Lec.6

INVASIVE VENTILATION

Modes of Mechanical Ventilation

- Controlled Mandatory Ventilation (CMV)
- Asst-Control Mandatory Ventilation (ACV)
- Synchronized Intermittent Mandatory Ventilation(SIMV)
- Continuous Positive Airway Pressure (CPAP)
- Pressure Support Ventilation (PSV)

Controlled Mandatory Ventilation (CMV)

- The ventilator delivers
  - preset tidal volume (or pressure) at a time triggered (preset) respiratory rate.
  - As the ventilator controls both tidal volume (pressure) and respiratory rate, the ventilator "controls" the patients minute volume
- Patient cannot breath spontaneously
- Patient cannot change the ventilator respiratory rate
- Suitable only when patient has no breathing efforts
  - Disease or under heavy sedation and muscle relaxants
- Asynchrony and increased work of breathing.
- Not suitable for patient who is awake or has own respiratory efforts
- Cannot be used during weaning

VOLUME CONTROL

- Setting
  - V_T, RR, Flow/Time, and FiO_2
  - V_T set at 6-12 ml/kg IBW
  - RR = 10-15 bpm
  - FiO_2 lowest possible to achieve oxygenation
  - I:E --- 1:2 – 1:4

- Flow rate is a measure of I:E, can be set separately in some models.

- Monitoring and alarms:
  - PIP relates to resistance and P_{Plat} relates to compliance.
  - High pressure alarm
  - Low pressure alarm 5 – 10 cm H20 below ventilating pres.
  - Low pressure and volume alarms signify leak in system.

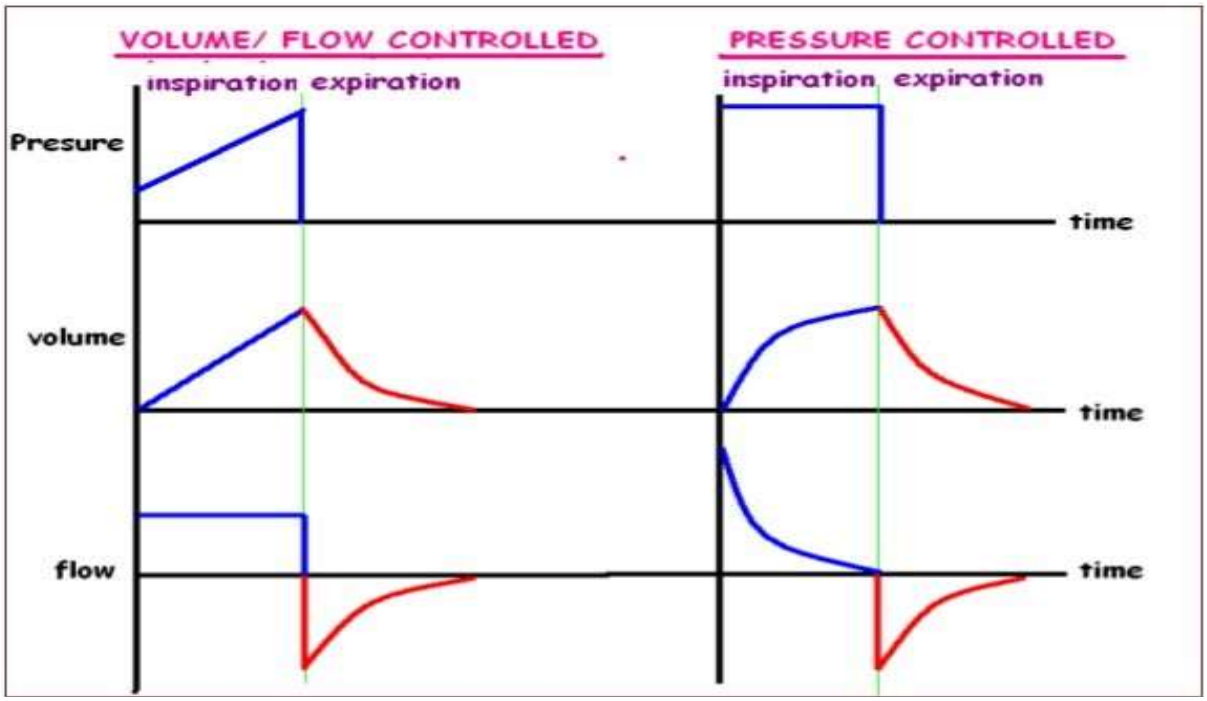
Advantages	Disadvantages
Predictable regulation of TV, MV	Higher incidence of barotrauma, volutrauma and VILI esp in ARDS and ALI
Better control over PaCO2 than PC	During assisted breath, flow rates may be insufficient leading to dys- synchrony and auto PEEP

