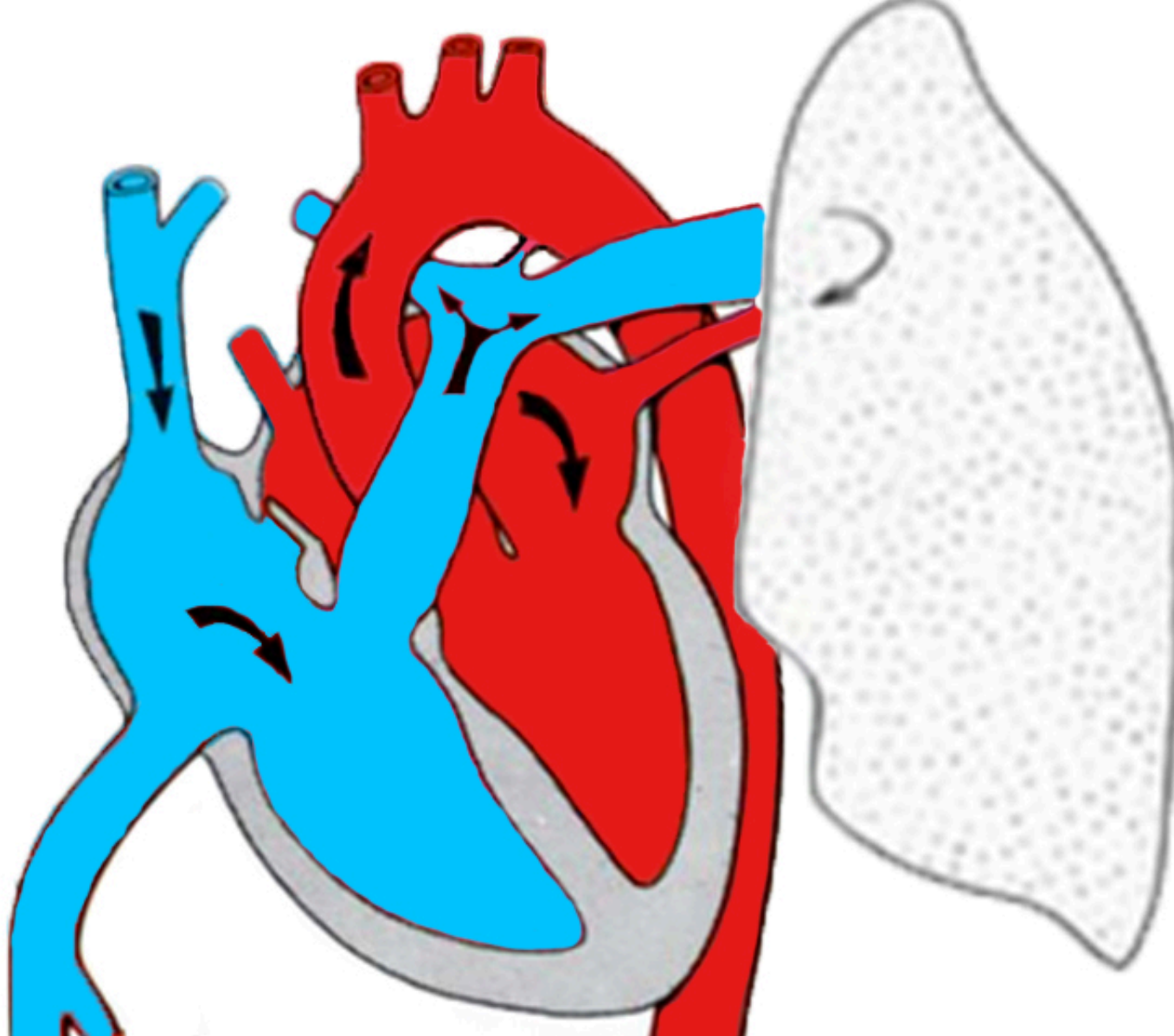


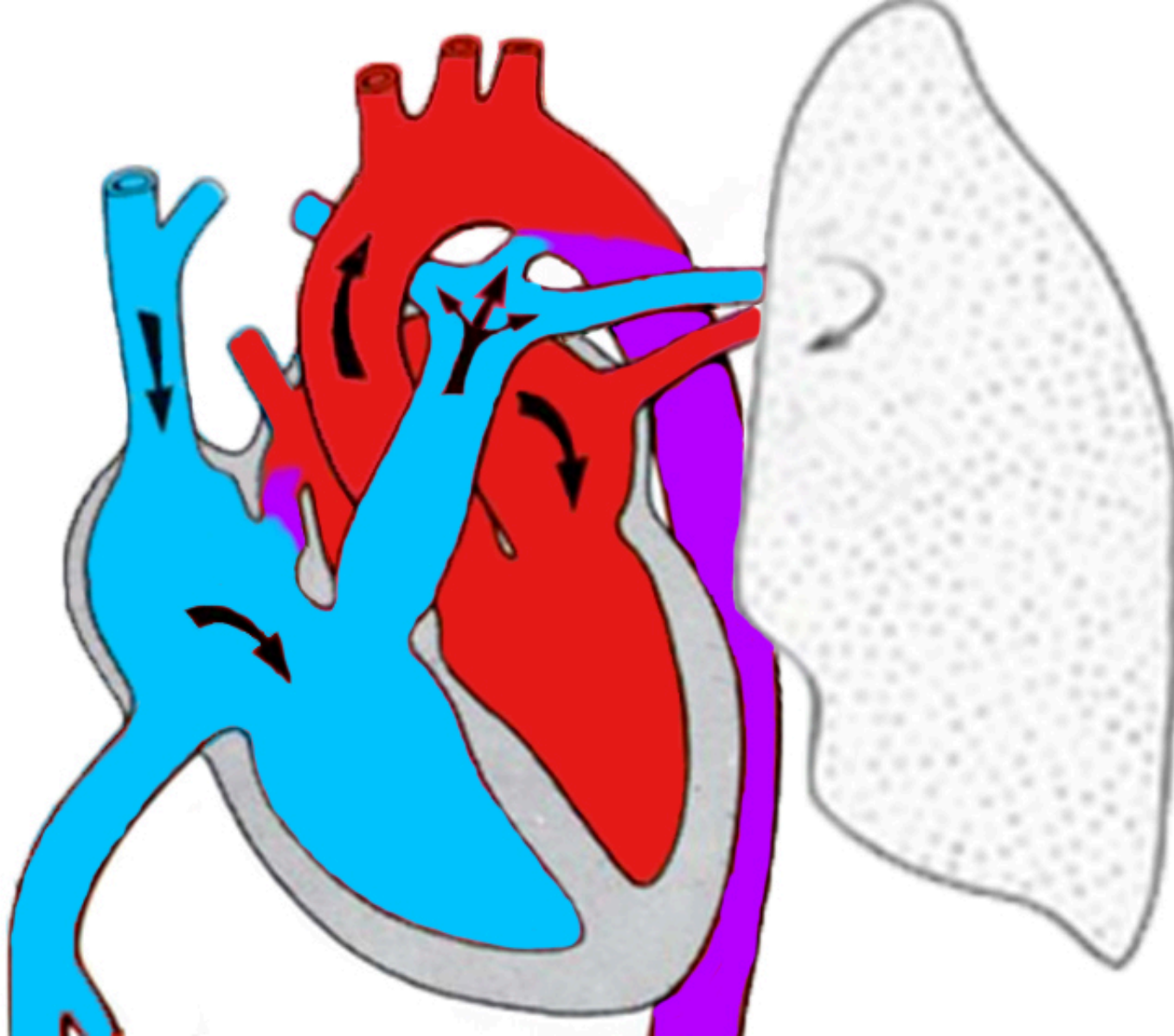
# Persistent Pulmonary Hypertension of the Newborn (PPHN)

