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Respiratory Therapies for the Pediatric Cardiac Population

Supplemental Oxygen: Flow

- Rate in which oxygen is delivered to supplement the patient's tidal volume
  - Measured in Liters per Minute (L/min)
- Every increase by 1 L/min equates to about a 4% increase in FiO_2, starting from 24%
- Use flowmeters to adjust based on patient's work of breathing
  - Standard (pediatric/adult): 1-15 LPM
  - Low flow (neonate/infant): 1/8 – 3.5 LPM

Below 1L Flow

Standard Flow

Supplemental Oxygen: Flow

- Connect to the wall or to a FiO_2 blender
  - If nasal cannula is connected to the flow meter on the wall, your patient will receive FiO_2 at the rate for which the flow is set
    - 1 LPM = 24%
    - 2 LPM = 28%
    - 3 LPM = 32%
  - If nasal cannula is connected to the flow meter on the blender, the nurse will be able to adjust the FiO2 based on patient's saturations and not effect the flow

Supplemental Oxygen: Fraction of Inspired Oxygen (FiO_2)

- Percentage or concentration of oxygen inhaled by a person
  - Natural air 21% oxygen
- Oxygen blenders allow oxygen concentration to be adjusted between 21%-100%
- Ability to keep the same flow but titrate FiO_2 on blender to give concentrated oxygen
  - Flow is needed to support the extra FiO_2 delivery
- Adjust FiO_2 to compensate for patient desaturations
- Reminder: Oxygen is a pulmonary vasodilator

Non-invasive Oxygen Delivery Systems

Device	**Nasal Cannula**	**Simple Face Mask**	**Venturi Mask**	**Non-Rebreather**	**High Flow Nasal Cannula (HFNC)**
					
Flow Rate	Infant (0-12 months): 1-2 L/min Pediatric & Adult: 1-4 L/min (max 6L for older patients)	6-10 L / min	Blue: 2L/min Yellow: 4L/min White: 6L/min Green: 8L/min Pink: 8L/min Orange:12L/min	10-15 L / min	2-60 L / min Initiate: 2 L / kg / min
FiO2	Each liter adds ~ 4% Fi02 1 LPM = 24% 2 LPM = 28% 3 LPM = 32%	40-60%	Blue: 24 % Yellow: 28% White: 31% Green: 35% Pink: 40% Orange: 50%	80-90% (not 100% because there may not be a perfect seal to the face)	21-100 %

