BASICS OF MECHANICAL VENTILATION

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MECHANICAL VENTILATION

- Mechanical Ventilation is ventilation of the lungs by artificial means usually by a ventilator.
- A ventilator delivers gas to the lungs with either negative or positive pressure.

Types of mechanical ventilation

- Negative pressure ventilation
  - Iron lung
  - Chest cuirase
- Positive pressure ventilation
  - Invasive
  - Non invasive

Goals of mechanical ventilation

1. Relieve respiratory distress
2. Decrease work of breathing
3. Improve pulmonary gas exchange
4. Reverse respiratory muscle fatigue
5. Permit lung healing

Variable

- Pressure
- Volume
- Flow
- Time

Breath description

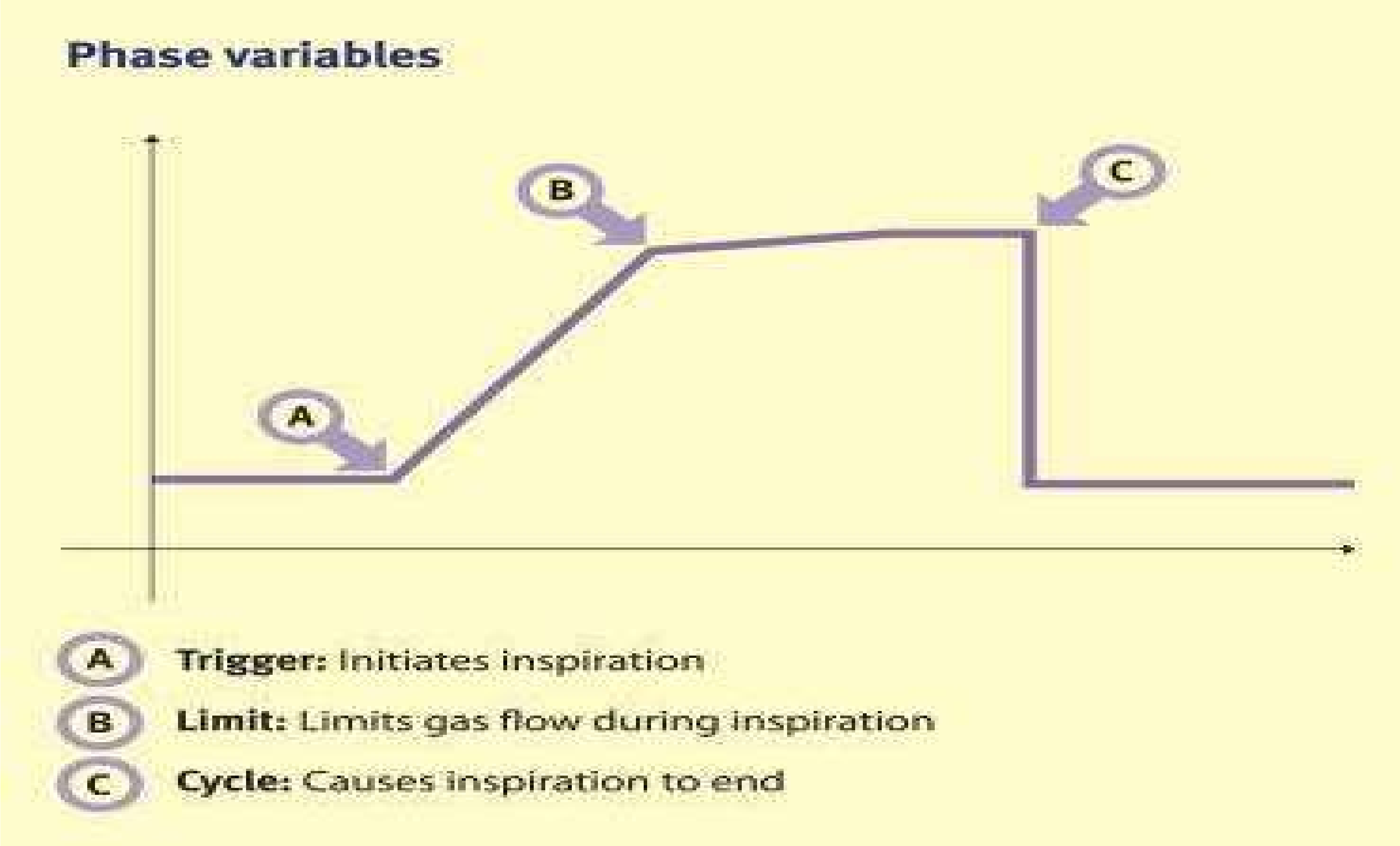
- Control –the mechanical breath goal, ie, a set pressure or a set volume

- Trigger –Variable which starts inspiration

Limit – the maximum permitted value during inspiration.