- Failure to achieve or sustain the normal decrease in PVR at birth, leading to severe respiratory distress and hypoxemia

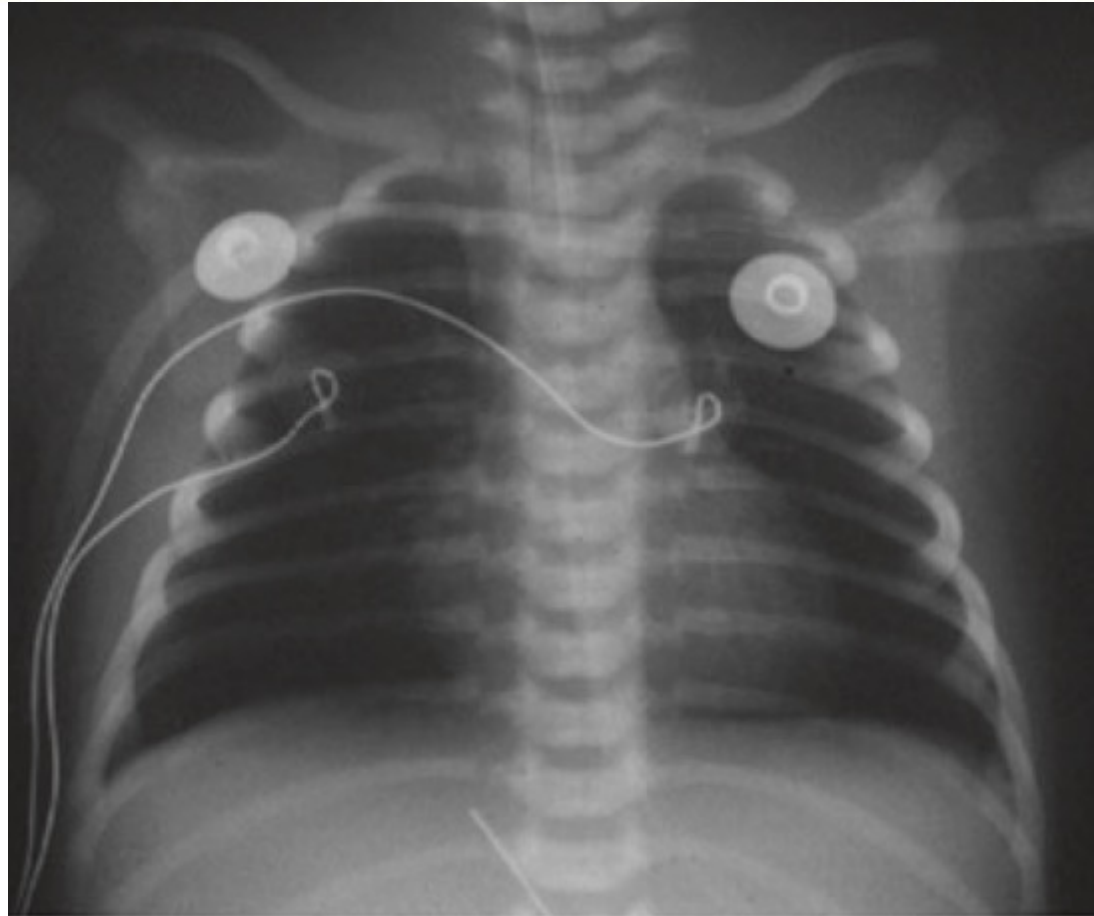
# PPHN

- 1-2/1000 live births
- ~10% of NICU patients
- Presentation:
  - Hypoxemia (differential cyanosis)
  - May/may not have increased work of breathing (if RDS/lung disease present)
- If suspected PPHN, need to rule out congenital heart disease





# PPHN



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# Ventilation and Oxygenation

- Ventilation is exchange of gases between the lungs and the atmosphere, allowing oxygen to enter the lungs and carbon dioxide to exit
- Oxygenation is the addition of oxygen to the body