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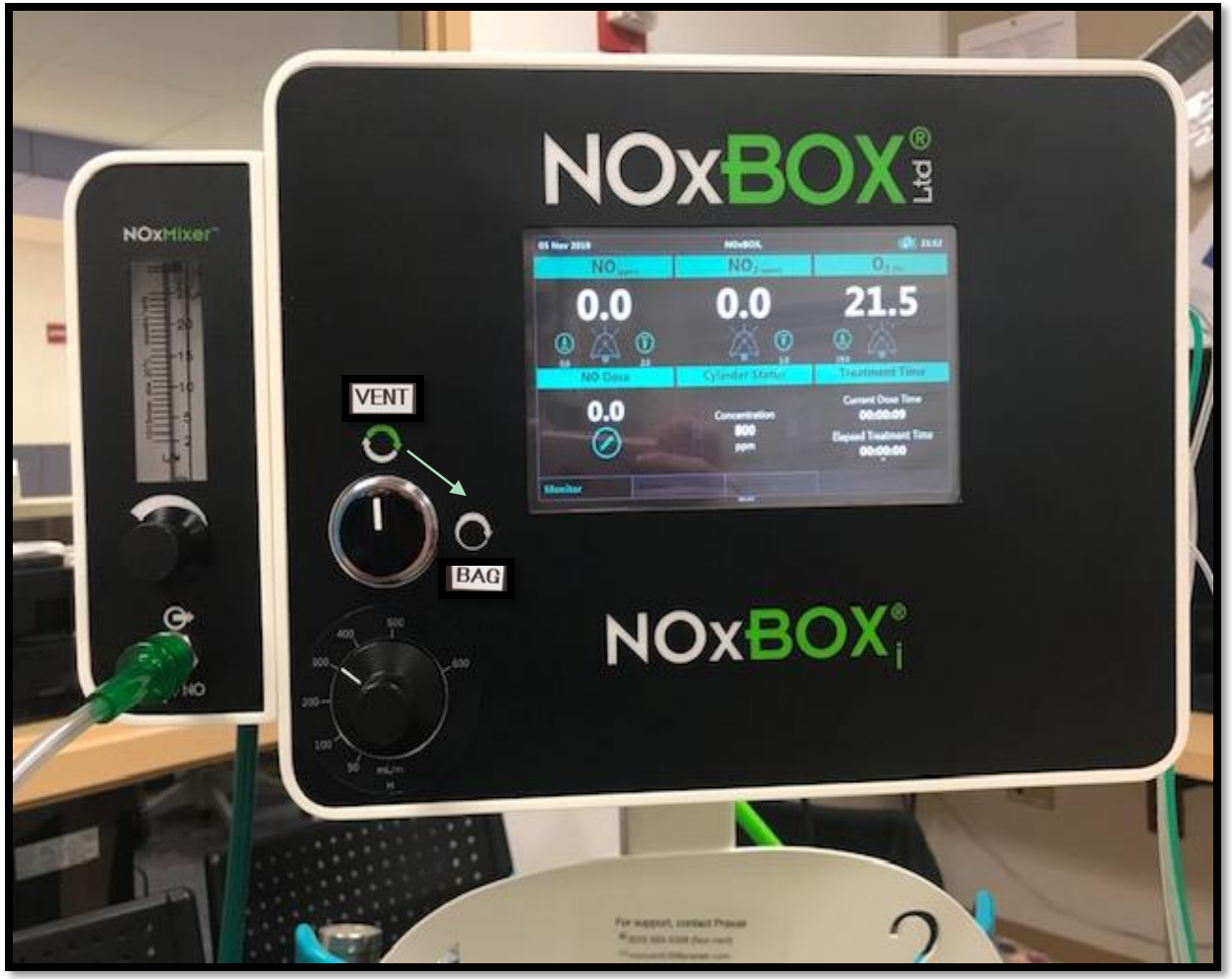
Supplemental Gases

Nitric Oxide (NO)

- Nitric Oxide is a vasodilator of the pulmonary arteries
  - Decreases PVR to avoid pulmonary under-circulation
  - Used with stiffness/hypertrophied/dysfunction of R heart
  - Used with pulmonary hypertension (acute)
- Important to ensure there is a continuous flow of nitric oxide through the circuit
- Manual BVM with NO



Hypoxic Mixture (Nitrogen)

- Therapy using nitrogen to reduce the FiO_2 to less than 21% in pre-operative single ventricle patients
  - Decreases arterial oxygen saturation to < 85% by controlling FiO2 between 14-20%

- Aim to relieve pulmonary over circulation before cardiac surgery
  - Vasoconstrictor of the pulmonary arteries

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Bubble CPAP

Bubble CPAP

- Creates pressure by placing the expiratory system in a column of liquid.
- Flow of air into the liquid causes bubbling of the liquid.
  - Creates small airway pressure oscillations that are transmitted to the baby's chest
  - Creates better lung inflation and improved gas exchange
- 7 sizes of prongs that can be measured to fit in the infant's nares and create a pressure seal.

Bubble CPAP: Equipment

Baby Bumper:
Helps to stabilize prongs in position. Applied to cannula and Velcro's to mustache or headband.

Headbands:
Holds the cannula in place and is based on patient's OFC. It can absorb sweat/moisture and gives you access to use of scalp IVs, probes, NIRS, etc.

Nasal Prongs:
Based on sizing chart of nares. Ensure these are **NOT** directly against the septum. Maintain distance of 2-3 mm between bridge of prongs and septum.