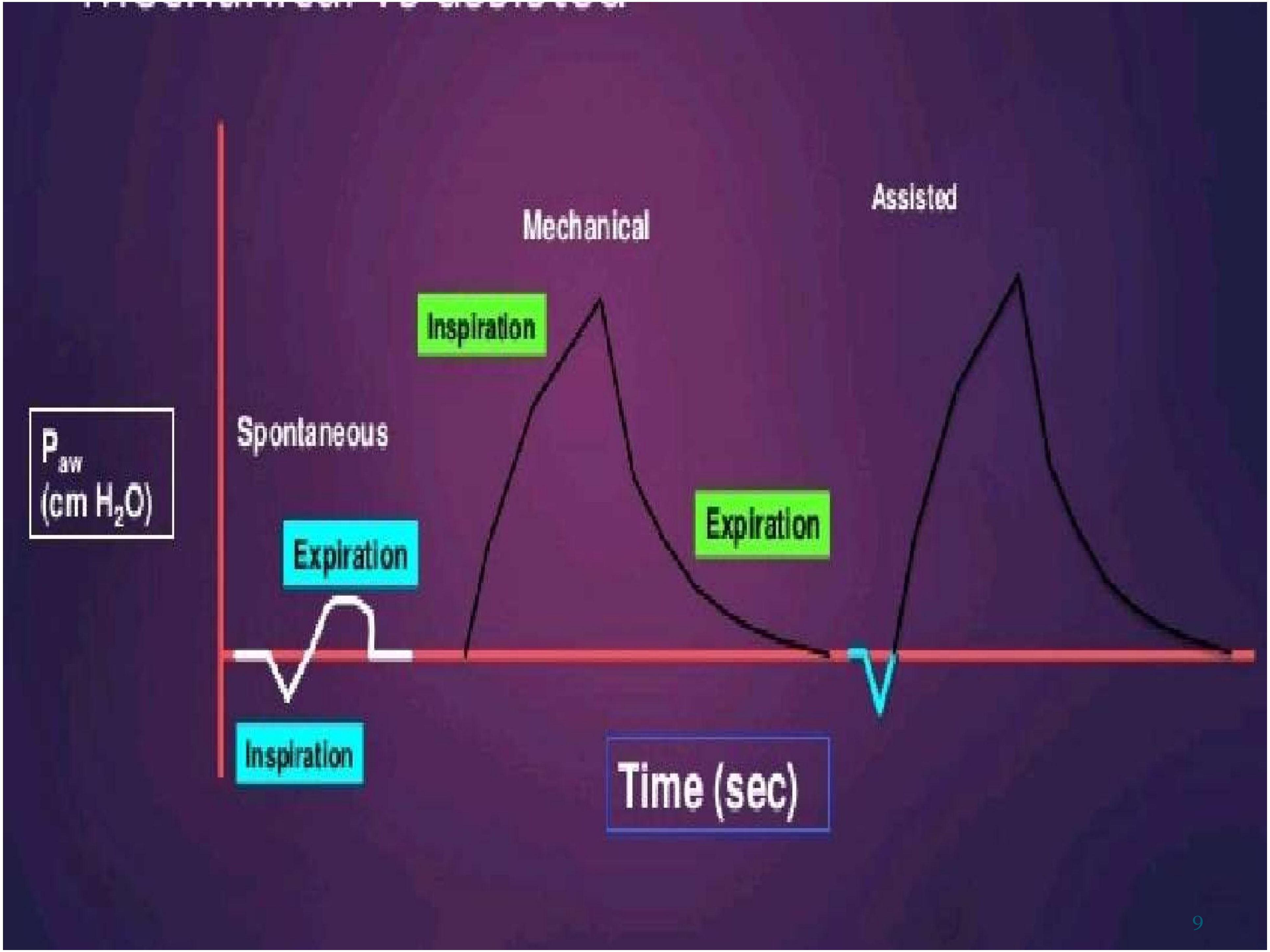
- Cycle – Variable which ends inspiration

