

UNDERSTANDING NEONATAL MODES OF VENTILATION

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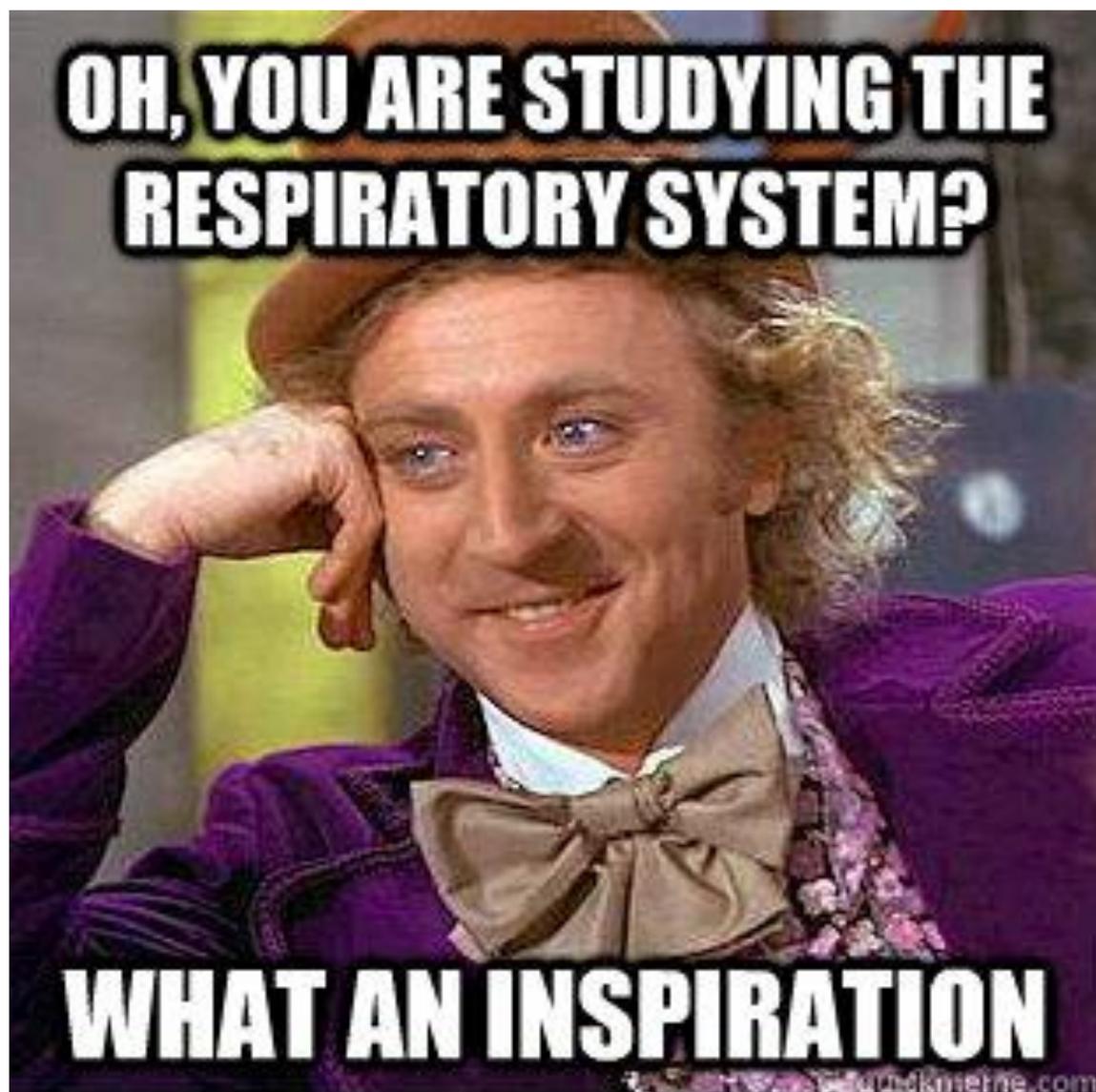
OBJECTIVES

- Healthcare professionals are able to self-report at least one management technique for Respiratory Distress Syndrome.
- Healthcare professionals are knowledgeable about best practices of differentiating modes of ventilation in treating premature lung disease.
- Healthcare professionals are able to self-report at least one indication for the use of Nitric Oxide treatment in the Neonatal intensive Care Unit.

DISCLOSURES

I have none





**OH, YOU ARE STUDYING THE
RESPIRATORY SYSTEM?**

WHAT AN INSPIRATION

Fetal Lung Development

RDS/PIE

Surfactant Deficiency

Modes of Ventilation

Nitric Oxide

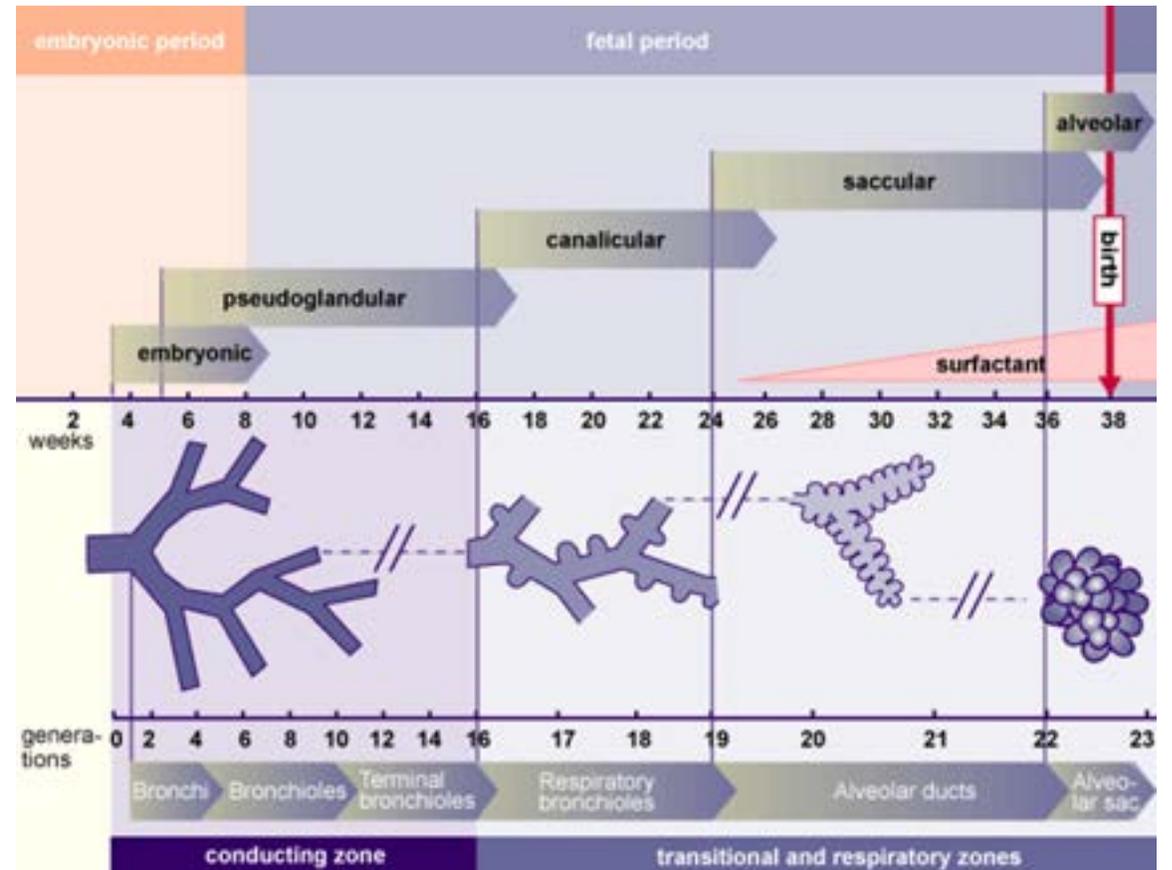
UNDERSTANDING NEONATAL MODES OF VENTILATION

FETAL LUNG DEVELOPMENT

- ❖ Saccular & Surfactant
- ❖ Alveoli develop when?