- Ventilator-induced lung injury (VILI)
- Acute respiratory distress syndrome (ARDS)
- Acute lung injury (ALI)
- Positive end-expiratory pressure (PEEP)

PRESSURE CONTROL

- **Setting**
  - Pressure < 30 cm H_2O
  - RR = 10-15 bpm
  - I:E --- 1:2 – 1:4
  - Inspiratory Time and Flow rate depend on I:E ratio and RR.
- **Monitoring and alarms:**

- Low Volume alarm: Set at the minimum acceptable V_T for the patient, signifies increased resistance or decreased compliance
- Low pressure alarm: Set at ~10 cm H2O below patients' ventilation pressure, signifies leak in the system.



ASST-CONTROL MANDATORY VENTILATION (ACV)

- The ventilator provides the patient with a pre-set tidal volume at a pre-set rate.
- The patient may initiate a breath on his own, but the ventilator assists by delivering a specified tidal volume to the patient.
- Client can breathe at a higher rate than the preset number of breaths/minute.
- The total respiratory rate is determined by the number of spontaneous inspirations initiated by the patient plus the number of breaths set on the ventilator.
- If the patient want to breathe faster, he or she can trigger the ventilator and receive a full-volume breath.

- Often used as initial mode of ventilation When the patient is too weak to perform the work of breathing (e.g. when emerging from anesthesia).
- The preset RR ensures that the patient receives adequate ventilation, regardless of spontaneous efforts.
- The patient can breathe faster than the preset rate but not slower.
- Patient can control RR but not V_T nor P_{aw}

Advantages:

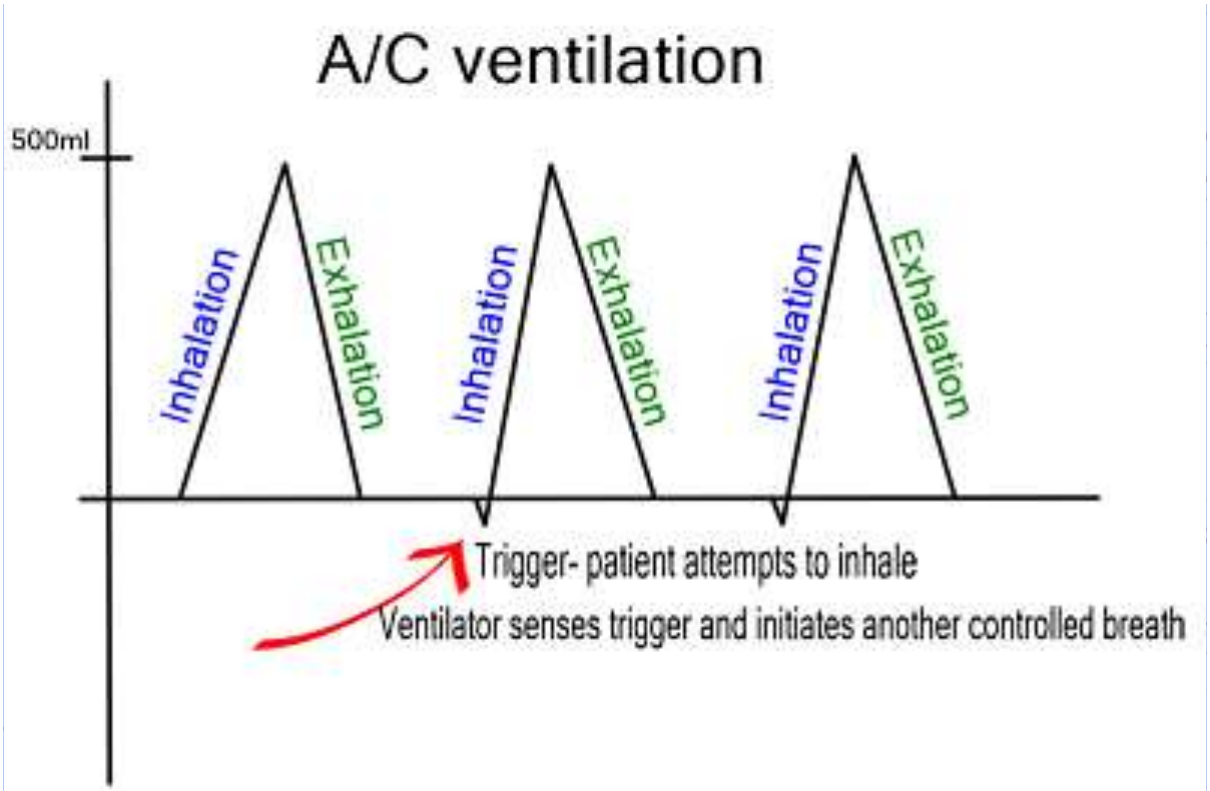
- Very small WOB, if correct trigger sensitivity is set.
- Allows patient to control MV (through RR) to normalise PaCO2