Phase variables

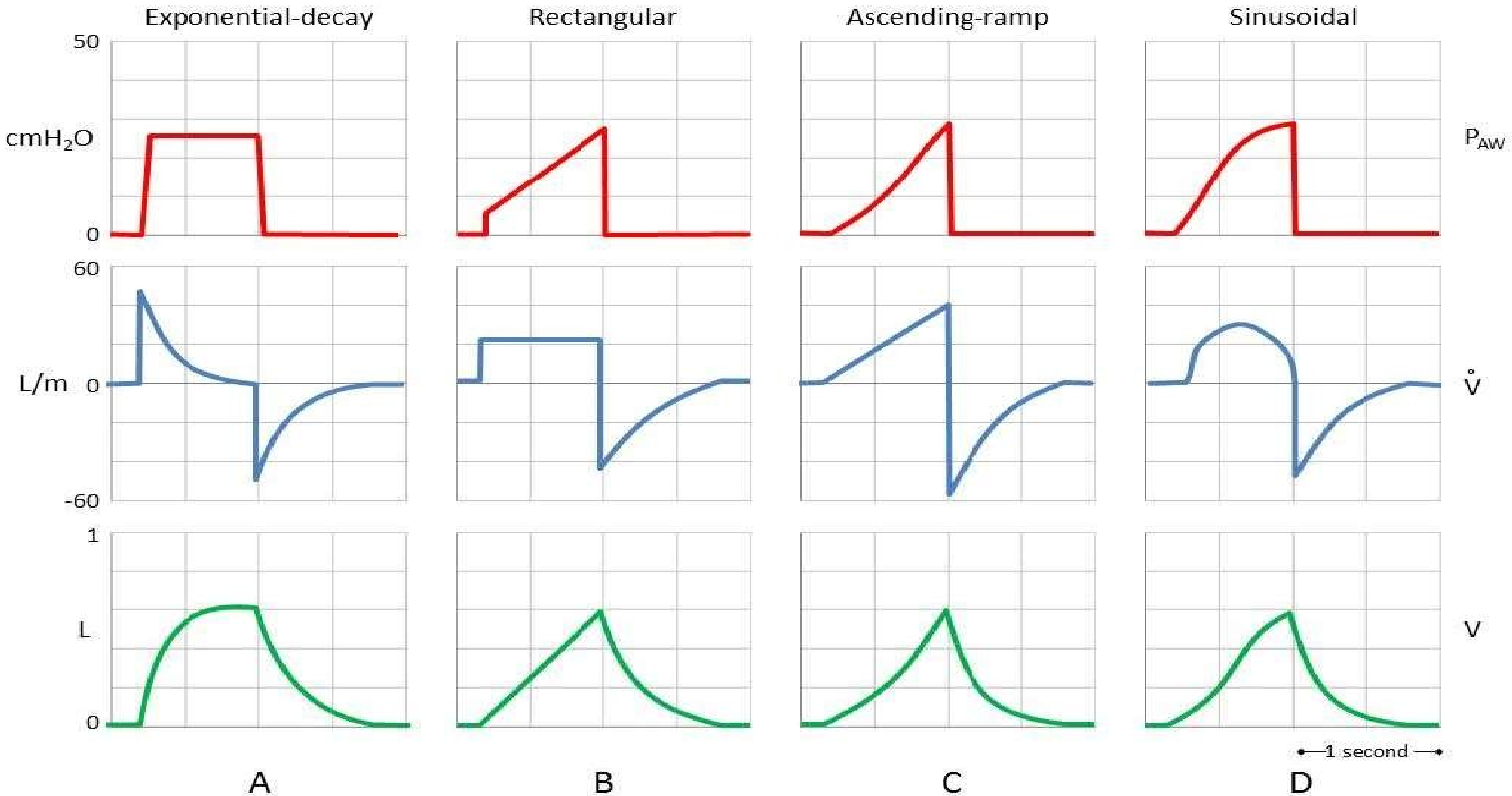


Breath types

- Mandatory breath
  - Ventilator does the work
  - Ventilator controls start and end of inspiration
- Assist control breath
  - patient triggers the breath
  - Venti. Delivers the breath as per control variable
- Spontaneously Supported breath
  - Pt. triggers the breath
  - Ventilator delivers pressure support
- Spontaneous
  - Patient takes on work
  - Patient controls start and stop


Mechanical
Assisted
Inspiration
Spontaneous
P_{aw}
(cm H_2O)
Expiration
Expiration
Inspiration
Time (sec)