- ❖ Fun fact – females are 2wks ahead of males in lung development



PREMATURE ALVEOLI

Alveoli are present in some infants as early as 32 weeks. However, they are not uniformly present until 36 weeks gestation



SURFACTANT DEFICIENCY

- Main characteristic of premature lungs/RDS
- Fetuses begin to produce surfactant between weeks 24 and 28 weeks.
- Surfactant deficiency **increases** the surface tension of the underdeveloped alveoli
- Maternal steroids help fetal lungs produce surfactant by...
- Babes born to Gestational Diabetic moms...

CLINICAL FINDINGS OF RDS

- Increased WOB
- Apnea
- Tachypnea
- Grunting
- Nasal flaring
- Cyanosis
- Increased O₂ needs

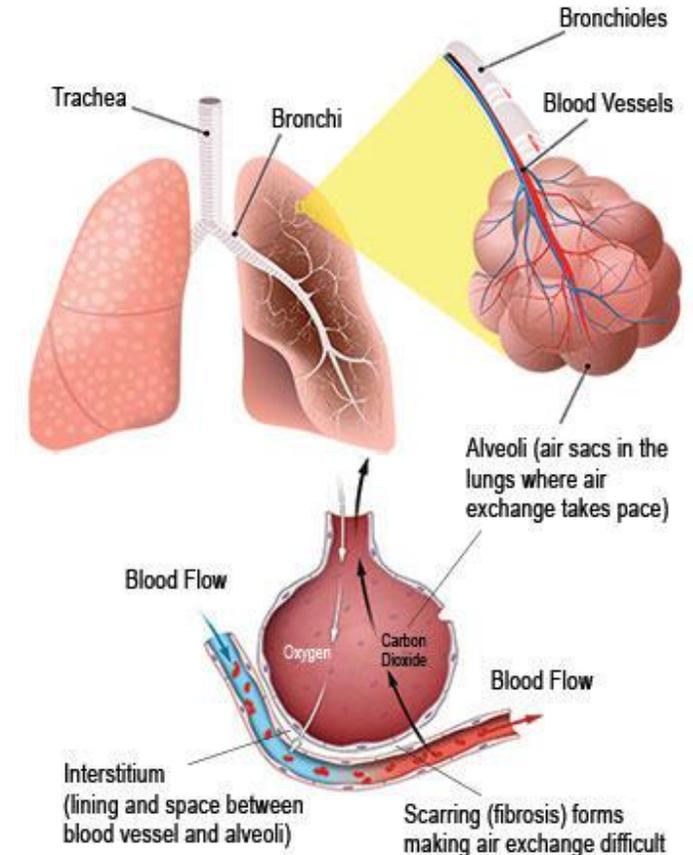


COMPLICATIONS

- alveolar rupture
- Infection
- Chronic lung disease/Bronchopulmonary dysplasia (BPD)
- Death
- Retinopathy of prematurity (ROP)
- Cardiac impairment
- Neurologic impairment/
Intracranial hemorrhage
- Pulmonary Interstitial Emphysema (PIE)

PULMONARY INTERSTITIAL EMPHYSEMA (PIE)

- Pulmonary interstitial emphysema (PIE) is when there are tiny ruptures in the alveolar sacs which results in **air getting trapped in the tissue outside the air sacs in the lungs**. That air becomes DEADSPACE, or air that does not participate in adequate gas exchange.
- Result from over-distention of the lungs
- With appropriate ventilation, it can resolve gradually over 2-3wks time
- Prevalent in ventilated ELBW/micro-preemies in the first 72hrs



MODES OF VENTILATION

- HFOV
- JET (HFJV)
- AVEA & DRAGER (CONVENTIONAL VENTILATION)
 - PRESSURE VS VOLUME
 - SIMV
 - AC
 - NIMV
 - CPAP

VENT TERMINOLOGY-

- **PIP** – highest level of pressure that exists in the lungs during inspiration, determines the size of the patient's vent breaths
- **Tidal Volume** – volume of air in mls that moves in or out of the lungs during a breath, determines the size of the patient's vent breaths
- **PEEP** – pressure in the lungs that exists at expiration, controls oxygenation
- **Rate** – number or frequency of breaths given per minute
- **I-time** – the time it takes to deliver a breath
- **Pressure Support** – set supportive inspiratory pressure that assists spontaneous breaths, determines the size of the patient's spontaneous breaths
- **MAP** (Mean Airway Pressure) – average constant pressure in the lungs during ventilation
- **Delta P** - the difference between two measured pressure values
- **Hertz** – unit of frequency equivalent to 1 breath per second
- **Servo** - driving pressure that automatically regulates flow

HIGH FREQUENCY OSCILLATING VENTILATOR HFOV

An unconventional “lung protective” form of mechanical ventilation

- First introduced in the 1970s
- Primarily used for neonates
- Minimizes cyclic stretch volutrauma