Disadvantages:

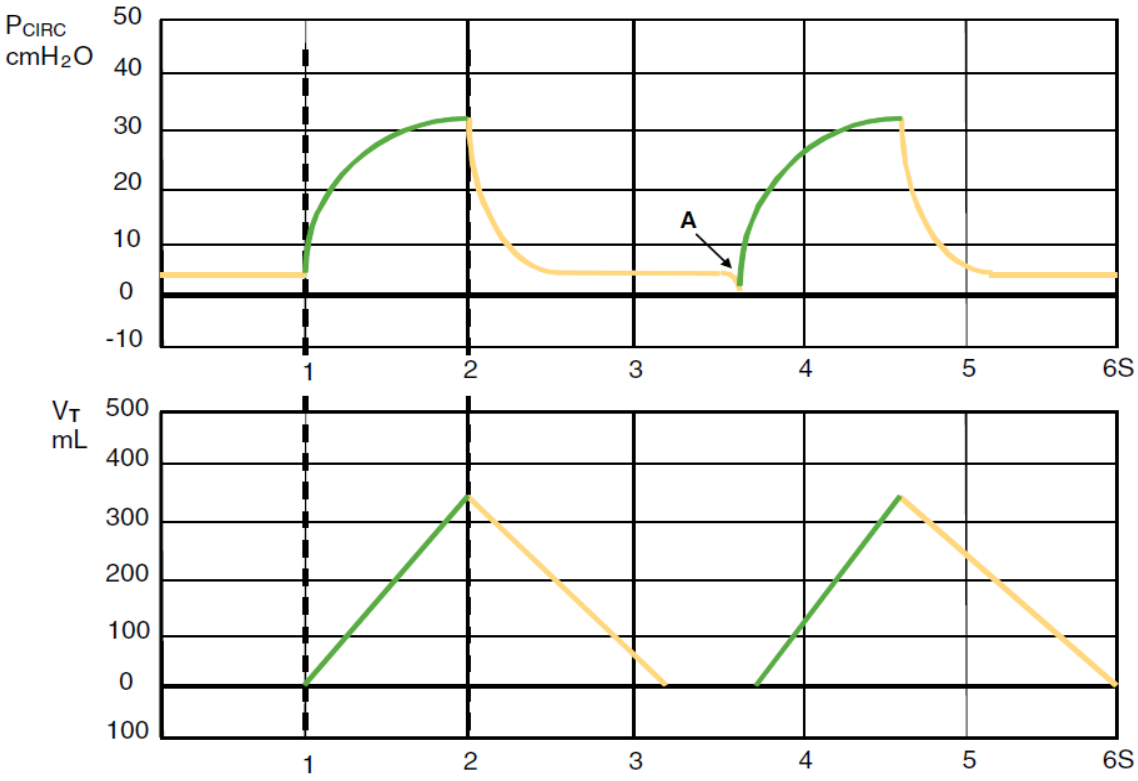
- Alveolar hyperventilation
- Respiratory alkalosis
- Higher pH and lower $PaCO_2$ compared to IMV