Scalar and Loop

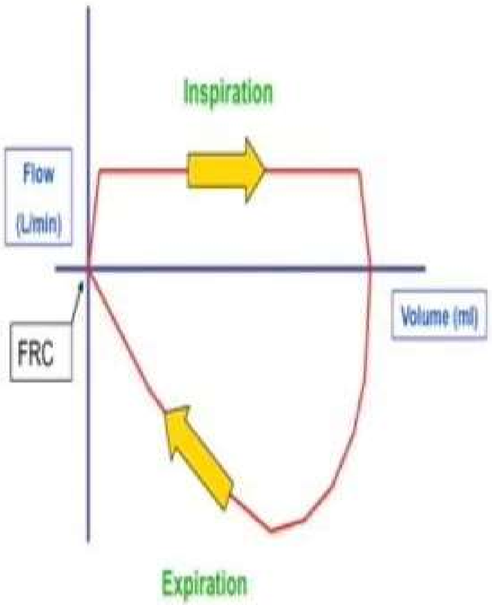


Scalars are waveform representation of pressure,flow,or volume on y axis vrs time on x axis.

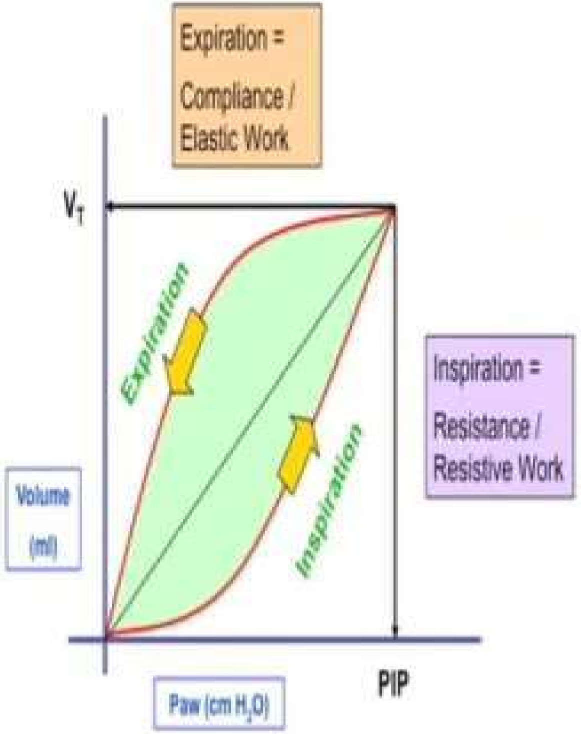
Loops

Loops are representations of pressure vs volume or flow vs volume

Flow Volume Loop



Pressure Volume Loop



What do I need to know?

- Indications for ventilator support present
- Non-invasive v/s Invasive ventilation
- Pressure v/s Volume ventilation
- Extent (Partial v/s Full) & mode of ventilation
- Key Ventilatory settings
- Appropriate Alarms and Back-up values
- Weaning

Indications

- Patient not breathing
- Patient breathing, …….but not enough
- Patient breathing enough, …….but hypoxemic / hypercapneic
- Patient breathing with normal gas exchange, ….but working hard
- Airway protection

Indications

- Clinical deterioration
- Hypoxia : $pO_2 < 60$ mm Hg
- Hypercarbia : $pCO_2 > 50$ mm Hg
- Tachypnea : RR >35
- Tidal volume <3-5 ml/kg
- Max. inspiratory pressure <-20 cm H_2O

Non- invasive ventilation CPAP /BiPAP

CPAP

- Patient continuously receives a set air pressure, during both inspiration and expiration.
- Patient has full control over respiratory rate, inspiratory time , and depth of inspiration.

BiPAP

- This provides a set inspiratory pressure and a different set of expiratory pressure
- Initial setting:

EPAP:5cm H_2O

IPAP: 8cm H_2O

O_2 @ 2-5 L/min

Final IPAP pressures of 15 to 22 cm H_2O are common

BiPAP

- Patient has full control over the respiratory rate, inspiratory time and depth of inspiration
- IPAP & EPAP can be increased by increments of 2
- BiPAP = CPAP + Pressure support during inspiration

Patients likely to benefit

1. Cardiogenic pulmonary edema , exacerbation of COPD , Post-op respiratory failure.
2. Neuromuscular disease with respiratory muscle weakness, OSA.
3. Terminally ill patients & Immuno compromised patients.