“HFOV is essentially a vibrating CPAP machine” – Anthony Tobin

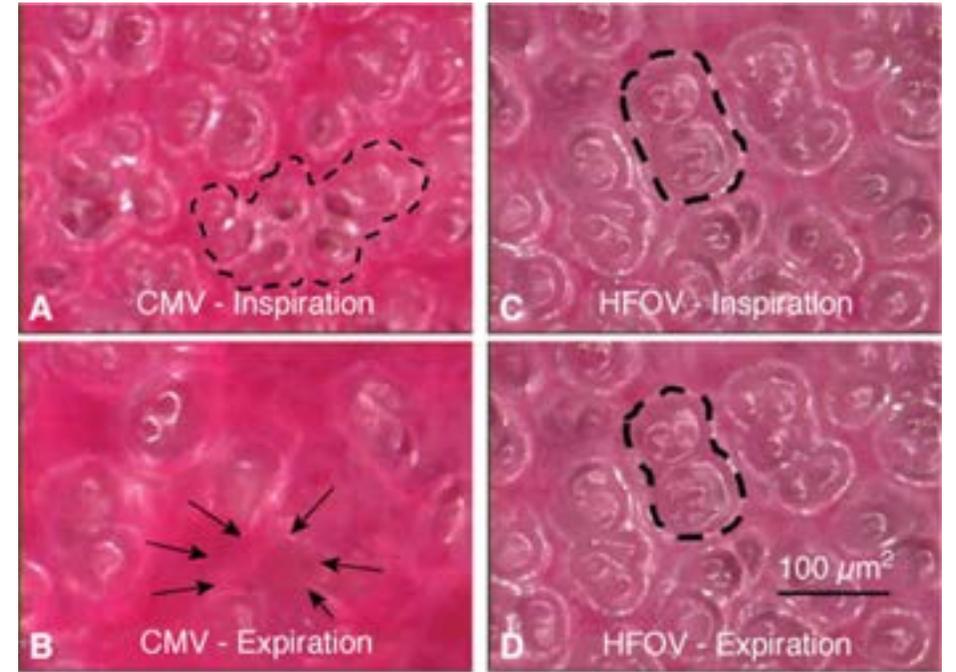


HFOV

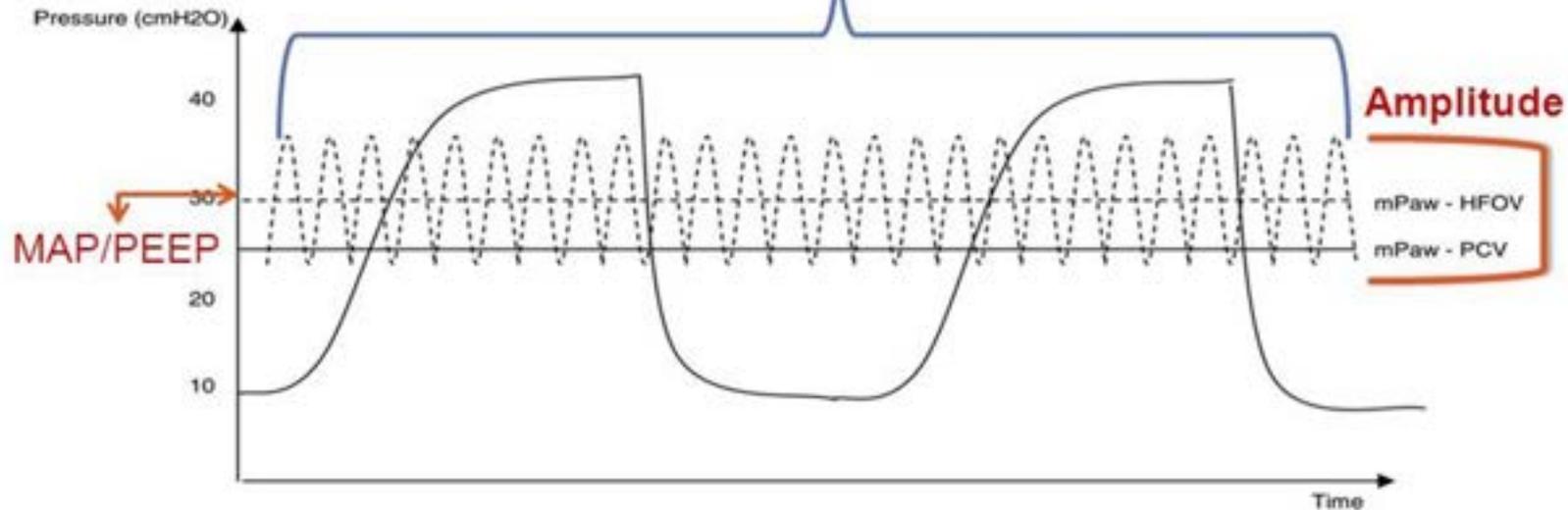
Characteristics of Function:

- Small (unmeasurable) Tidal Volumes (1-4ml/kg)
- Delivered at high frequencies (3-15 Hz) with an oscillatory pump/piston
- Both ACTIVE inhalation and exhalation
- Maintains constant lung recruitment
- Aims to prevent lung injury from over distension

HOLY ALVEOLI...



Oscillation/Frequency Hz



*Its much harder to open alveoli than to keep them open

HFOV

Indications for use:

- Extreme V/Q Mismatch (un-manageable blood gases)
- Hydrops
- Any pt who needs ventilated with higher pressures/MAP
- Congenital Diaphragmatic Hernia (CDH)
- Persistent Pulmonary Hypertension of the Newborn (PPHN)
- Extreme prematurity when JET not available

HFOV

Sensor Medics 3100-A CONTROLS

- MAP – mean airway pressure
- Delta P – amplitude
- Hz – frequency
- FiO₂

Pig lung video <https://www.youtube.com/watch?v=T-d35aEc2-k>

<https://www.youtube.com/watch?v=QXB6hp6nlZw>



HFOV

Example settings:

- MAP 12 (generally will start 2 above measured MAP on conventional)
- DeltaP 24 (generally 2x the MAP)
- HZ 10

HFOV

Management of Settings

Decreased oxygenation



Increase MAP/FiO₂

Decreased ventilation/jiggle



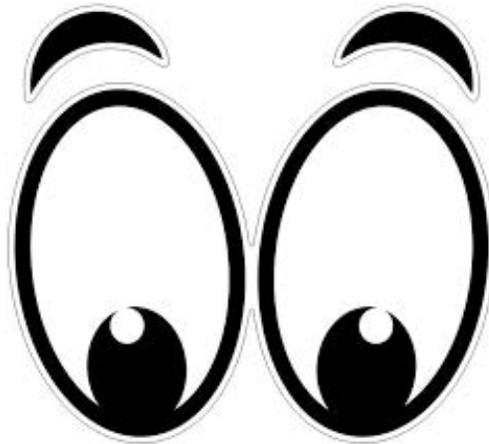
(ex ABG: 7.11/82)

Increase Delta P or possibly decrease Hz (opposite of conventional)

**always monitor CXR for over-inflation – may need to decrease MAP

HFOV - TROUBLESHOOTING

What is one of the most reliable ways to know your HFO kid is ventilating??



JIGGLE

<https://www.youtube.com/watch?v=tszki0i-Zys>

HFOV

Jiggle (crucial to patient's ventilation)

Note upon initial start of HFOV

Lost jiggle

- first attempt to suction (tube may be slightly plugged)
- Reposition babe – check ETT placement
- One sided jiggle – ETT displacement/pnuemo
- Lung compliance
- May need re-intubated

HFOV

KNOW YOUR JIGGLE!!!!

KNOW YOUR JIGGLE!!!!

KNOW YOUR JIGGLE!!!!

KNOW YOUR JIGGLE!!!!



HFOV

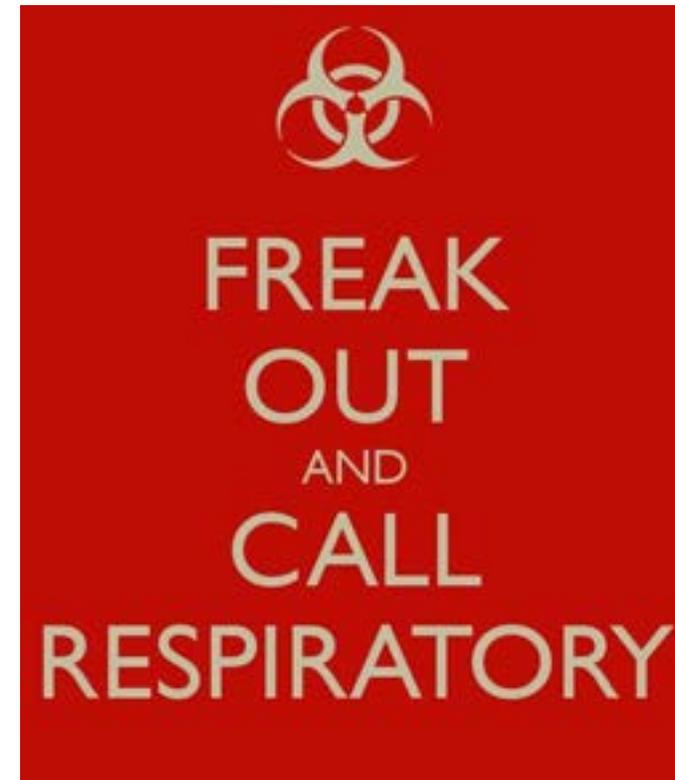
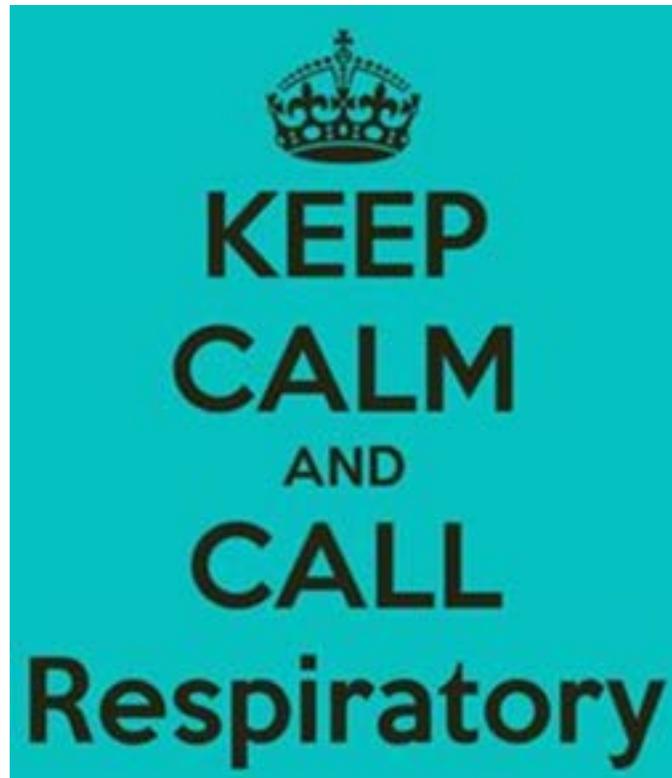
Troubleshooting/Management

- Suction prn/before ABG's
- Call RT for all head repositioning
- ALARMS

Causes of alarms:

- needs suctioned
- sx catheter pulled back too far
- sx port left open
- pt lung compliance
- pt breathing over HFO
- water in circuit
- humidifier dry
- leak in system
- disconnect
- extubation

MY HFOV IS ALARMING...



