



**Does this person need vasopressors?**

- Consider all etiologies of shock (cardiogenic, obstructive, hypovolemic, and distributive); are other treatments (fluids, blood transfusions, inotropes, etc.) indicated?
- Is there evidence of hypoperfusion? Is BP accurate?

**What is my blood pressure goal?**

Use mean arterial pressure (MAP) as your goal; target MAP >65  
MAP > 60 mmHg [may be equivalent](#) to MAP > 65 mmHg in patients over 65 years old

Although higher MAP goals are generally not beneficial, some patients (neurological issues, stenosed coronaries, etc) may benefit from higher individualized MAP goals

**Which vasopressor to start?**

Treat the underlying physiology (is a mixed vasoconstriction and inotropy desirable?, [High PA pressures](#) → VASO, Anaphylaxis → EPI)

**Push-dose versus continuous infusion**

[Push-dose](#) good for transient hypotension (e.g. post intubation) or when pressor infusion is not immediately available. Two options:

- PHENYLEPHRINE** syringe (pre-mixed); administer 50-100 mcg
- EPINEPHRINE**: combine 1 cc of a 10 cc Epi syringe (1:10,000 ACLS dose) with 9 cc of saline (makes 100 mcg epi in 10 cc); administer 10-20 mcg at a time (repeat q1 minute)

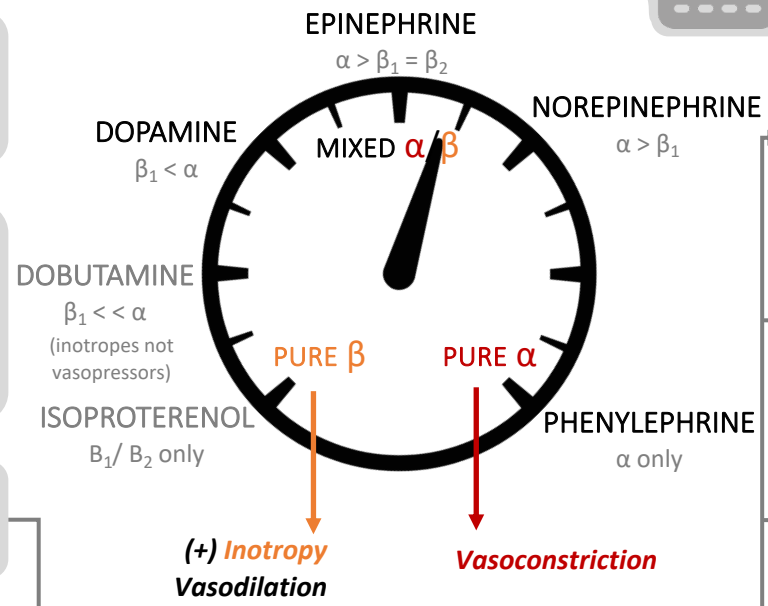
If a patient requires push dose, expect a need for an ongoing infusion.

**Add additional pressors if needed**

Again consider the physiology. Does this person need *inotropy*? Do they need **blood products/fluid**? **Steroids**? Are they acidemic? For sepsis, [no benefit to starting in a particular sequence](#), though NE → VASO → EPI → PHENYL → DA is common.

**Weaning vasopressors**

Wean one pressor at a time; may be advantage to [weaning VASO before NE](#). Some patients may benefit from adding MIDODRINE 10 mg 8 hr PO to [facilitate weaning from pressors/liberating from ICU](#). Consider contraindications and renal dosing.



**NOREPINEPHRINE** 0.5 – 30 mcg/min  
(a.k.a. Levophed, 'levo', noradrenaline)  
Good general purpose pressor with combined vasoconstriction and inotropy  
Often used first line for septic shock.

**EPINEPHRINE** 1 – 10 mcg/min  
(a.k.a. adrenaline)  
Ideal for anaphylactic shock (also has bronchodilator activity)  
Increases lactic acid production

**VASOPRESSIN** 0.01 – 0.06 units/min  
Long half-life; hard to titrate, often used at a fixed dose. Non-catecholamine pressor;  
Good adjunct for septic shock  
Unlike other pressors it does not ↑ PA pressures but higher risk for gut ischemia

**PHENYLEPHRINE** 20 – 80 mcg/min  
(a.k.a. Neosynephrine 'neo')  
Pure  $\alpha$  effects; good for pure vasodilatory states or in patients who cannot tolerate inotropy (tachycardia or Afib w/ RVR)

**DOPAMINE** 1 – 20 mcg/kg/min  
Mixed effects; May be vasodilatory at low doses (hard to 'wean' off)  
In patients with cardiogenic shock, DA is [more arrhythmogenic](#) than NE.