4 Weaning mode.

Non- invasive ventilation

Advantages:

1 Complications of intubation -avoided

2 Allows speech ,feeding

Disadvantages:

1.Patient should be alert with normal respiratory drive and intact upper airway

2 Cannot protect airway and does not provide full 100% ventillatory support

4 Claustrofobia & uncomfortable for patients

Assessment of effectiveness

- Improvement in:

1. Respiratory rate and heart rate
2. Dyspnea
3. Oxygen requirement
4. Hypercarbia

Full Ventilatory Support

- Provides all the energy for Alveolar Ventilation
- Every breath is fully supported by the ventilator
- In classic control modes, patients are *unable* to breathe except at the controlled set rate
- In newer control modes, machines may act in assist-control, with a minimum set rate and all triggered breaths above that rate are also fully supported.
- Ensures that patient is not required to do any Work .Of.Breathing

Partial Ventilatory Support SIMV,PSV,VS

When to Consider:

- Spontaneously breathing patient.
- Comfortably provide a portion of their required minute volume
- Useful for weaning patients from MV support

When not to consider:

- Should be avoided in case of patients with ventilatory muscle fatigue

Pressure Control versus Volume Control Ventilation

	PRESSURE	VOLUME
Tidal Volume	Variable	Constant
Peak Ins Pressure	Constant	Variable
Dys-synchrony	Less	More likely
Barotrauma	Less	More likely
Flow Pattern	Decreasing	Preset

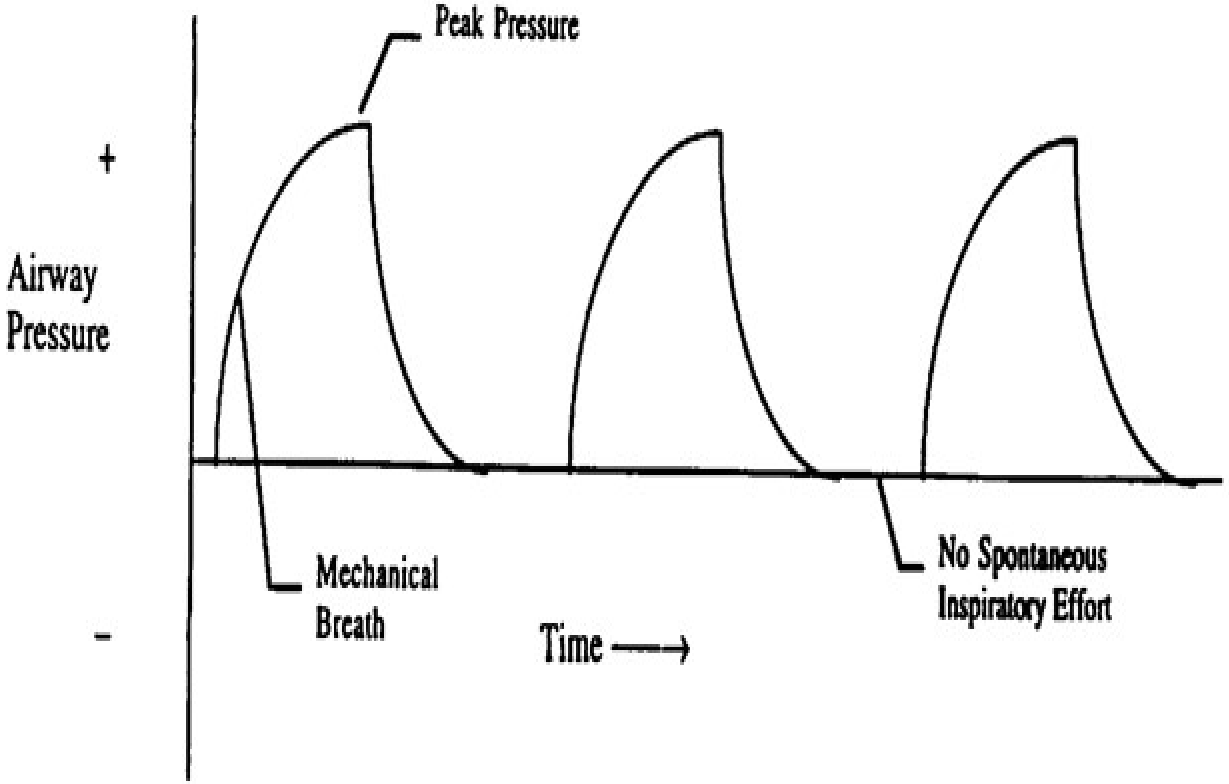
Pressure vs Volume Target

- Balance CO_2 removal v/s lung protection
- If CO_2 clearance more important than lung protection, use *VOLUME*
- If lung protection is more important than CO_2 removal use *PRESSURE*
- If patient triggered ventilation, synchrony may be enhanced with *PRESSURE*

Controlled Mode Ventilation Volume control

- The ventilator delivers a preset TV at a specific R/R and inspiratory flow rate.
- It is irrespective of patients' respiratory efforts.
- In between the ventilator delivered breaths the inspiratory valve is closed so patient doesn't take additional breaths.
- PIP developed depends on lung compliance and respiratory passage resistance.