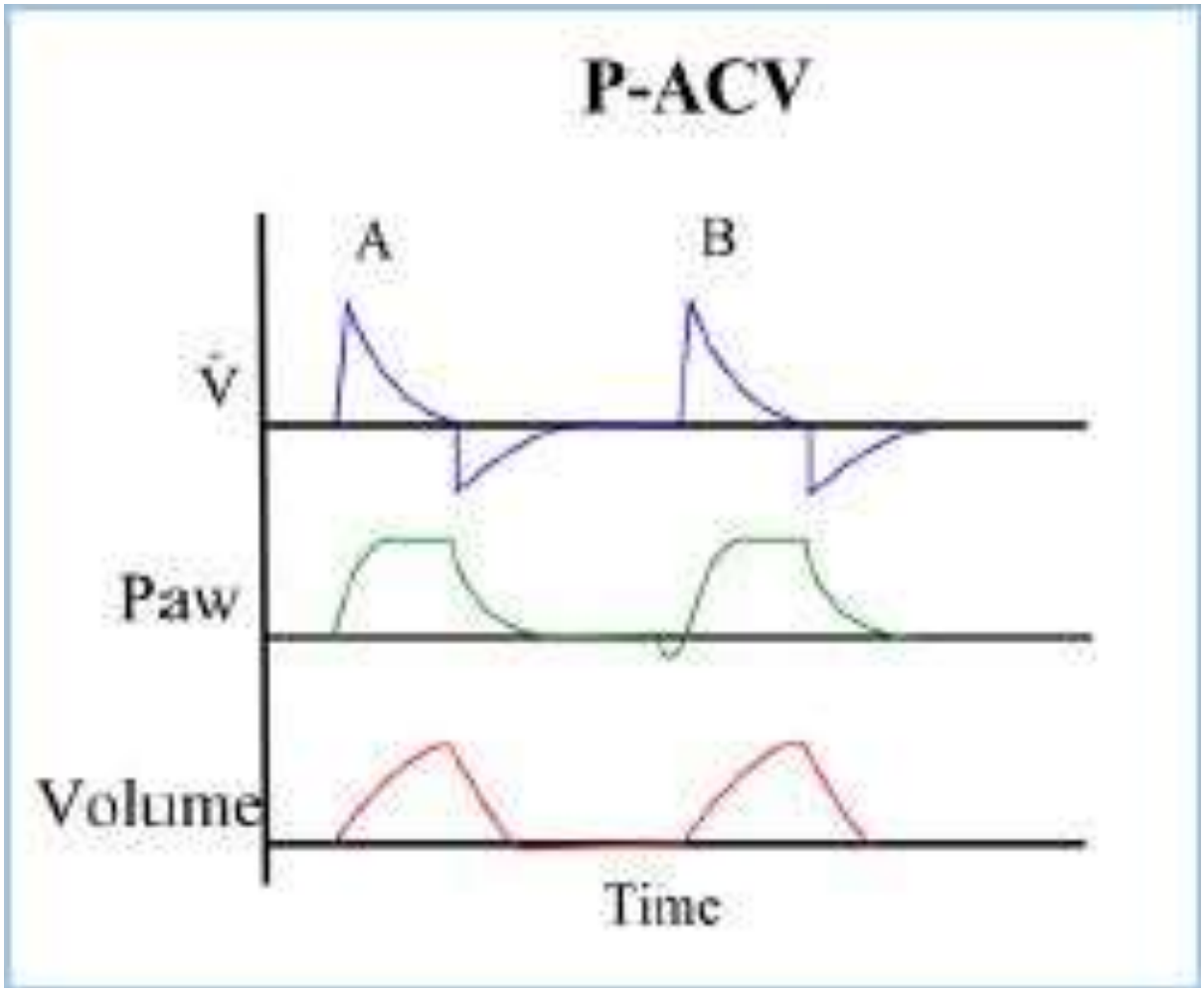
Contraindications:

- Irregular RR
- Cheyne – Stokes respiration
- Hiccoughs
- Brainstem injury



Assist Control





Synchronized Intermittent Mandatory Ventilation (SIMV)