**Central versus peripheral administration?**

Do not wait for central access to begin pressors if needed!  
[It is safe and effective](#) to give vasopressors peripherally if:

- The IV is newly placed, in a larger vein (4mm or larger) and not in the hand, wrist, or antecubital fossa
- You have a protocol to monitor for extravasation
- You know [what to do if there is extravasation](#) (protocol)

PHENYLEPHRINE, NOREPINEPHRINE, EPINEPHRINE can be given peripherally. (Avoid VASOSPRESSIN peripherally) In the case of high dose pressors, multiple pressors, or prolonged infusion central venous access is recommended.

(requiring > 2 pressors)

**Vasopressor refractory shock**

Am I treating the cause of shock?

- Consider differential d/dx of shock (e.g. don't treat blood loss w/ pressors!)
- Acidosis decreases efficacy of pressors!**

Increase dose of pressors: EPI, NE, DA, PHENYL do not have a true max dose.

Consider **stress dose steroids** and **alternative agents** (such as methylene blue, angiotensin II) or **interventions** (VA ECMO)

**STEROIDS**

**Stress Dose Steroids**

- Hydrocortisone 50 mg q6 hrs IV
- Wean over days as pressor requirement decreases
- Reduces [pressor requirement/duration](#)

**METHYLENE BLUE**

[Nitric oxide scavenger](#) that can be used if pressor refractory

- 1 – 2 mg/kg SLOW IV push
- Good for refractory hypotension or hypotension due to vasoplegia (e.g. after cardiopulmonary bypass)





**HYPOXIA** = insufficient oxygen in the tissues, several types exist:

- ISCHEMIC – not enough blood flow to deliver oxygen
- ANEMIC - blood unable to carry enough oxygen
- TOXIC - cells unable to use oxygen (e.g. cyanide poisoning)
- HYPOXEMIC - low oxygen levels in the blood

There are **SIX CAUSES** of **HYPOXEMIC HYPOXIA**

1. Low Inspired FIO<sub>2</sub>

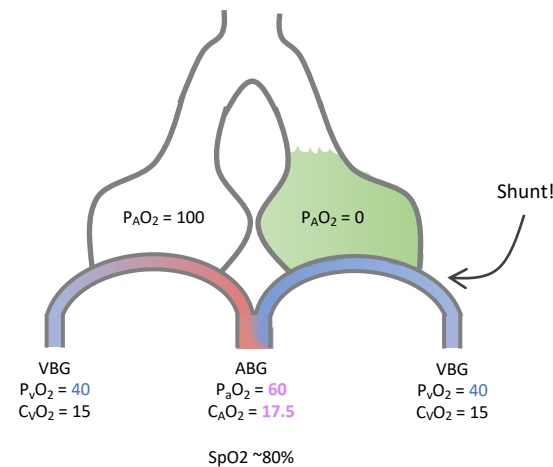
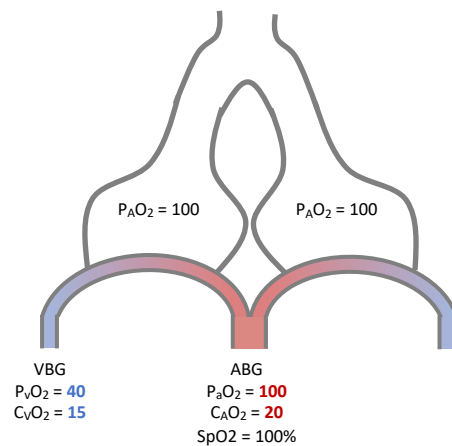
2. Alveolar Hypoventilation