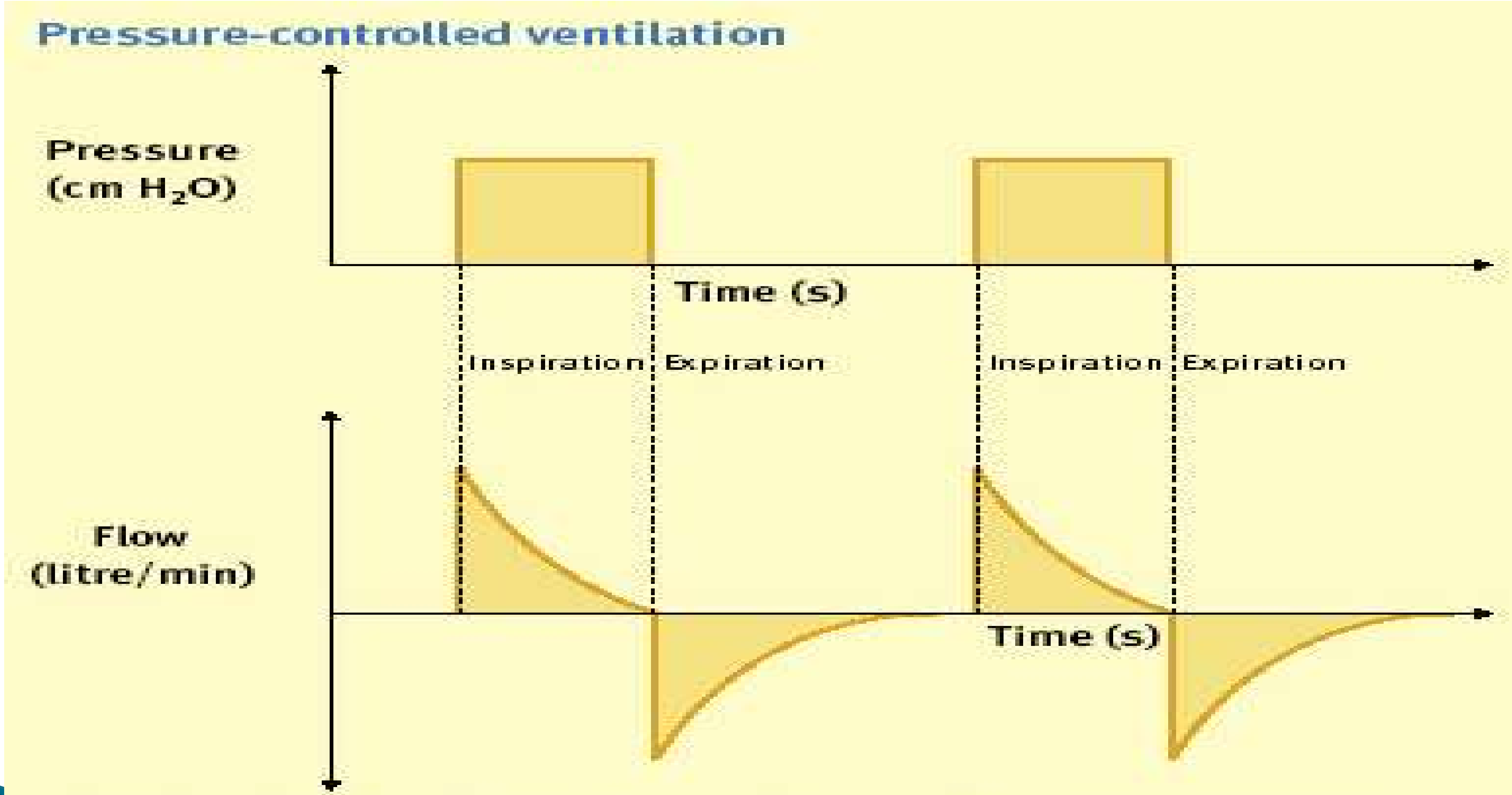
Controlled Mode Ventilation



Pressure Controlled Ventilation

- Ventilator gives pressure limited, time cycled breaths thus preset inspiratory pressure is maintained.
- Decelerating flow pattern.
- Peak airway/alveolar pressure is controlled but TV, minute volume & alveolar volume depends on lung compliance, airway resistance, R/R & I:E ratio.