# Respiratory Support

- Supplemental O<sub>2</sub>
  - Nasal cannula
  - Oxyhood
  - Blow-by oxygen
- PEEP/Supplemental O<sub>2</sub>
  - Nasal or mask CPAP
  - High Flow Nasal Cannula

# Respiratory Support

- Supplemental O<sub>2</sub>
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# Respiratory Support

- PIP/Supplemental O<sub>2</sub>
  - Self-inflating bag
- PIP/PEEP/Supplemental O<sub>2</sub>
  - Flow-inflating bag
  - T-piece resuscitator
- Artificial airway
  - Laryngeal mask
  - Endotracheal tube

# Respiratory Support

- PIP/Supplemental O<sub>2</sub>
  - Self-inflating bag
- PIP/PEEP/Supplemental O<sub>2</sub>
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# Self-Inflating Bag



# Self-Inflating Bag

- Delivers PIP and oxygen
  - Varies with each breath – controlled by person squeezing bag
- Works without flow source if needed
- Can attach to endotracheal tube
- Does not deliver CPAP/PEEP: will suffocate infant if you do not provide breaths while mask is sealed to infant's face!



# Flow-Inflating Bag



# Flow-Inflating Bag

- Delivers PEEP (CPAP)/PIP (NIPPV)/oxygen
  - PIP varies with each breath – controlled by person squeezing bag – may need higher flows to give higher PIP/PEEP
- Can attach to endotracheal tube
- Requires airflow source

# T-Piece Resuscitators



Neopuff™



Neo-Tee®

# T-Piece Resuscitator

- Delivers set PEEP (CPAP)/PIP (NIPPV)/oxygen
- PIP is consistent – adjusted by user if needed
- Can attach to endotracheal tube
- Requires airflow source
- Requires more setup/preparation
- Takes longer to adjust PIP

# Continuous Positive Airway Pressure (CPAP)

- Introduced in 1971
- Continuous flow CPAP
  - Bubble CPAP
  - Ventilator-derived CPAP
- Variable flow CPAP
- High Flow Nasal Cannula