HFOV

Weaning:

- First wean $\text{FiO}_2 \leq 40\%$ (except when lungs are overinflated on CXR)
- Wean MAP in 1-2 increments until setting is 8-10
- Wean Delta P in 1-2 increments until setting is 20-25
- Switch to conventional

JET (HFJV)

- Developed in the 80's after so much preemie death from PIE
- An unconventional “lung protective” form of mechanical ventilation
- Small (unmeasurable) Tidal Volumes (1 - 4ml/kg)
- Delivered at high frequencies/Rates (240-660bpm)
- ACTIVE inhalation but PASSIVE exhalation
- Maintains constant lung recruitment
- Aims to prevent lung injury from over distension
- Less mean & peak pressures are needed to ventilate/oxygenate



JET VALUES -

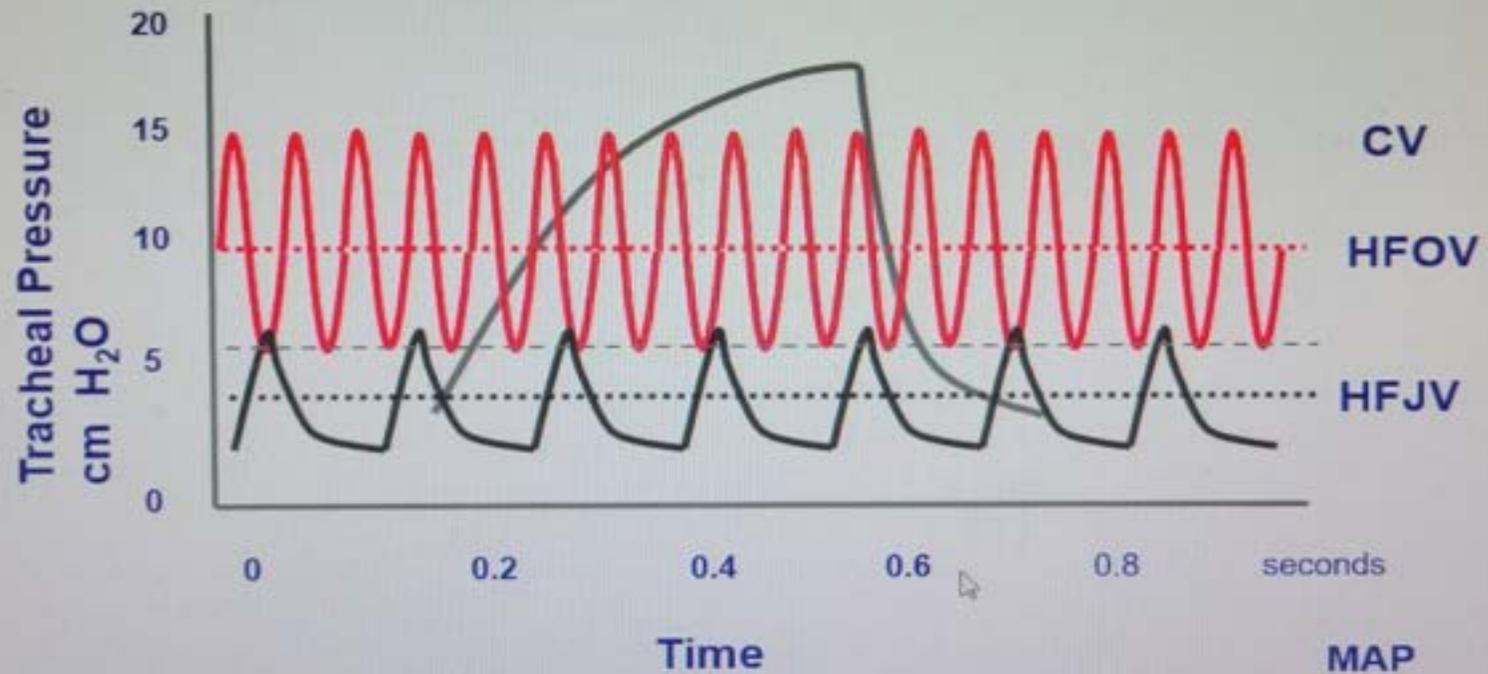
- CONTROLS
 - PIP – adjust to manage CO2
 - RATE – wont change much, but may adjust to manage CO2 (slower than HFO)
 - I-time – always 0.02
 - PEEP – set on Draeger not JET, adjust to manage oxygenation
- MONITOR (will fluctuate) –
 - Want PIP/PEEP measurements to be close to set
 - Servo – trending value
 - Delta P – numeric difference in PIP-PEEP
 - MAP – average pressure of PIP/PEEP



WHY JET VS HFO???

- ACTIVE vs PASSIVE exhalation
- JET uses lower pressures overall due to passive exhalation
- HFO can be used to prevent PIE, but cannot fix or heal PIE
- The JET'S high velocity, small tidal-volume jet breaths cannot penetrate injured areas of the lung with high resistance, allowing those areas to rest and heal
- Moving forward in our NICU.....
- <https://www.youtube.com/watch?v=50GF36sKy4E>

PRESSURE WAVEFORM COMPARISON



Boros, et al. Ped Pulm. 1989; 7:35-41

JET MANAGEMENT OF SETTINGS

Decreased Oxygenation  Increase MAP by increasing PIP, PEEP or both

Decreased Ventilation
(ex: ABG 7.11 / 82)  Increase delta P by increasing PIP/decreasing PEEP or increase the rate

**unlike the HFO, JET rates are conventionally proportionate

**always monitor CXR for over-inflation – may need to decrease PIP/PEEP

CONSIDERATIONS -

- Must use in conjunction with conventional vent for PEEP
- Remember to adjust both Fio2 knobs
- JET may shut off with suctioning, but suction patient as usual/PRN
- Yellow monitored values will fluctuate with changes in pressure in lungs/circuit
- JIGGLE – less pronounced than on HFO
- CALL RT
- CALL RT
- CALL RT!!!



ALARMS & SIGH BREATHS -

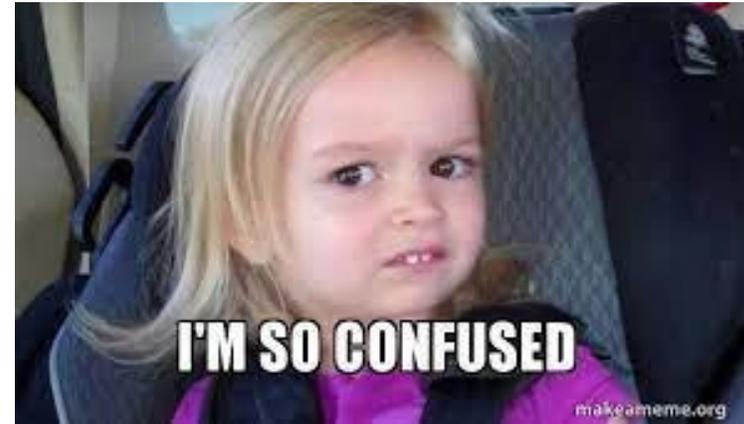
Only 2 alarm settings – MAP & SERVO

Both are auto-set by JET

May fluctuate with

- Baby breathing over
- Water in circuit
- Babe needs suctioned
- Leak in system
- Pneumothorax
- Changes in lung compliance

CALL RT with ANY alarms!