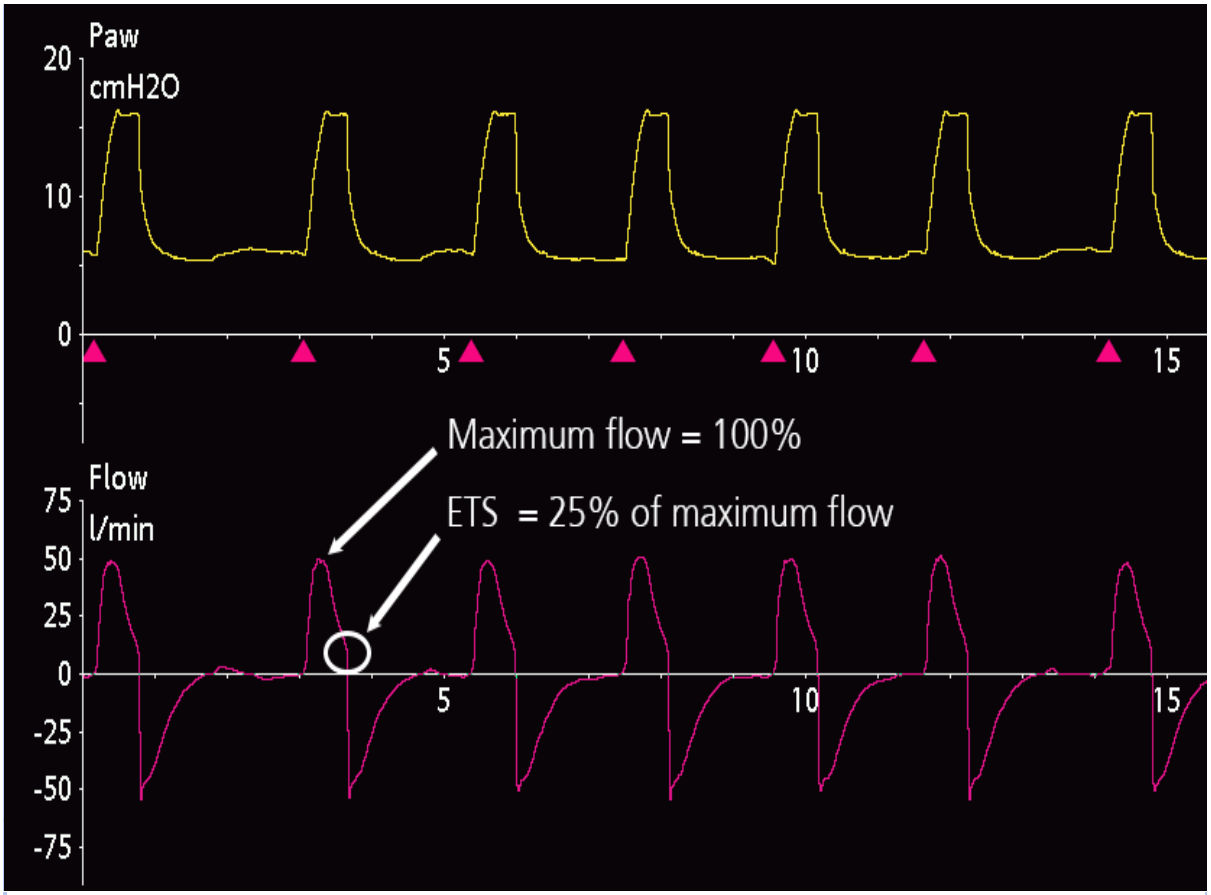
- Breaths are given are given at a set minimal rate, however if the patient chooses to breath over the set rate no additional support is given
- One advantage of SIMV is that it allows patients to assume a portion of their ventilatory drive
- SIMV is usually associated with greater work of breathing than AC ventilation and therefore is less frequently used as the initial ventilator mode
- Like AC, SIMV can deliver set tidal volumes (volume control) or a set pressure and time (pressure control)

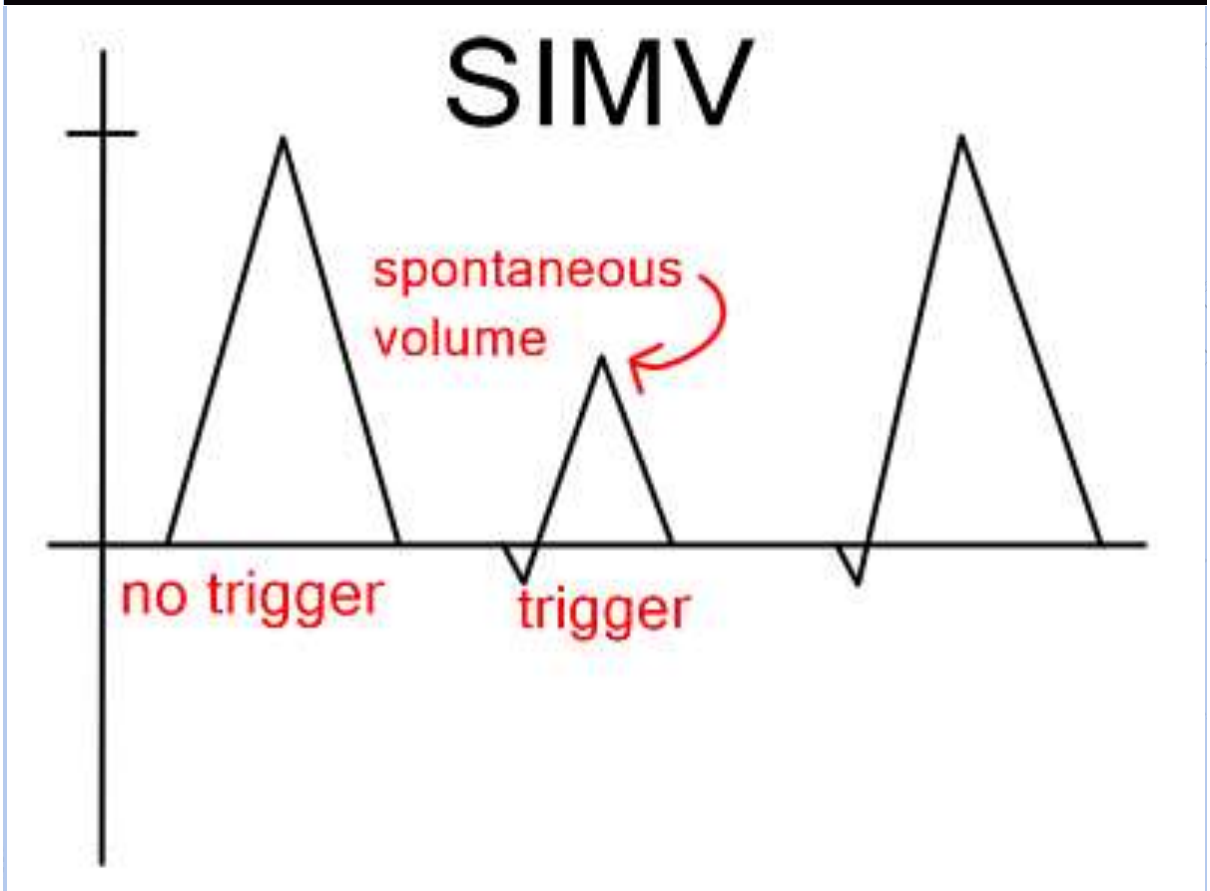
- Negative inspiratory pressure generated by spontaneous breathing leads to increased venous return, which theoretically may help cardiac output and function
- The problem of ‘breath stacking’ and dys-synchrony was addressed by SIMV.
- But, problems of WOB and R_{aw} during spontaneous breath persisted.
- This is tackled with use of **Pressure Support** as adjunct.
- Inspiratory flow is provided to maintain a pressure plateau if inspiratory effort is sensed.
- Breath is terminated once patients inspiratory flow declines below a set limit.
- Thus, patient triggered, pressure limited, flow cycled assisted ventilation.
- SIMV and spontaneous mode always used with PSV in modern practice.