# CPAP



# CPAP

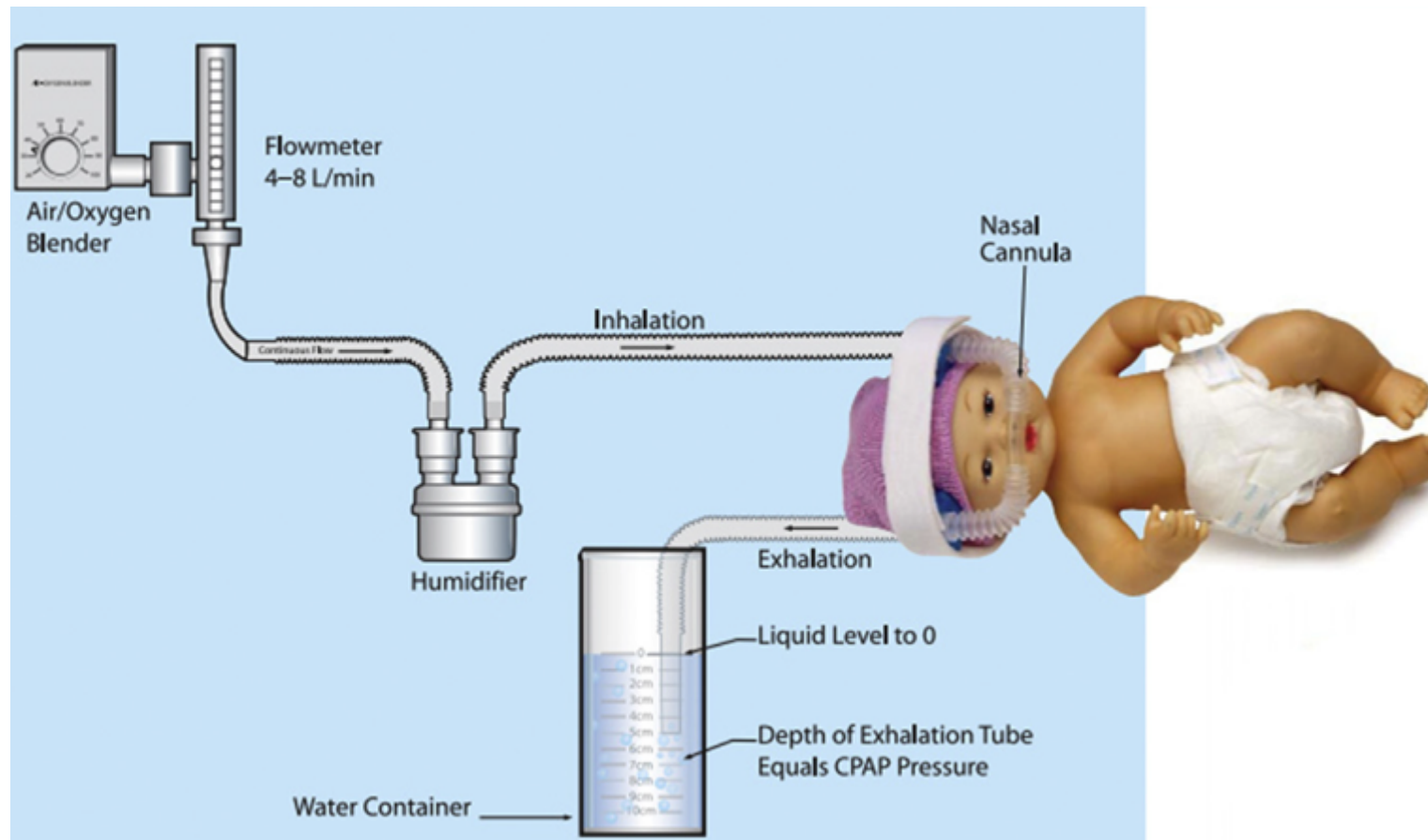
- Continuous flow CPAP
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- Variable flow CPAP
- High Flow Nasal Cannula

# CPAP (mask or nasal)

- Delivers PEEP and oxygen
- Closed system
  - Most systems require seal to deliver pressure
  - if nasal delivery and mouth open, infant not receiving desired PEEP
- If prongs, monitor for nasal septum breakdown



# Bubble CPAP



# High-Flow Nasal Cannula

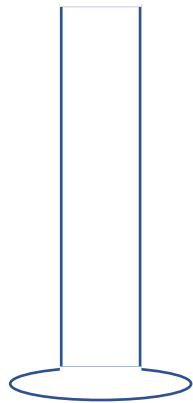


# High-Flow Nasal Cannula

- Delivers PEEP and oxygen
- Flow  $\geq$  2 L/minute
- Open system
  - Does not require tight seal like CPAP
- Difficult to know exact PEEP
- Unlike nasal cannula, requires humidifier/heater