- Sigh breaths can be used by dialing in breaths via the conventional ventilator
- Primarily used to attempt to clear areas of atelectasis
- Rates of 4-10 breaths per min, PIP's of 10 over PEEP
- Also used for apnea (babe not breathing over JET)
- DO NOT USE MANUAL BREATH BUTTON

WEANING

First goal is always wean Fio₂ to less than 40%

Wean PIP in increments of 1 until around 14-18

May switch to conventional or just extubate right from JET

AVEA & DRAGER (CONVENTIONAL)

PRESSURE VS VOLUME

SIMV

AC

NIMV

CPAP



PRESSURE VS VOLUME

Pressure Mode-

- PIP is set, Volume (VT) is variable
- Can be used for both SIMV & AC modes
- Typically used for near term/term babes (lungs close to fully mature)
- Most common mode for BPD/chronic lung babes
- Average set PIP is 18-24

Volume Mode – (volume guarantee)

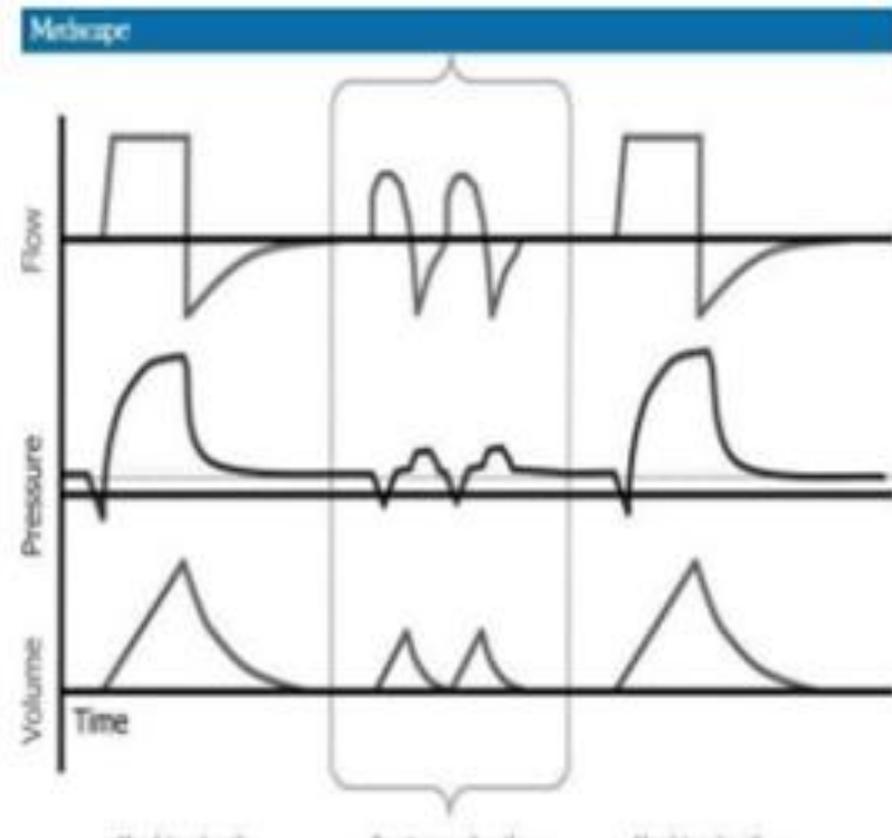
- VT is set, PIP (pressure) is variable
- Can be used for both SIMV & AC modes
- Typically used for preterm babes (lungs not fully mature)
- Minimizes “Volutrauma” or damage to lungs caused by over-distention
- Average set VT is 4-6mls/kg

SIMV

Synchronized Intermittent Mandatory Ventilation

- Set PIP or VT, PEEP, RATE, PS, I-Time
- Vent breaths will be larger than spontaneous breaths
- Mostly used for term/near term pt's & those having trouble syncing with the vent
- Ideal for pt's with a BPD diagnosis to prevent air trapping

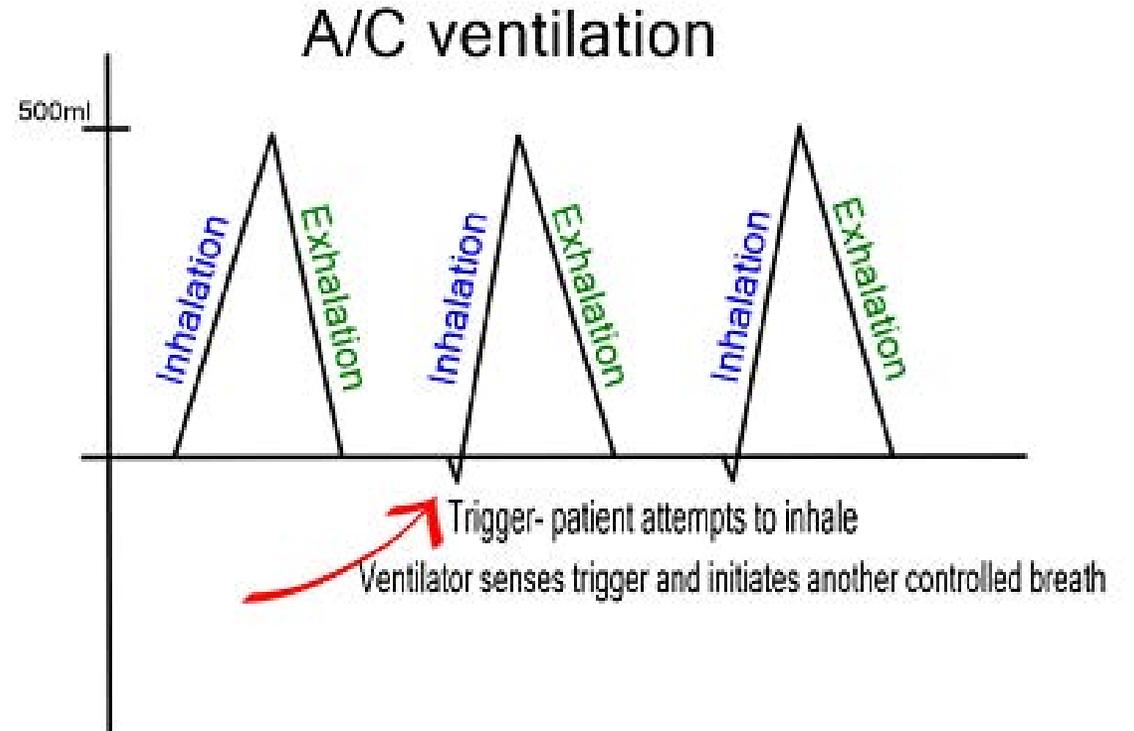
SIMV



AC

Assist Control

- Set PIP or VT, PEEP, RATE, I-Time (no pressure support)
- Each breath is the same size
- Pt can trigger but will receive same size of breath each time
- Ventilator has more control
- Most common mode used in our unit



CONVENTIONAL MANAGEMENT OF SETTINGS

Decreased oxygenation

ABG 7.31 / 56 / 38



Increase PEEP / FiO₂ / Possibly
increase PIP / VT

Decreased ventilation

ABG 7.11 / 80 / 65



Increase Rate / PIP / Possibly
increase pressure support / VT



CONVENTIONAL - TROUBLESHOOTING

High Rate/Autocycling ($> 100\text{bpm}$)