Advantages	Disadvantages
Maintains respiratory muscle strength/ avoids atrophy	May provide false sense of improvement of lung function
Reduces V/Q mismatch	Desire to wean too early and failed weaning.
Decreases mean airway pressure	
Facilitates weaning	
P.S: Increases V_T , decreases patients' RR, decreases WOB	

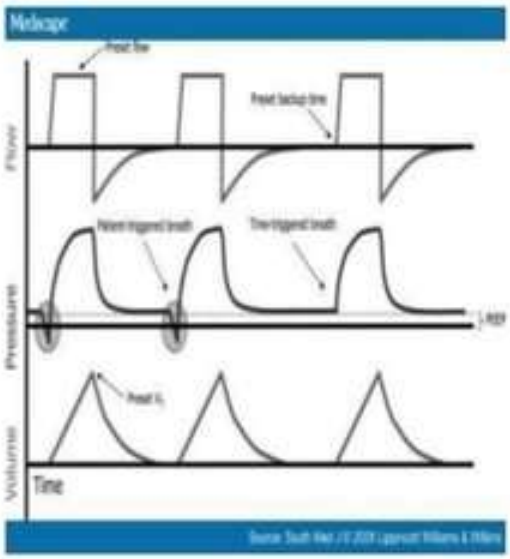
- **Settings:**
  1. **SIMV+PS–VCV**
     - V_T - 6-12 ml/kg IBW
     - RR – 10 – 15 bpm
     - I:E – 1:2 – 1:4
     - FiO_2 – titrated to PaO_2
     - PS: PIP – P_{plat} (min 5 cm H_2O)
     - High pressure alarm
     - Low pressure/ vol alarm

  2. **SIMV+PS–PCV**
     - Pressure - < 30 cm H_2O
     - Low pressure alarm
     - Low volume alarm

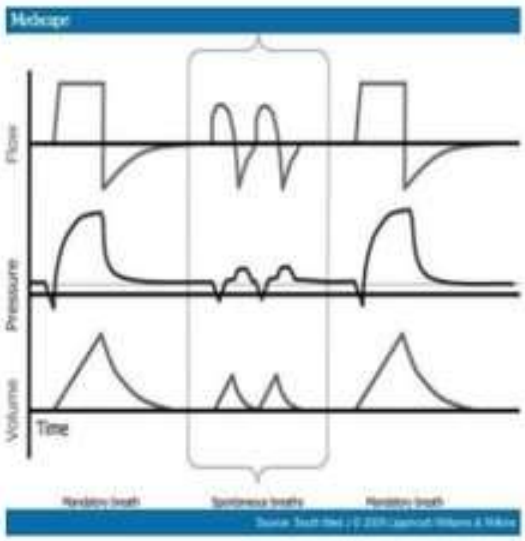

Paw
cmH2O
20
10
0
5
10
15
Maximum flow = 100%
ETS = 25% of maximum flow
Flow
l/min
75
50
25
0
-25
-50
-75
5
10
15