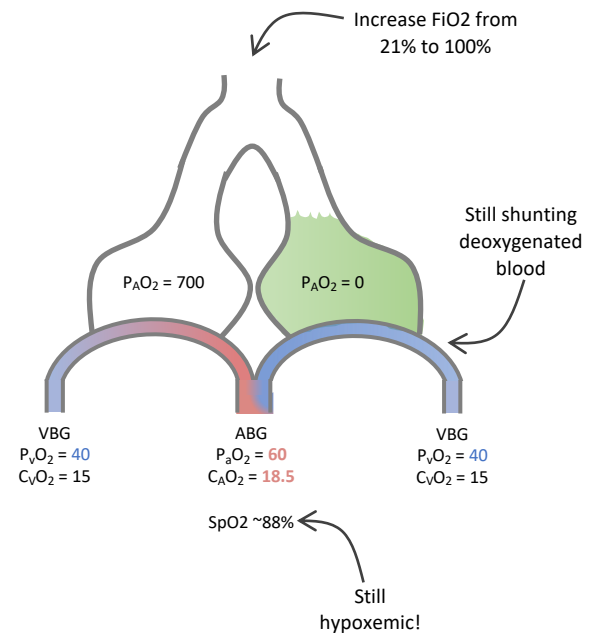
3. V/Q Mismatch

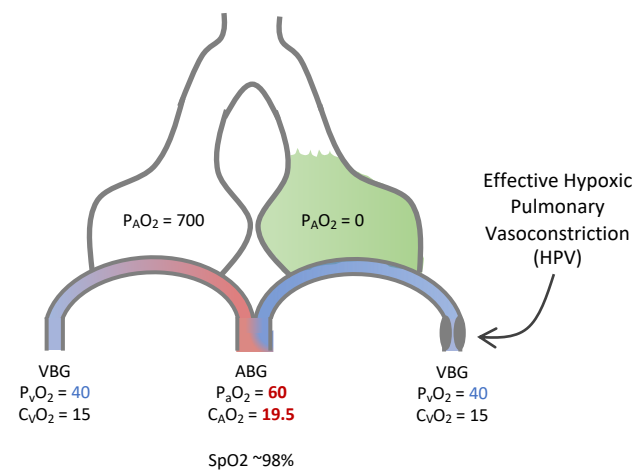
4. Shunt

5. Impaired diffusion


6. Low SvO<sub>2</sub>





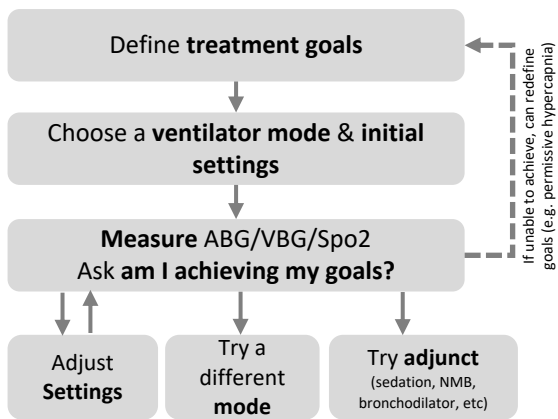


	People with more effective HPV	People with less effective HPV
People with Stronger Hypoxic Ventilatory Drive	Short of breath but near normal SpO2 <i>“Uncomfortable normal”</i>	Very uncomfortable with very low SpO2 <i>Respiratory distress</i>
People with weaker Hypoxic Ventilatory Drive	Well feeling with near normal SpO2 <i>Normal appearing</i>	Minimal distress with very low SpO2 <i>“Happy hypoxemic”</i>

Effective Hypoxic Pulmonary Vasoconstriction (HPV)  


# OVERVIEW OF VENTILATOR MODES by Nick Mark MD


[onepagericu.com](http://onepagericu.com)  
 @nickmark  
 Link to the most current version → 

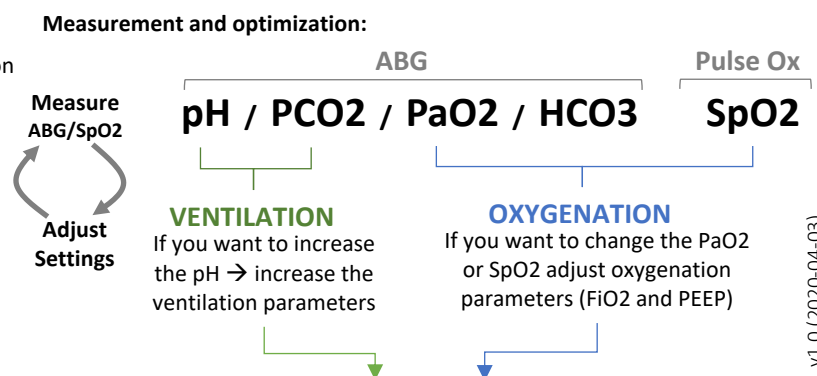


- Goals for mechanical ventilation:**
1. **Oxygenation** – support PaO<sub>2</sub>/SpO<sub>2</sub>
  2. **Ventilation** – maintain pH
  3. **Patient comfort** – vent synchrony, ↓ sedation
  4. **Facilitate weaning** – minimize muscle loss, promote readiness to wean from support

**Ventilator Modes:**  
 Fall into two broad categories: **pressure** and **volume** modes. Each mode has three features:

- Trigger (T) – what initiates a breath?
- Cycle (C) – what ends a breath?
- Limit (L) – what stops a breath early?