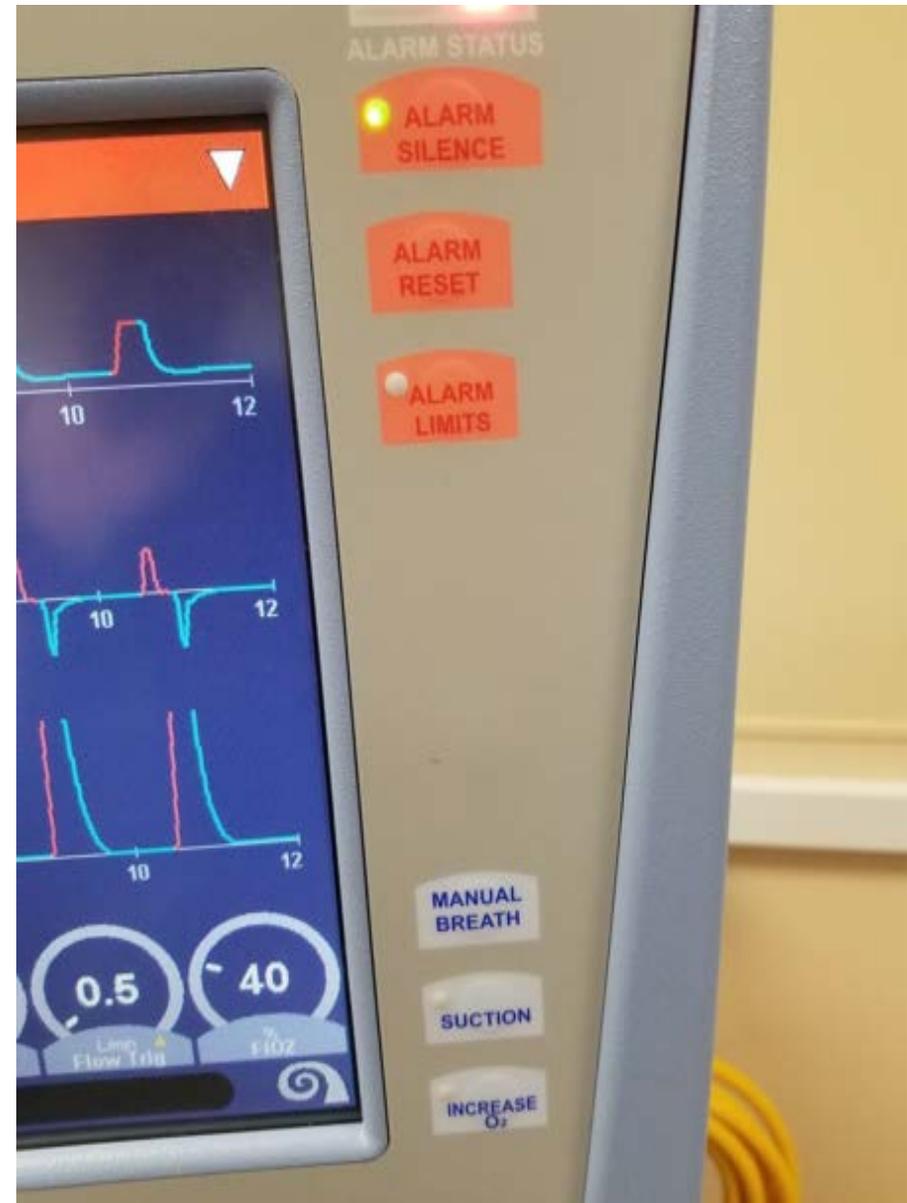
- pt tachypneic
- Port on suction open/suction catheter pulled back too far
- Water in circuit
- Flow sensor wet
- Patient extubated
- Large ETT leak

Low V_e (minute volume)

- ETT too small/large leak
- Leak in circuit
- Patient disconnected/extubated

Pressure limit/volume limit/circuit occlusion

- Hiccups
- Coughing
- Patient “bearing down” or stretching
- Patient needs suctioned/compliance issue
- Water in circuit



WHEN ALL ELSE FAILS...



CONVENTIONAL WEANING/EXTUBATION

Based on pt condition

ABG's

PIP 14-18

RATE 15-20

FiO₂ <40%

In VG – may wean the volume slightly

NON-INVASIVE VENTILATION

- Includes both NIMV & NCPAP
- Can be done on Avea or Drager
- Ram Cannula
- Flexi-Trunk



RAM VS FLEXI-TRUNK

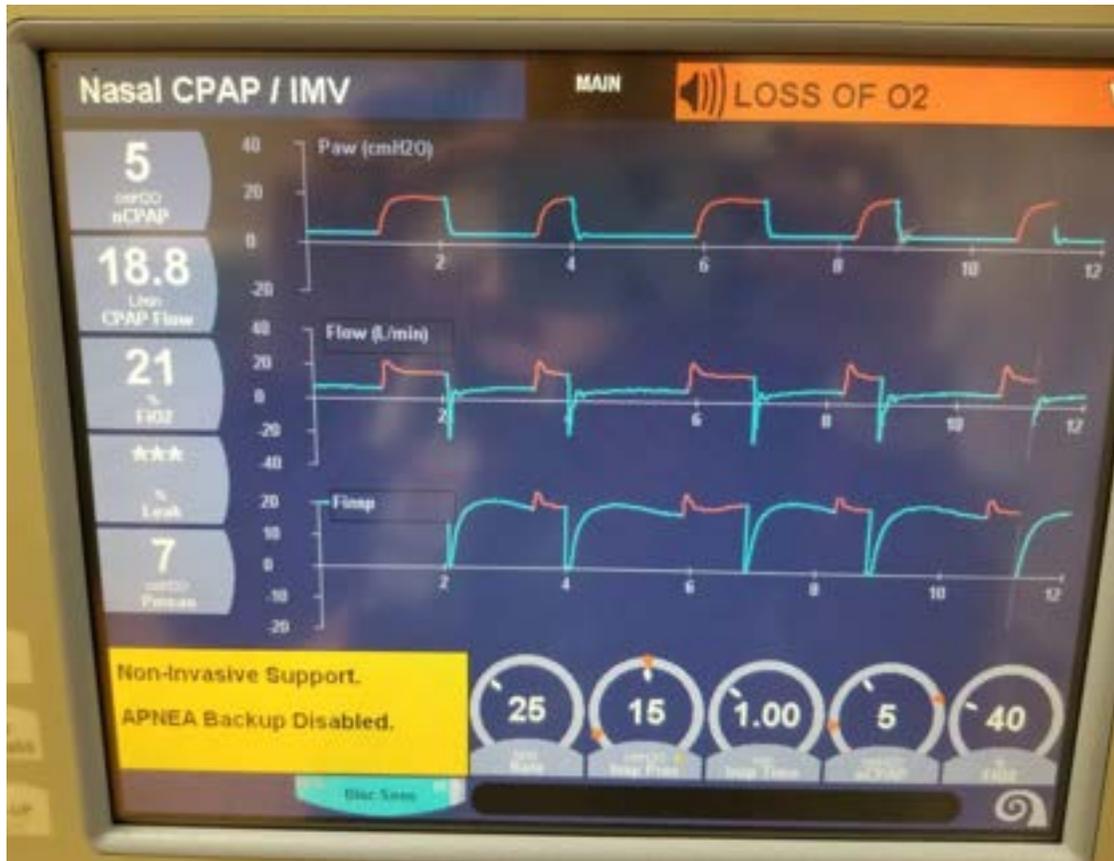


NIMV

Non-invasive Mechanical Ventilation

- Pressure controlled unsynchronized breaths
- Helps facilitate extubation in neonates who still require respiratory support
- Indicated for neonates with moderate apnea and slightly hypercarbic blood gases
- PIP 20 PEEP 5 iTIME 1 sec RATE 25