PC- CMV

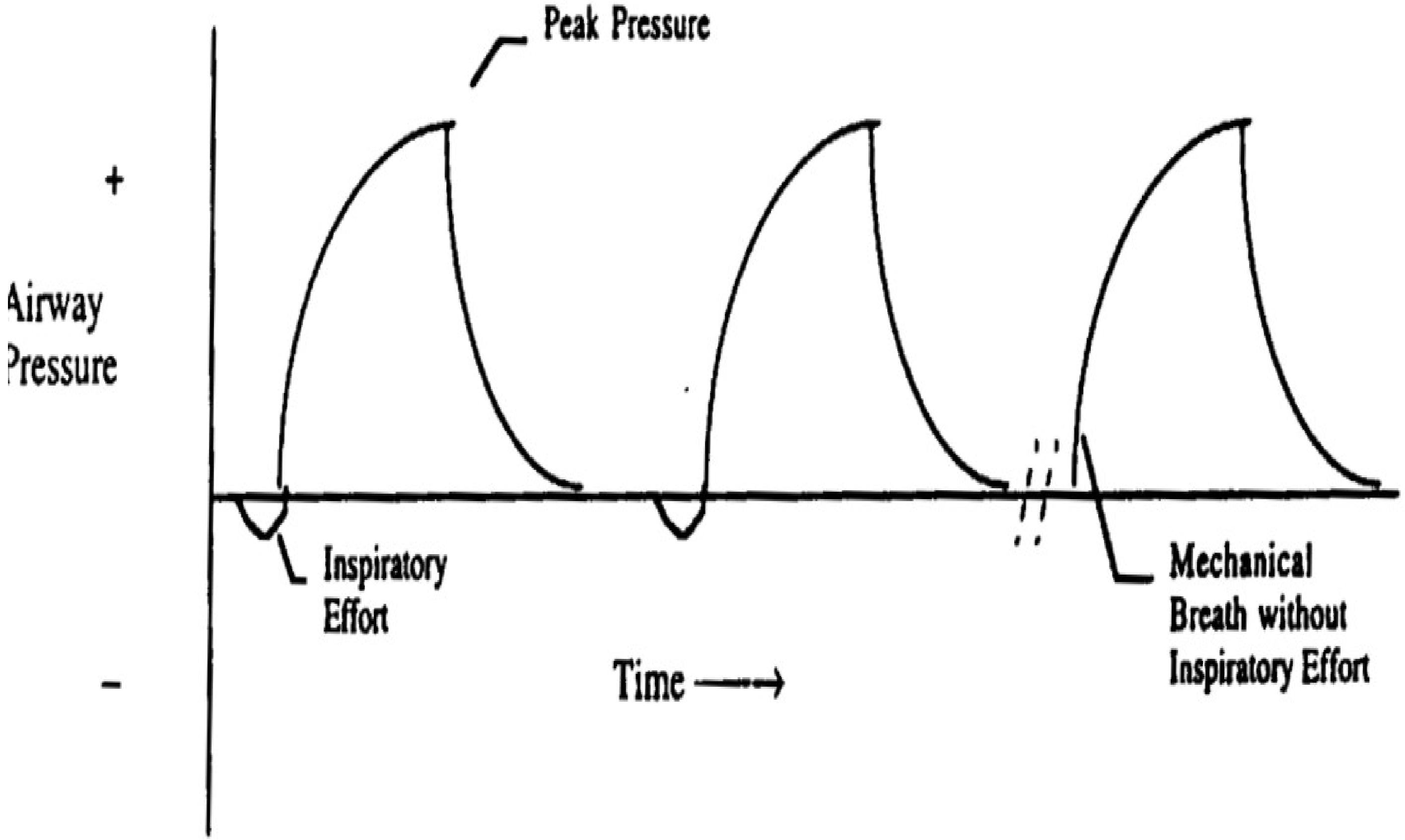


A decelerating inspiratory flow pattern is delivered resulting in a fixed pressure throughout the breath

ASSIST-CONTROL MODE Ventilation (A-C Mode)

- Ventilator assists patient's initiated breath, but if not triggered, it will deliver preset TV at a preset respiratory rate (control).
- Mandatory mechanical breaths may be either patient triggered (assist) or time triggered (control)
- If R/R > preset rate, ventilator will assist, otherwise it will control the ventilation.