Baby Mustache:
Helps to stabilize prongs in position. Applied directly to baby's upper lip.

Bubble CPAP: Nursing Responsibilities

Prong checks	Prevention of nasal obstruction or injury	Gastric distention & feeding	Headband assessment:	Oxygenation
• Complete to ensure skin and septum integrity. Prongs should not be pressing up against the nares, you may have to adjust if needed with the help of RT. • **Document** "septum intact" in the Respiratory Assessment Freq comment section during assessment.	• Check proper prong positioning & maintain nasal patency (suctioning) • Do not use creams, gels, Duoderm, etc. on the septum	• May experience abdominal distention during delivery from swallowing air • Recommended to use OG tube for gastric decompression because NG tubes will cause a break in the CPAP seal and potential skin breakdown	• Ensure your headband is not too tight around the baby's head to prevent misshaping.	• Bubble CPAP is connected to the same oxygen blenders. Adjust FiO_2 as necessary. • To ensure adequate ventilation and pressure, assess for continuous bubbling in the chamber frequently.

Bubble CPAP: Troubleshooting

Intermittent bubbling	• Poor airflow and poor nasal prong position • Leak at mouth
No bubbling	• Prongs are not in position (out of nose, leak at mouth) • Poor airflow will be associated
Air leak	• Usually due to an open mouth • Chin straps available that attach to the Baby Head Band
Poor airflow	• Ensure nares patency (suction if needed) • Ensure pressure seal in nares (use supports to stabilize the prongs)

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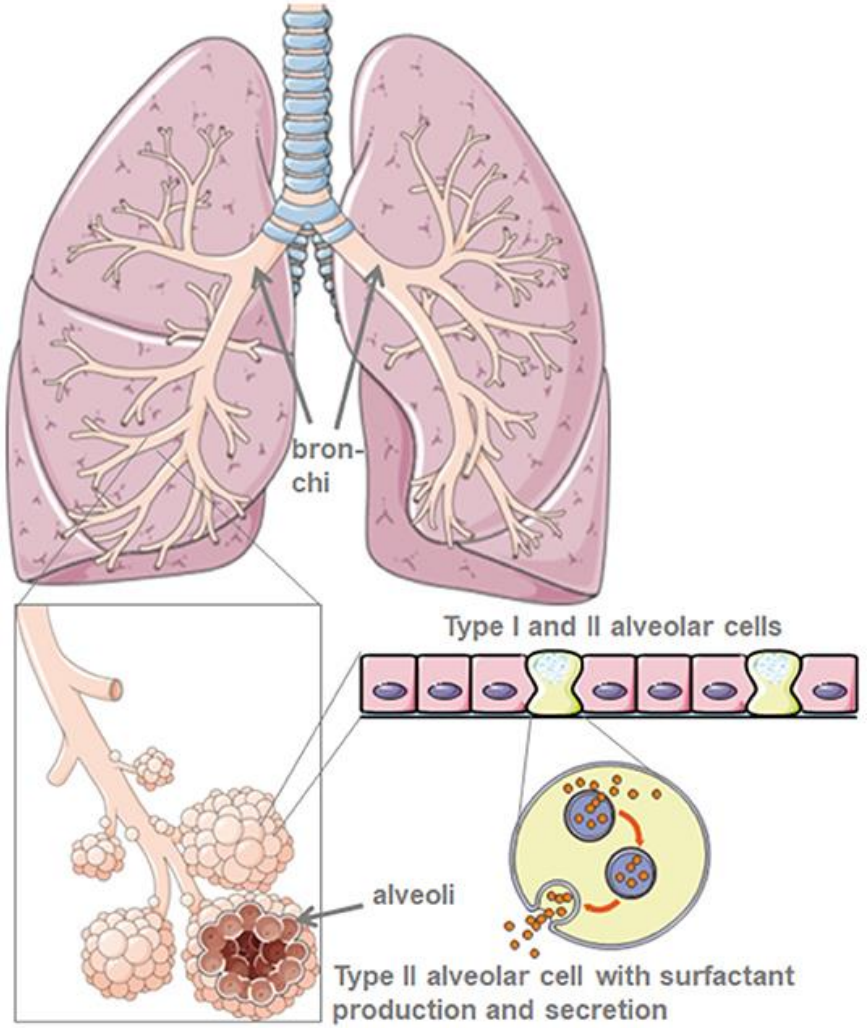
Mechanical Ventilation