NIMV

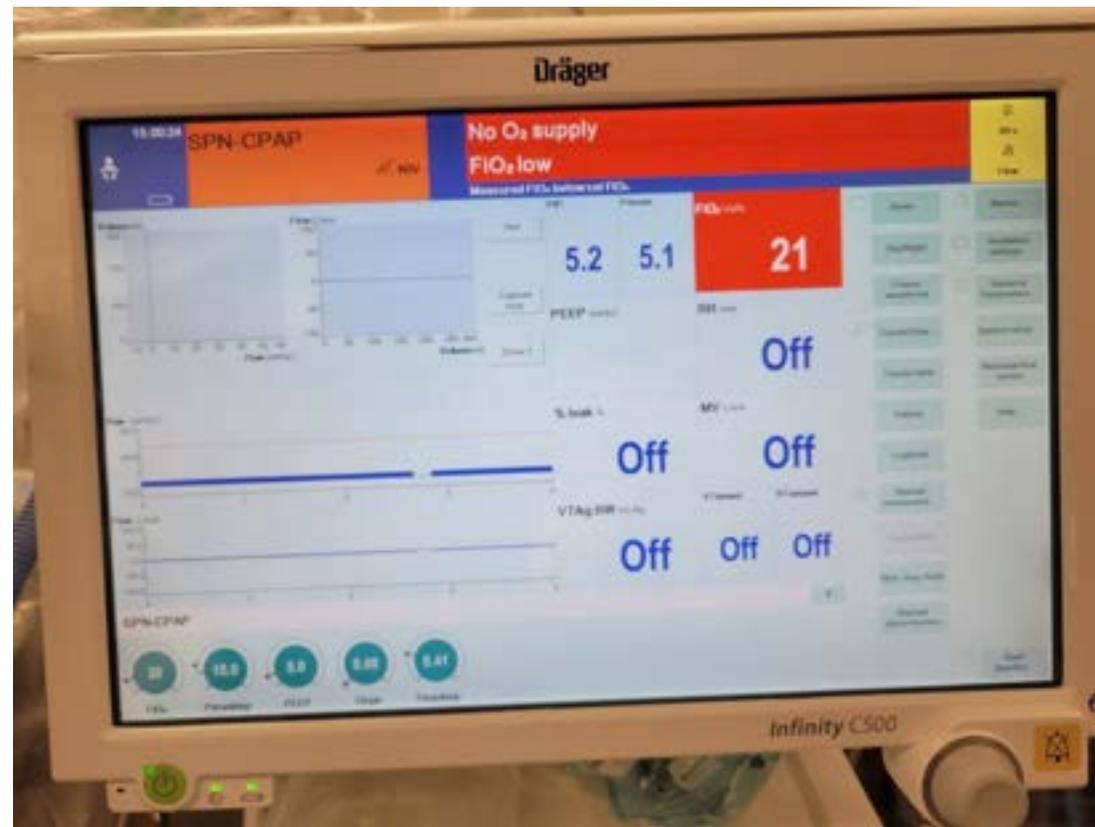
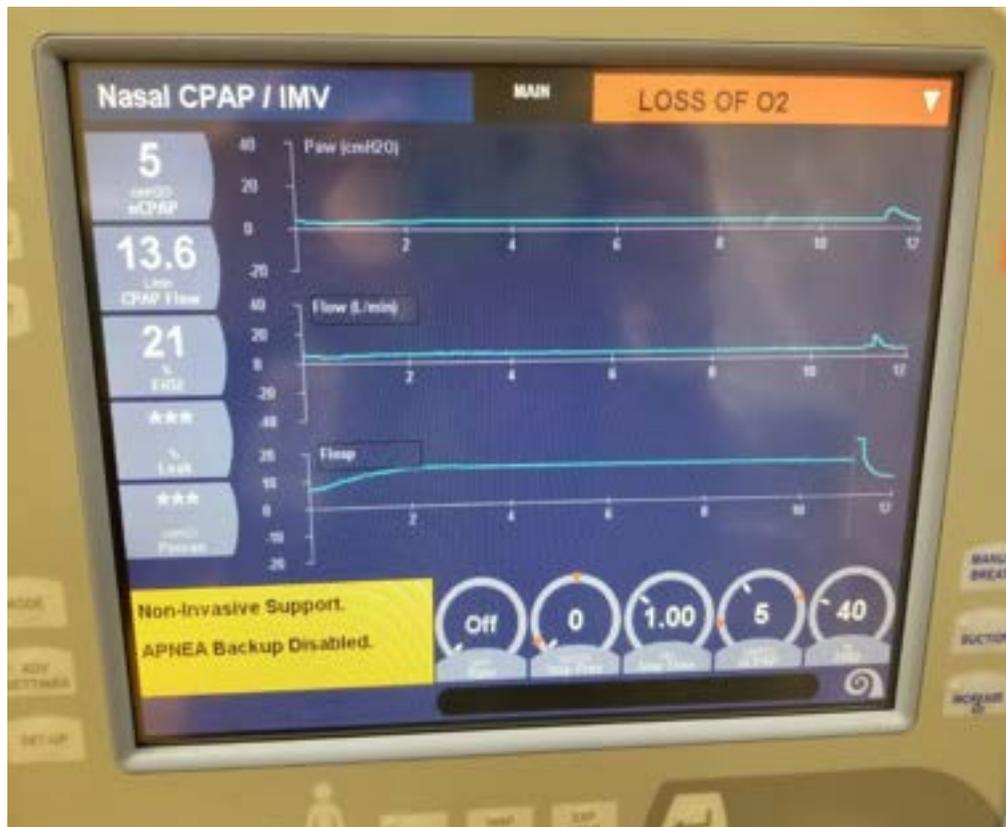


CPAP

Continuous Positive Airway Pressure

- 1971 Dr. Gregory introduced CPAP
- Constant level of pressure in the airways on both inhalation/exhalation
- Enhances airway patency, improves lung recruitment
- Initial setting CPAP of 5, may go up to 8
- Wean FiO₂ to room air before d/c
- Prior to 1971, mortality for RDS was 90% in infants with birth weights between 750-1500 gm.