Each mode has Pro's and Con's to consider.



Mode	Description	Pro's	Con's	Major settings / example	Monitor
<b>VC</b> Volume Control (a.k.a. assist control volume)	Every breath delivered (mandatory and patient triggered) are all the same set <b>volume</b> T – time/pressure/flow, C – volume, L – volume	Good general-purpose mode; Ensures a minimum MV is achieved. Good mode for lung protective ventilation ( <a href="#">LPV</a> )	Requires you to monitor pressures to avoid barotrauma. (See my <a href="#">OnePager</a> on ARDS for details.)	<b>RR, TV, PEEP, FIO<sub>2</sub></b> <b>12 bpm, 450cc, +8, 60%</b> <i>(RR – respiratory rate, TV – tidal volume)</i>	Pressures (Ppeak, Pplat)
<b>PC</b> Pressure Control (a.k.a. assist control pressure)	Every breath delivered (time & patient) are a set <b>pressure</b> for a set time T - time/pressure/flow, C – time, L - pressure	Good for limiting pressure; may be more comfortable for select patients. Also can be used for LPV (no difference in <a href="#">mortality</a> )	Requires you to monitor volumes to avoid volutrauma or hypoventilation	<b>RR, IP, T<sub>i</sub>, Risetime, PEEP, FIO<sub>2</sub></b> <b>12 bpm, 25 cmH<sub>2</sub>O, 0.9 sec, 0.15 sec, +8, 60%</b> <i>(IP – inspiratory pressure, T<sub>i</sub> – inspiratory time)</i>	Volumes (TV, MV)
<b>PRVC</b> Pressure Regulated Volume Control (a.k.a. VC+)	<b>Hybrid</b> PC mode that dynamically changes inspiratory pressure to deliver a desired volume T - time/pressure/flow, C – volume, L - volume	Guarantees TV but delivers pressure-controlled breaths; (e.g. low risk of causing VILI), which potentially may be more comfortable for patients	In patients who are struggling to breathe the machine will provide less support	<b>RR, TV, T<sub>i</sub>, Risetime, P<sub>max</sub>, PEEP, FIO<sub>2</sub></b> <b>12 bpm, 450cc, 0.9 sec, 0.15 sec, 30 cmH<sub>2</sub>O, +8, 60%</b> <i>(P<sub>max</sub> – maximum pressure)</i>	Pressures & volumes
<b>SIMV</b> Synchronous Intermittent Mandatory Ventilation	Delivers mandatory breaths with a fixed volume but patient <b>can't</b> trigger (patient breaths are not the same as mandatory breaths); can use PS T – time , C – volume, L - volume	May be useful for patients with hiccups to avoid alkalemia	Seldom used; not effective for weaning; often found to be uncomfortable	<b>RR, TV, PEEP, FIO<sub>2</sub></b> <b>12 bpm, 450 cc, +8, 60%</b>	Pressure (Ppeak Pplat)
<b>PS</b> Pressure Support	<b>All</b> breaths are patient initiated; ventilation determined solely by patient (no backup rate). T – pressure/flow, C – flow, L - pressure	<b>Ideal weaning mode</b> (used in SBTs and for prolonged periods); <b>most comfortable</b> because it allows patient to control ventilation	Does not guarantee a rate; need to monitor to ensure adequate ventilation	<b>PS, PEEP, FiO<sub>2</sub></b> <b>+10, +5, 40%</b> <i>Note that PS is above PEEP so "Ten over Five" PIP = 15cmH<sub>2</sub>O</i>	Volumes (TV, MV)
<b>APRV</b> Airway Pressure Release Ventilation (a.k.a. Bi-Vent)	<b>Inverse ratio ventilation</b> (e.g. I time > E time) that allows patient to breath spontaneously; can combine w/ PS T – time, C – time, L - pressure	Great for ARDS patients who are spontaneously breathing (e.g. not on NMB); <b>may improve comfort &amp; oxygenation</b> (but <b>no mortality benefit</b> )	Complex mode/settings; Risk of VILI if settings are done improperly; doesn't make sense if on NMB	<b>T<sub>High</sub>, T<sub>Low</sub>, P<sub>high</sub>, P<sub>low</sub>, FIO<sub>2</sub></b> <b>5.5 sec, 0.5 sec, 25 cmH<sub>2</sub>O, 0 cmH<sub>2</sub>O, 60%</b> <i>(Thigh/low – time high/low, Phigh/low – pressure high/low Note that P<sub>low</sub> is analogous to PEEP)</i>	Volumes & gas exchange PCO <sub>2</sub> / EtCO <sub>2</sub>

v1.0 (2020-04-03)