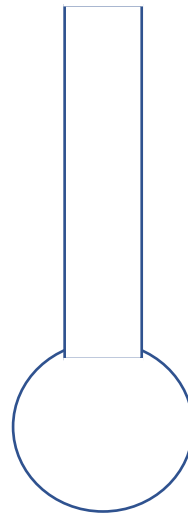
# FRC

No FRC

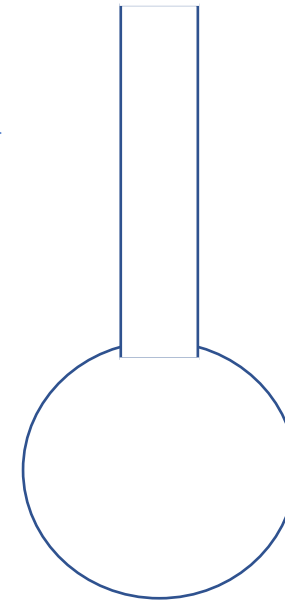


CPAP  
HFNC

At rest/expiration



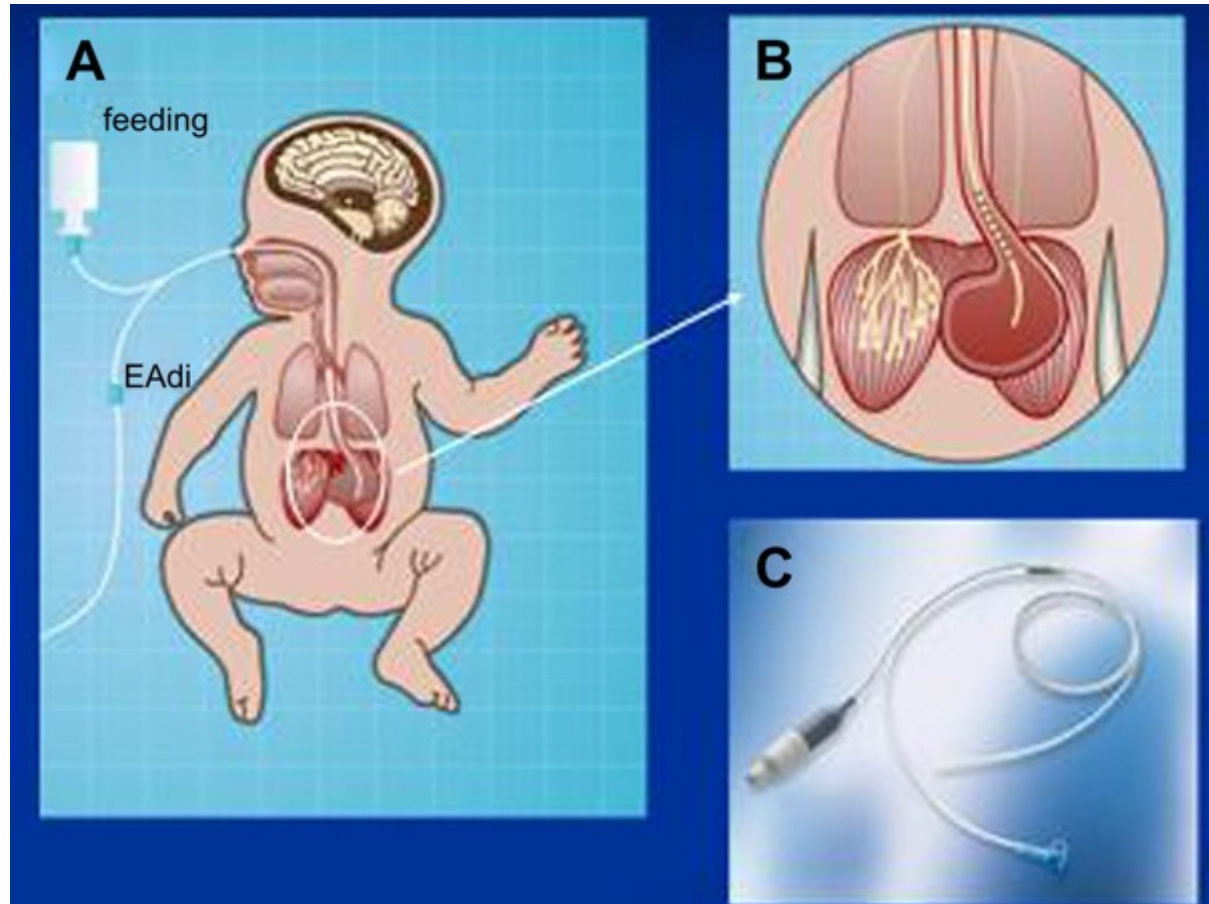
Inspiration



# Non-Invasive Positive Inspiratory Pressure Ventilation

- NIPPV
- A.k.a nasal intermittent positive inspiratory pressure
- Delivers PEEP and positive inspiratory pressure (PIP) at set rate without the presence of endotracheal tube
- Some modes may synchronize with patient's breathing effort (e.g. NAVA)
- Use same delivery interface as with CPAP