(Invasive & Noninvasive)

Mechanical Ventilation: Common Terminology

- Flow
  - Air behaves in a fluid manner, moving from an area of high pressure to low pressure
    - Air flows in during inspiration because alveolar pressure is less than atmospheric pressure
    - Exhalation is passive and dependent on the patient

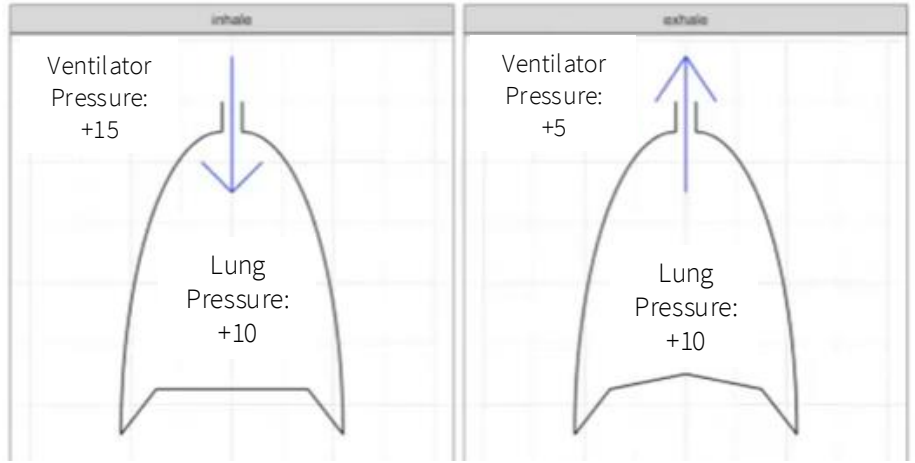
- Gas Exchange and Transport
  - Alveolus: functional unit of gas exchange through simple diffusion
  - Two types of epithelial cells
    - Type 1 : gas exchange
    - Type 2 : produce surfactant → mixture of fat and proteins (phospholipid/protein composition) that coats the alveoli and prevents the alveoli from sticking together when exhaling



Mechanical Ventilation: Common Terminology

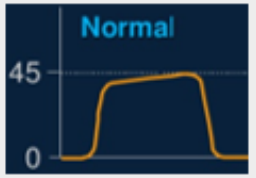
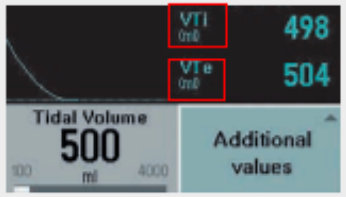
- Airway Resistance
  - Resistance to the flow of air through the respiratory tract during inspiration and expiration
    - Dependent on the dimension of the airway, viscosity of the gas, and turbulent/laminar flow
    - High resistance = larger driving pressure required to produce the same flow rate

- Compliance
  - "Stiffness" of the lungs and chest wall
    - Low compliance = need for bigger pressure to move air into lungs
    - High compliance = need for less pressure to move air into the lungs
  - Decreased compliance with increased age and/or disease
  - Varies within the lung according to the degree of inflation
  - Lung volume:
    - Low volume: difficult to produce that initial inflation
    - High volume: chest wall expansion is limited



Ventilators actively inhale by increasing the pressure outside of the chest (airway pressure)
Called positive pressure ventilation