# VOLUME ASSIST/CONTROL VENTILATION

by Nick Mark MD



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Link to the most current version →

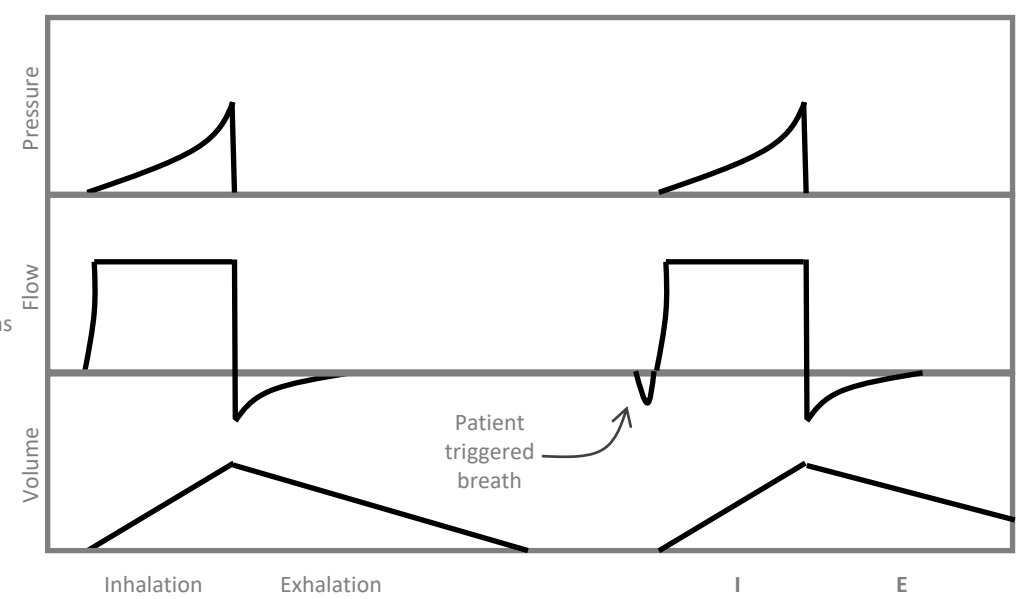
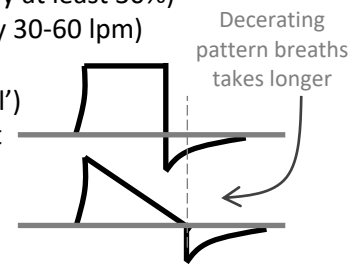


## How does this mode work?

- Delivers a set volume of air with each breath; patient triggered breaths are identical to machine triggered breaths
- Time and patient triggered, volume cycled, volume limited mode

## What are the variables I set?

- **RR** – respiratory rate
- **TV** – tidal volume (better to express in terms of cc/kg PWB than ccs)
- **PEEP** – positive end expiratory pressure (typically at least +5)
- **FiO2** – fraction of inhaled oxygen (typically at least 30%)
- $\dot{V}$  – (“v dot”) inspiratory flow rate (typically 30-60 lpm)
- **Flow pattern** – is the flow constant (e.g. square wave) or decelerating (“decel”)  
Decel may be more comfortable but it prolongs the inspiratory phase



## When should I use this mode?

- Ensures that a patient receives a minimum MV
- This is a good general-purpose mode; good for providing Lung Protective Ventilation (LPV)
- PRVC [may have lower peak pressures](#); pressure modes may be more comfortable for select patients

## What do I need to monitor?

- Need to make sure the peak pressure and plateau pressure do not exceed safe limits.  
→ If  $P_{plat}$  is too high decrease the Tv
- You will also need to monitor MV. If the patient is triggering excessively (or auto-triggering), they can become alkalemic.

## Choosing Initial settings

- RR - Try to match the persons initial minute ventilation by selecting a rate to match their pre-intubation MV needs.
- TV - Use 8cc/kg PBW and adjust as needed. For patients with ARDS (or at high risk) consider starting at 6cc/kg PBW.
- Start with low PEEP and high FiO2 and wean to maintain SpO2 goal (typically > 90%).