# Neurally Adjusted Ventilatory Assist (NAVA)

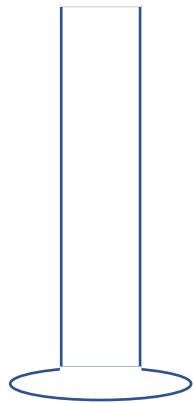


# Neurally Adjusted Ventilatory Assist (NAVA)

- Catheter measures electrical activity of diaphragm (Edi)
- Ventilator delivers breaths synchronized to initiation, size, and termination with each patient breath

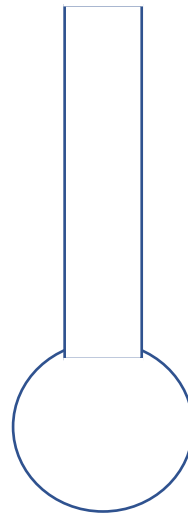
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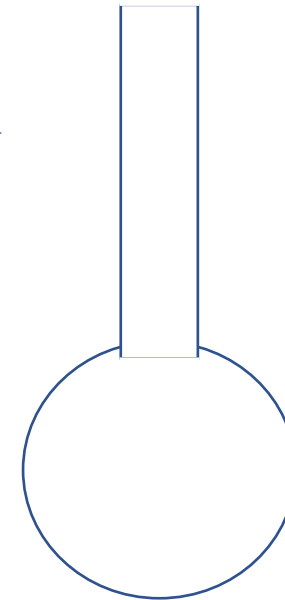
**CPAP**  
**HFNC**

At rest/expiration



**NIPPV**

Inspiration





# On The Horizon/Cutting Edge

- Non-invasive high frequency ventilation
- Minimally invasive surfactant therapy

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# Which mode of support?

## Keep It Simple

- Term vs preterm
- Tachypnea only vs increased WOB
- FiO<sub>2</sub> needs: < or ≥ 40%

# Which mode of support?

## Keep It Simple

- Term
  - Can use oxyhood or nasal cannula depending on work of breathing/ $\text{FiO}_2$  needs/high suspicion for TTN
- Preterm
  - Would not recommend oxyhood or nasal cannula as patient likely to need PEEP
  - Exception if closer to 37 weeks birth gestation and high suspicion for TTN

# Which mode of support? Keep It Simple

- Tachypnea only
  - Can use oxyhood or nasal cannula depending on  $FiO_2$  needs/high suspicion for TTN
- Increased WOB
  - HFNC or CPAP

# Which mode of support? Keep It Simple

- $\text{FiO}_2 < 40\%$ 
  - If term, can use oxyhood or nasal cannula depending on work of breathing/high suspicion for TTN
- $\text{FiO}_2 \geq 40\%$ 
  - HFNC or CPAP

# Case Examples

- Full term infant delivered via scheduled c-section at 39 0/7 wks. Mother not in labor
- Infant with nasal flaring/subcostal retractions at birth that seem to be improving
- Tachypneic and sats in 80s without oxygen
- With  $\text{FiO}_2$  at 30%, sats are in 90s



# Which Respiratory Mode?

- Nasal cannula or oxyhood
- If increased WOB persists and not improving by 2-4 hrs, HFNC or CPAP

# Case Examples

- 35 wk infant delivered via induction for ... (insert reason). Infant eventually delivered via c-section for non-reassuring fetal heart tones
- Infant with tachypnea/nasal flaring/subcostal retractions at birth. Sats in low 80s without oxygen

# Which Respiratory Mode?

- HFNC or CPAP
- Patient needs PEEP: do not use NC or oxyhood
- May need surfactant: monitor for improvement with HFNC/CPAP and fio<sub>2</sub> need

# What about NIPPV?

- May need to continue to using NIPPV once patient stabilized in delivery room if patient has apnea but would need to monitor closely and assess if patient needs intubation

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**Questions?**