SIMV
spontaneous
volume
no trigger
trigger

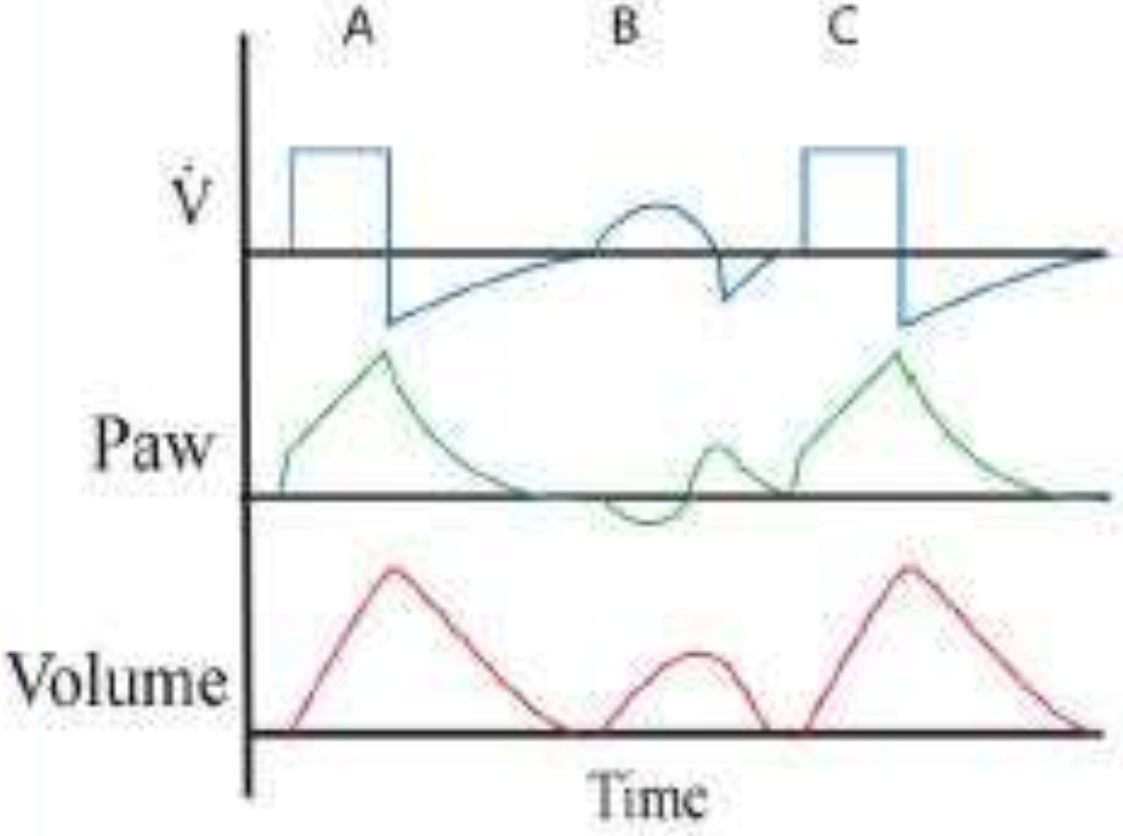
Assist Control



SIMV



V-SIMV

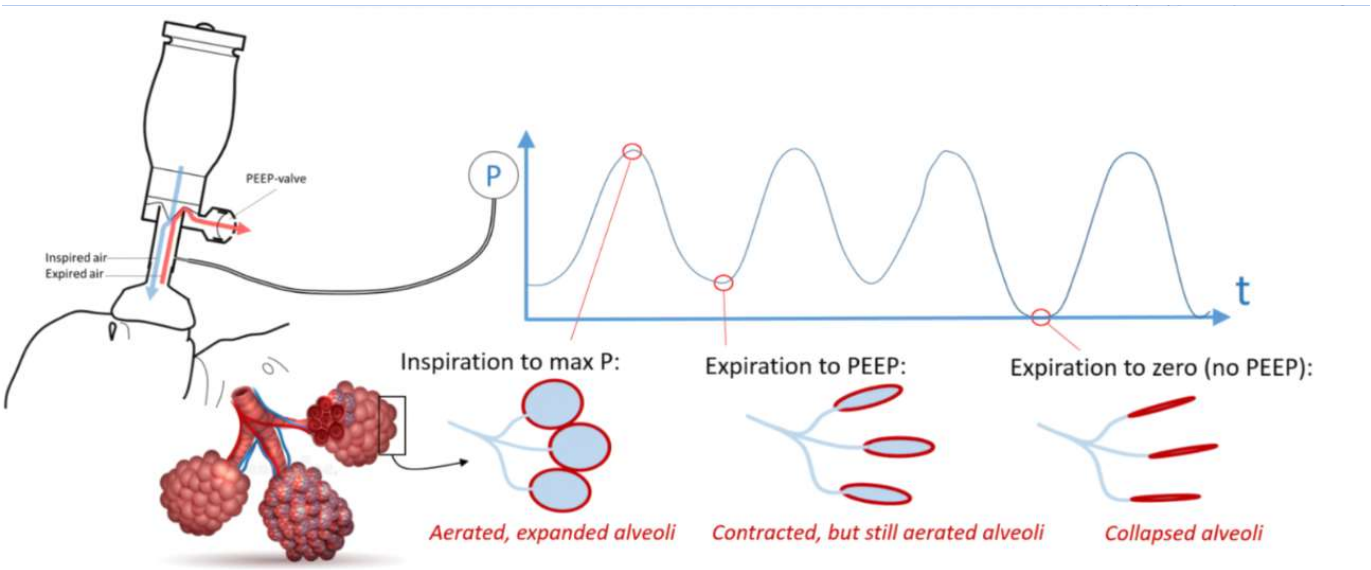


Pressure Support Ventilation (PSV)

- The patient must initiate all pressure support breaths.
- During weaning using the PSV mode the level of pressure support is gradually decreased based on the patient maintaining an adequate tidal volume (8 to 12 mL/kg) and a respirator y rate of less than 25 breaths/minute.
- PSV weaning is indicated for:
- Difficult to wean patients
- Small spontaneous tidal volume

Positive End-expiratory Pressure PEEP

- The amount of positive pressure that is maintained at end-expiration.
- Typical settings for PEEP are 5 to 20 cm H2O
- PEEP increases oxygenation by preventing collapse of small airways
- It increases the functional residual capacity of the lungs
- A typical initial applied PEEP is 5 cmH20. However, up to 20 cmH20 may be used in patients undergoing low tidal volume ventilation for acute respiratory distress syndrome (ARDS)



COMPLICATION of PEEP

- Hypotension
- Pneumothorax
- Decreased Cardiac Output
- Nosocomial Pneumonia
- Increased Intracranial Pressure (ICP).
- Alarms turned off or nonfunctional.
- Sinusitis and nasal injury.
- Mucosal lesions Aspiration.
- GI bleeding.
- Inappropriate ventilation (respiratory acidosis or alkalosis).
- Thick secretions.
- Patient discomfort due to pulling or jarring of ETT or tracheostomy.
- High PaO2, Low PaO2.
- Anxiety and fear.
- Dysrhythmias or vagal reactions during or after suctioning.
- Incorrect PEEP setting.
- Inability to tolerate ventilator mode.

Alarms and Common Causes

High Pressure Limit	Low Pressure	High Respiratory Rate	Low Exhaled Volume