ABG: pH / PCO<sub>2</sub> / PaO<sub>2</sub> / HCO<sub>3</sub>



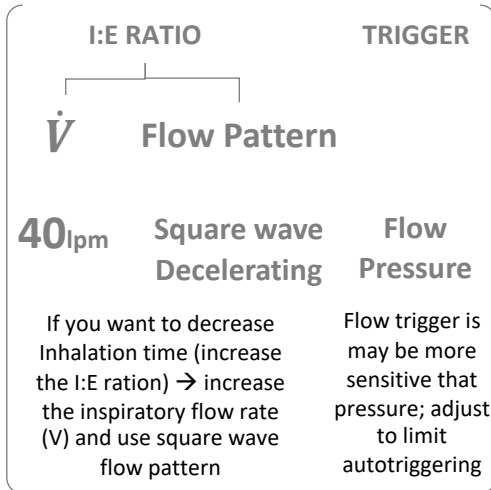
SETTINGS: **RR** **Tv** **PEEP** **FiO2**

EXAMPLE: **12**<sub>bpm</sub> **6**<sub>cc/kg</sub> **+5** **50%**

If you want to **increase** the pH → **increase** the minute ventilation (MV) by changing the RR and TV

If you want to **increase** the PaO<sub>2</sub> or SpO<sub>2</sub> **increase** the FiO<sub>2</sub> and PEEP

Advanced settings



**40**<sub>lpm</sub> **Square wave** **Flow**  
**Decelerating** **Pressure**

If you want to decrease Inhalation time (increase the I:E ration) → increase the inspiratory flow rate (V) and use square wave flow pattern

Flow trigger is may be more sensitive that pressure; adjust to limit autotriggering





## PRESSURE CONTROL

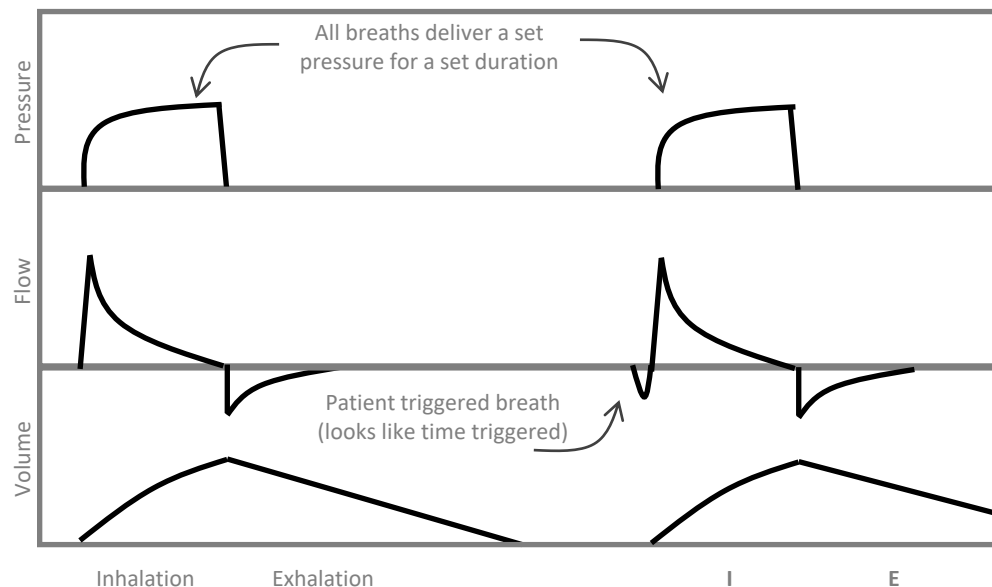
### How does this mode work?

- Patient triggered, flow cycled mode
- Delivers a set pressure for a set duration with each breath
- There is no 'backup rate'
- The size and frequency of breaths is completely determined by the patient.

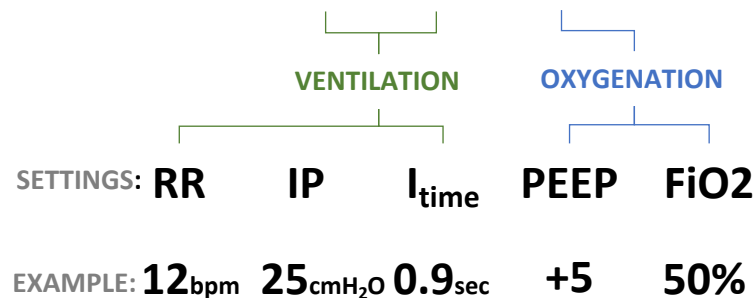
### When should I use this mode?

### What do I need to monitor?

- If you have selected the proper IP (IP = Pplat) then the flow should be zero by the end of each breath.