CPAP



NIMV/CPAP - TROUBLESHOOTING

Staying secured to face

Water/rainout in tubing

Condition of patient's nose

May need a chin strap

NITRIC OXIDE

Indications

How it works

Considerations



NITRIC OXIDE - INDICATIONS

PPHN

Persistent fetal circulation

Meconium aspiration

Pneumonia

Sepsis

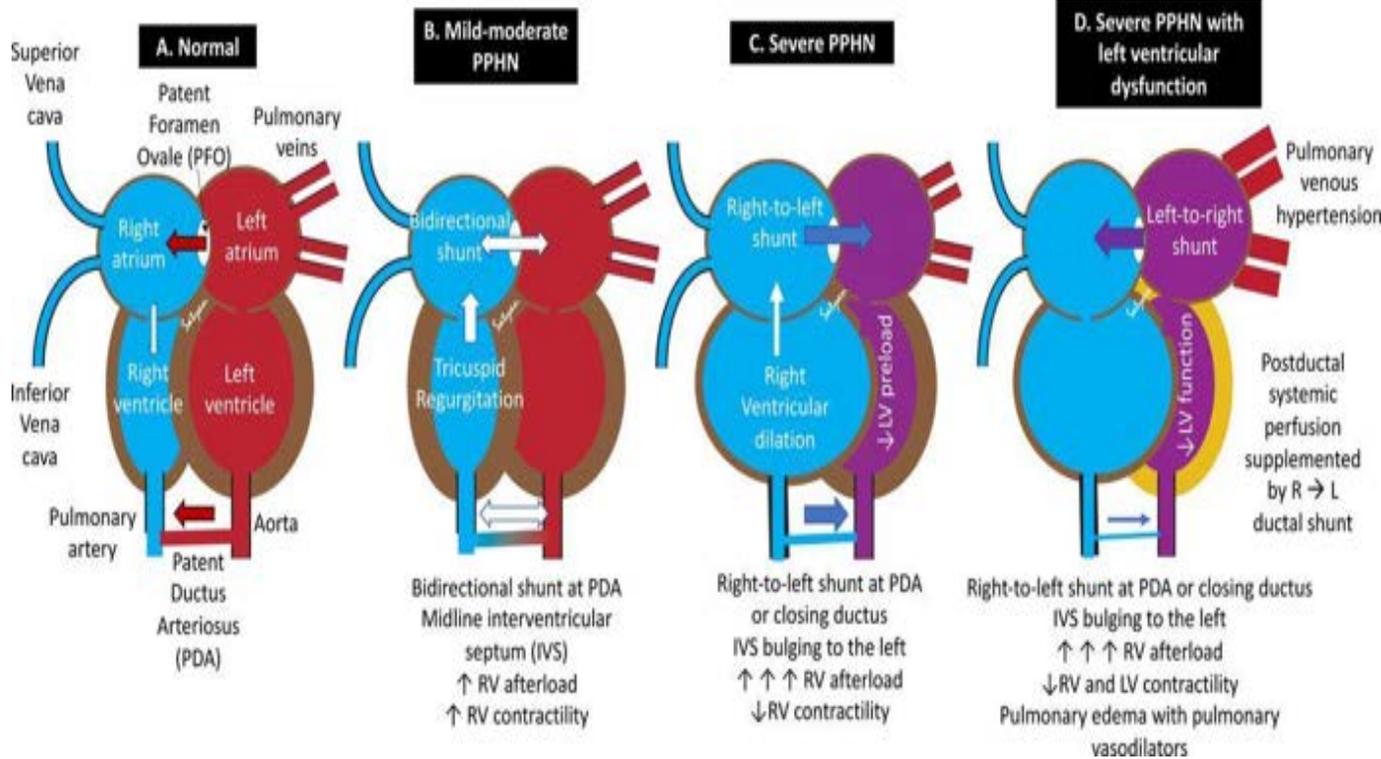
CDH

Pulmonary hypoplasia

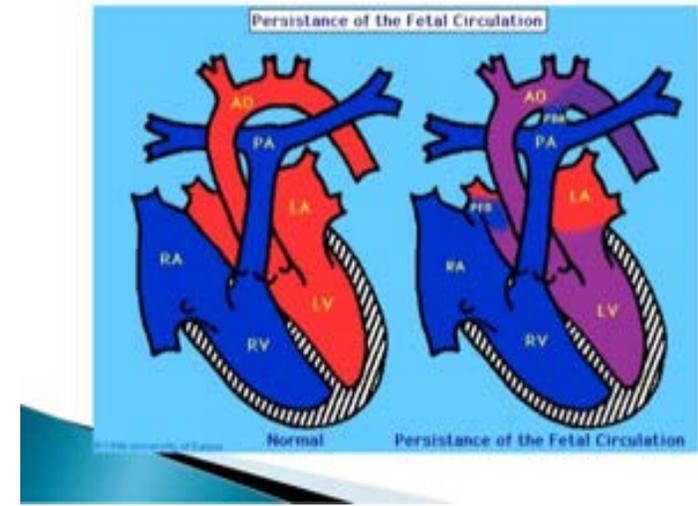
NITRIC OXIDE (NO)

- Produces pulmonary vasodilation
- Redistributes blood flow
- Improves the ventilation/perfusion (V/Q) mismatch
- Initial settings – 20ppm

NITRIC OXIDE



Persistent fetal circulation



NITRIC OXIDE CONSIDERATIONS

- *Auto-calibrates 1 x/day
- *Read FIO₂ of Nitric machine except when using the JET
- *Ask RT how to manually bag patient
- *Weaning – FIO₂ < 60%, PaO₂ > 80, and resolved PPHN on echo



Guess what....?

We're DONE!

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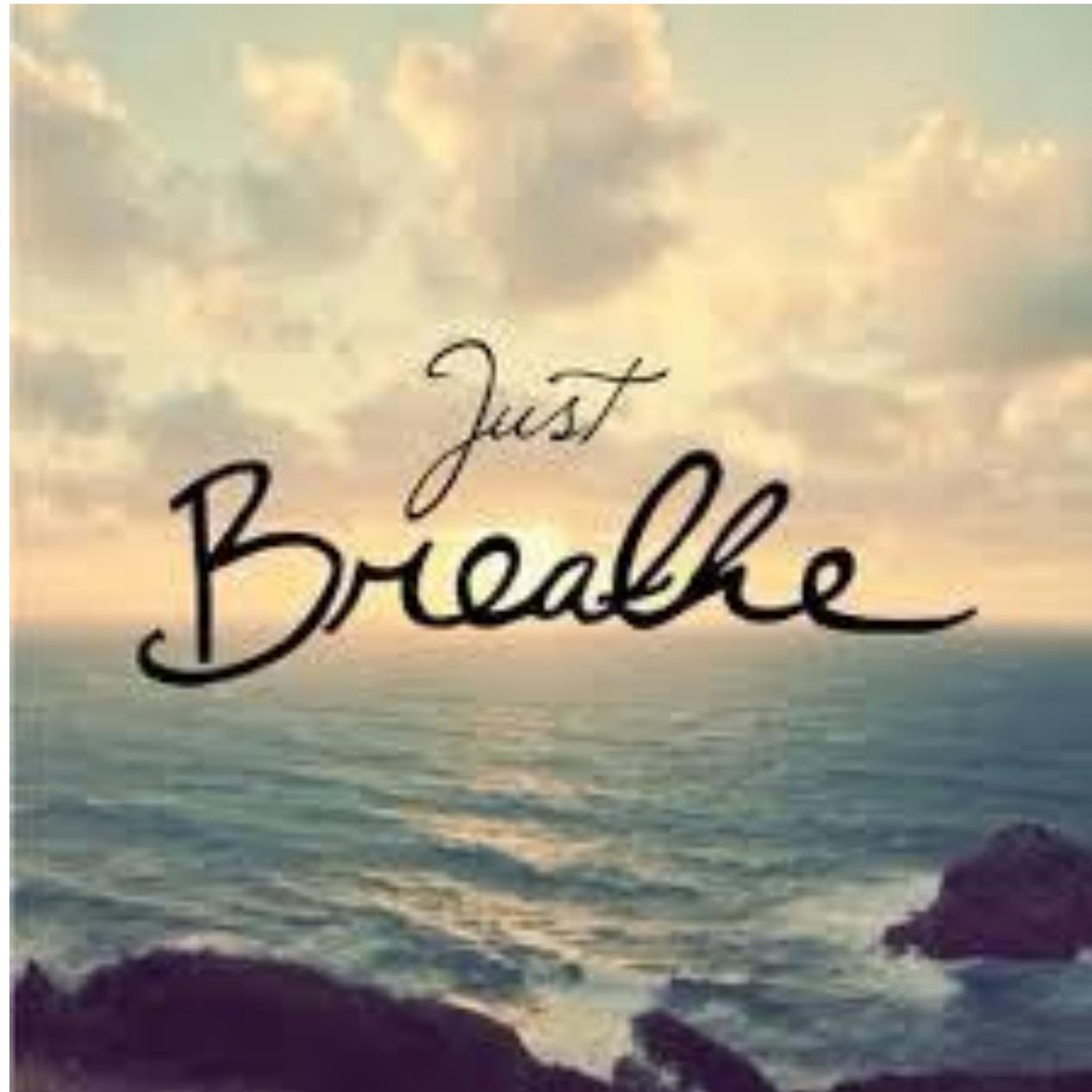
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Just
Breathe