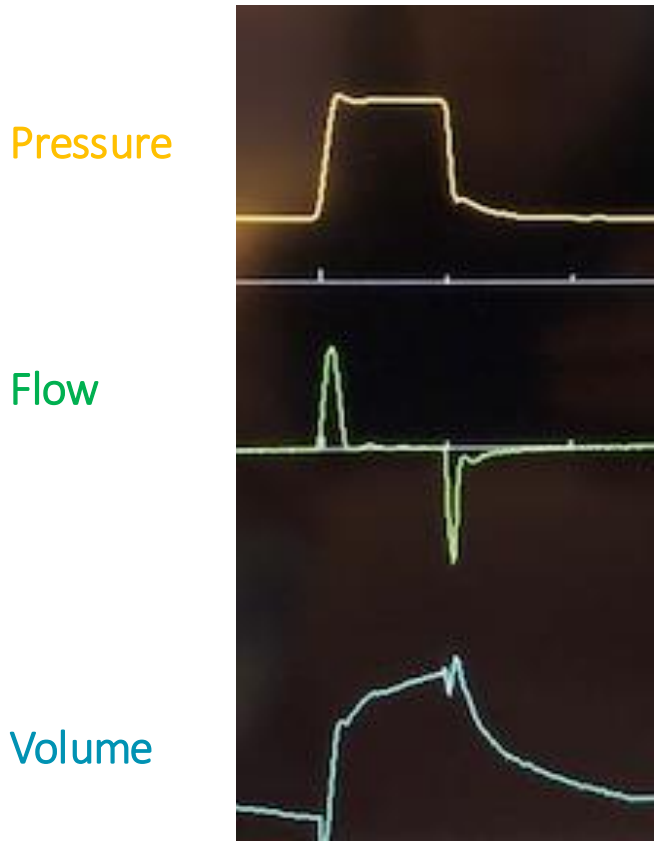
Mechanical Ventilation: Common Terminology

End Tidal CO_2 $EtCO_2$		Measurement of exhaled carbon dioxide (CO_2). Useful for trending (capnography) and determining effective ventilation. Normal ranges are usually 35-45 mmHg.
Mean Airway Pressure (MAP)		Average pressure applied to the lungs during a respiratory cycle. Useful for monitoring hemodynamic performance and risk of barotrauma during mechanical ventilation.
Peak Airway Pressure (PAP)		Highest amount of pressure applied to the lungs during inhalation. Normal ranges are usually 18-30 cmH_20. Increases with airway resistance.
Positive End Expiratory Pressure (PEEP)		Maintained in the alveoli and helps to prevent collapse of the airways at the end of exhalation. Normal ranges are usually 5-10 cmH_20.
Tidal Volume (TV)		Volume of air moved between inhalation and exhalation. Normal ranges are usually 8-10 ml/kg (CICU, PICU) 500 ml (adults) VTi: inspired tidal volume, delivered by ventilator VTe: exhaled tidal volume