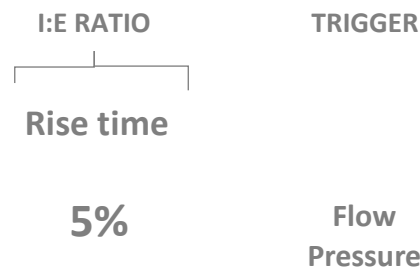
### ABG: pH / PCO<sub>2</sub> / PaO<sub>2</sub> / HCO<sub>3</sub>



If you want to change the pH → increase the IP and I<sub>time</sub> to increase the volume delivered or increase the RR

If you want to change the PaO<sub>2</sub> or SpO<sub>2</sub> adjust FiO<sub>2</sub> and PEEP

### Advanced settings



A faster rise time (e.g. a smaller percent) is associated with a slight decrease in I:E

Flow trigger is generally more sensitive than pressure



## PRESSURE SUPPORT

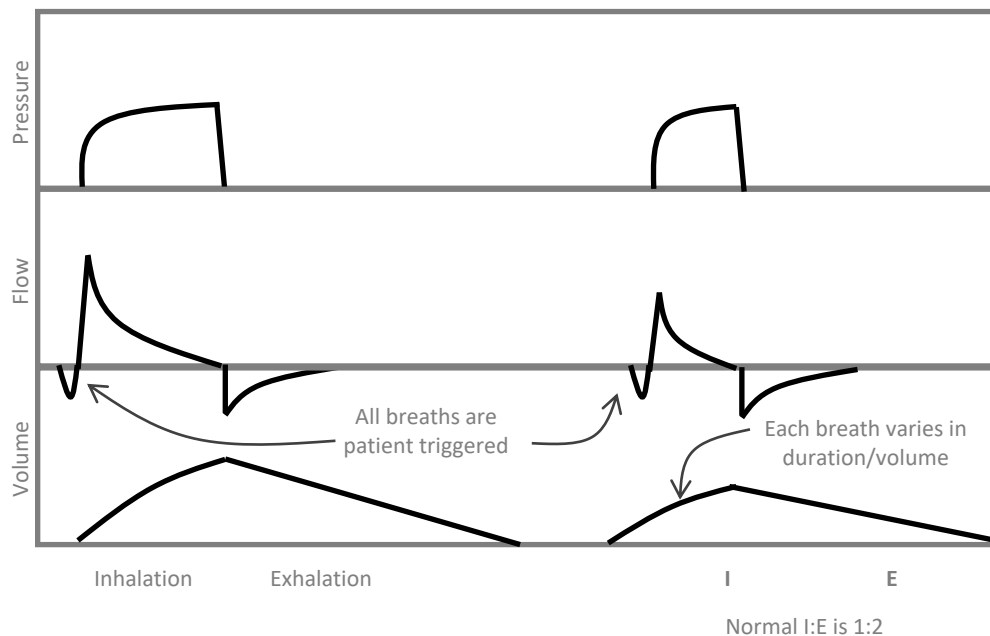
### How does this mode work?

- Time and patient triggered, time cycled mode
- Delivers a set pressure for a set duration with each breath
- Patient triggered breaths are identical to machine triggered breaths

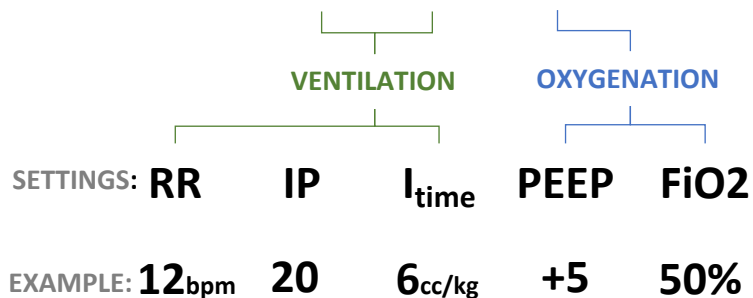
### When should I use this mode?

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- If you have selected the proper IP (IP = Pplat) then the flow should be zero by the end of each breath.