▪Secretions in ETT/airway or condensation in tubing. ▪Kink in vent tubing ▪Patient biting on ETT ▪Patient coughing, ▪gagging, or trying to talk. ▪Increased airway pressure from bronchospasm or pneumothorax	▪Vent. tubing not connected. ▪Displaced ETT or trach tube.	▪Patient anxiety or pain ▪Secretions in ETT/airway ▪Hypoxia ▪Hypercapnia	▪Vent tubing not connected ▪Leak in cuff or inadequate cuff seal ▪Occurrence of another alarm preventing full delivery of breath

REMEMBER TWO RULES.....

- An alarm should never be silenced until the cause has been investigated and corrected.
- If the source of the alarm cannot be determined, disconnect the client from the ventilator and use a hand-held resuscitation bag for manual ventilation with 100% oxygen until the problem can be resolved

During mechanical ventilation

- The oxygenation is determined by the FiO2, PEEP and mean airway pressure
- PaCO2 is determined by minute ventilation.

It is important to note that **mechanical ventilation** does **not** heal the patient. Rather, it allows the patient a chance to be stable while the medications and **treatments** help them to recover

Initial ventilator setting

Mode—assist/control (volume or pressure)	
Tidal volume	6–8 mL/Kg ideal body weight (see formula in Appendix B)
Inspiratory time	0.7–1.2 s
Inspiratory flow	Four times minute ventilation (approx)
Rate	12–20 breaths/min
PEEP	4–5 cm H_2O
FiO_2	1.0
Plateau pressure	<30 cm H_2O
Once the patient is stabilized	
FiO_2	To maintain PaO_2 more than 60 mmHg or SpO_2 more than 93–94% in normal lung and 88–92% in hypercapnic respiratory failure
PEEP	Set according to FiO_2 requirements (predetermined according to the degree of hypoxemia)
Plateau pressure Driving pressure (plateau-PEEP)	Recheck in an attempt to keep plateau pressure below 30 cm H_2O Keep below 13 cm H_2O

Dr Mahir Hussein Hasan
M.B.Ch.B / F.I.B.M.S
Anaesthesia and Intensive Care