Mechanical Ventilation: Pressure Control Mode

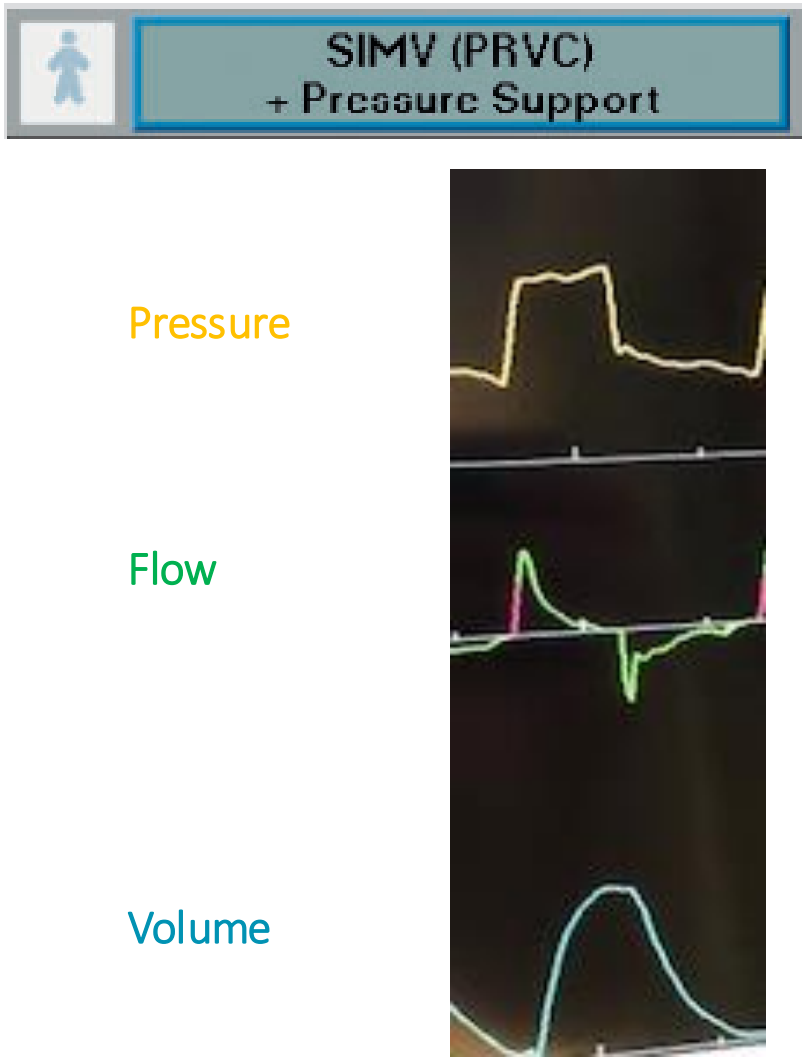
- Pressure control: control of the airway pressure (peak pressure set, volumes variable)
  - Airway pressure is fixed throughout inspiration and flow will decrease throughout inspiration
    - PC above PEEP + PEEP = Peak pressure
  - Flow & volume are dependent on pressure

- Ventilator responsibilities:
  - Increases pressure to a set number during inhalation
  - Air flows into the lungs with the jump in airway pressure and flows into the patient's lungs
    - Passive expiration (dip)



Mechanical Ventilation: Pressure Regulated Volume Control Mode

- PRVC: ventilator adjusts peak inspiratory pressure to target a tidal volume
  - Airway pressure is fixed throughout an inspired breath but can vary between breaths
  - PEEP, PIP, FI02, Tidal Volume (suggest)
- Ventilator responsibilities:
  - Uses pressure regulated waveforms
  - Hold steady airway pressure during inhalation and releases for exhalation
- Difference between PRVC and PC
  - Ventilator will automatically adjust the PIP in order to try and target the tidal volume



Pressure Regulated Volume Control (PRVC) vs Pressure Control Modes of Ventilation

	PRVC	Pressure Control
Tidal Volume (VT)	Set	Variable
Peak Inspiratory Pressure	Variable	Set
Patient Population	Healthy Lungs (Same day surgery patients, caths, etc.)	Unhealthy Lungs (Chronic Intubation, Infection, Effusions, etc.)
Advantages	• Quickly see changes in lung compliance • Less effect on venous return and cardiac output.	• Less Barotrauma
Disadvantages		• No guaranteed tidal volumes

Troubleshooting hypoxia for an intubated patient

*Use the DOPE mnemonic

D	Displacement	Check the ETT position, auscultate bilateral lung sounds, confirm placement w/ capnography and/or a chest x-ray
O	Obstruction	Pass a suction catheter to clear any obstruction; consider replacing ETT if there is concern that tube remains obstructed
P	Pneumothorax	Auscultate bilateral breath sounds, assess for symmetry in chest rise, obtain chest x-ray
E	Equipment	Check ventilator and all circuit connections; disconnect patient from circuit and manually bag
(R)	Rigidity	Consider chest wall rigidity if Fentanyl was given
(S)	Stomach	Assess for gastric distention