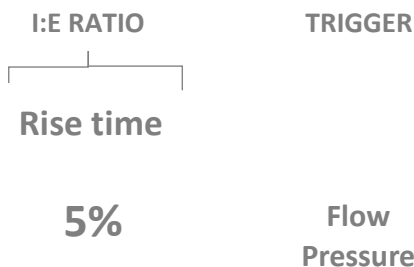
### ABG: pH / PCO<sub>2</sub> / PaO<sub>2</sub> / HCO<sub>3</sub>



If you want to change the pH → increase the IP and I<sub>time</sub> to increase the volume delivered or increase the RR

If you want to change the PaO<sub>2</sub> or SpO<sub>2</sub> adjust FiO<sub>2</sub> and PEEP

### Advanced settings

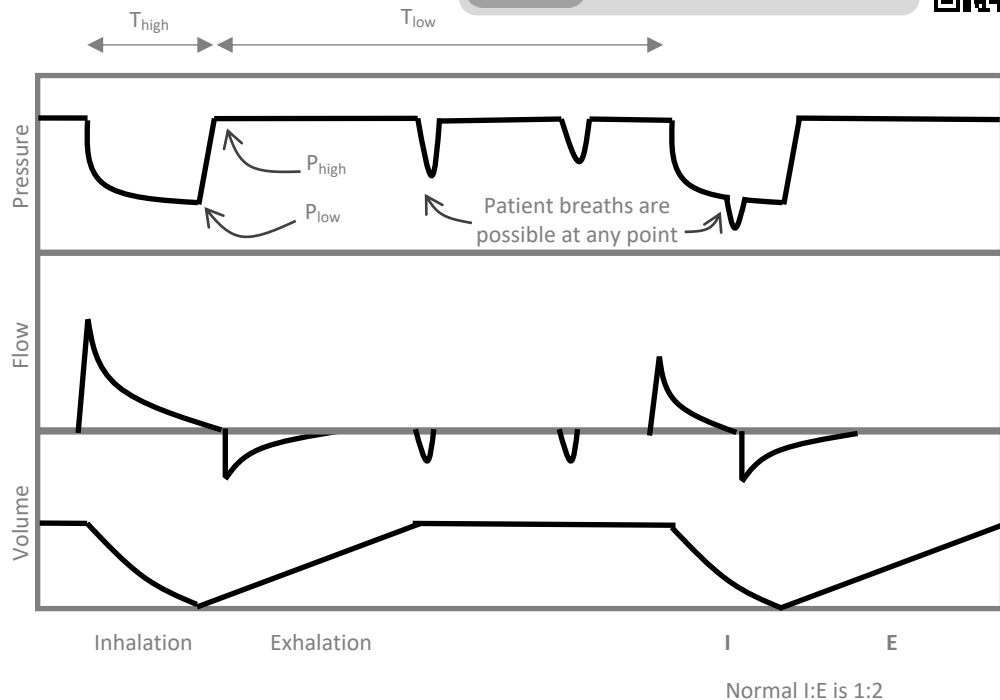


A faster rise time (e.g. a smaller percent) is associated with a slight decrease in I:E

Flow trigger is generally more sensitive than pressure



## AIRWAY PRESSURE RELEASE VENTILATION



### How does this mode work?

- Delivers a set pressure for a set duration with each machine breath
- Patient breaths are not the same as machine breaths but can occur at any point in the respiratory cycle
- This is used for Inverse Ratio ventilation (e.g. more time in I than E in contrast to normal physiology)
- Time and patient triggered, time cycled, pressure limited mode

### When should I use this mode?

- **Theoretical** benefits include less need for sedation or NMB by permitting spontaneous respiration, improved [oxygenation](#), and improved hemodynamics. Spontaneous respiration may preserve diaphragm strength and improve lower lobe atelectasis.

### What do I need to monitor?

- If you have selected the proper IP (IP = Pplat) then the flow should be zero by the end of each breath.
- There are risks of causing lung injury if the  $T_{high}$  is too long and derecruitment occurs. There are also risks of derecruitment if compliance or resistance change and  $T_{low}$  is not changed.

### Choosing Initial settings

- Set  $P_{high}$  = the plateau pressure (as measured on VC)
- Set  $P_{low}$  = 0 (to maximize)
- Set the  $T_{high}$  (minimum of 4 sec) and  $T_{low}$  to adjust the ventilation;

ABG: pH / PCO<sub>2</sub> / PaO<sub>2</sub> / HCO<sub>3</sub>



SETTINGS:

**Tlow Phigh Plow FiO<sub>2</sub>**

EXAMPLE:

**20 6cc/kg +5 50%**

If you want to change the pH → increase the IP and  $T_{low}$  to increase the volume delivered or increase the RR

If you want to change the PaO<sub>2</sub> or SpO<sub>2</sub> adjust FiO<sub>2</sub> and PEEP

Advanced settings

**PS 5% PEEP Flow Pressure**

A faster rise time (e.g. a smaller percent) is associated with a slight decrease in I:E

Flow trigger is generally more sensitive than pressure