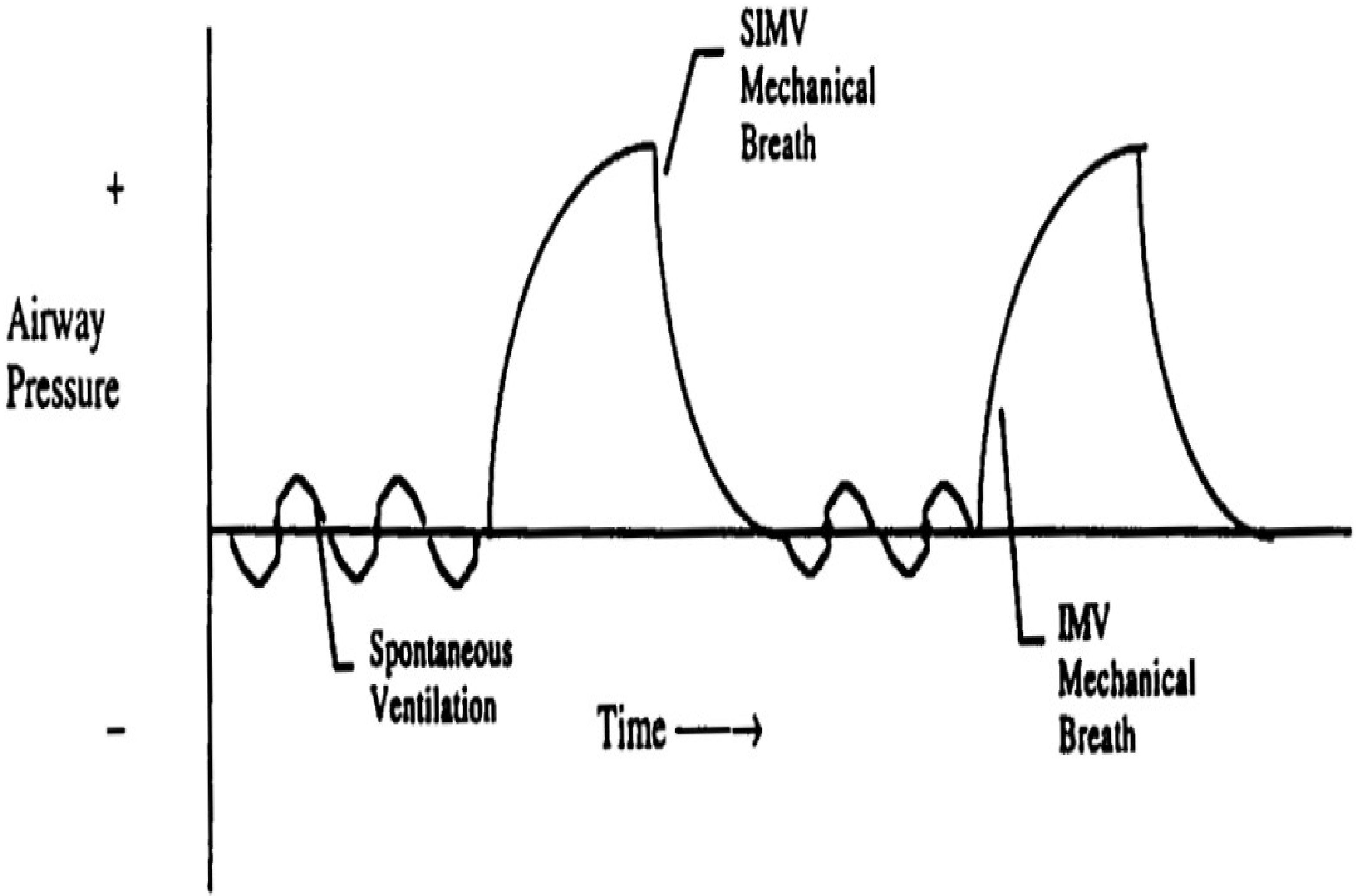
A-C Mode Ventilation



Synchronized Intermittent Mandatory Ventilation (SIMV)

- Ventilator delivers either assisted breaths at the beginning of a spontaneous breath or time triggered mandatory breaths.
- Synchronization window- time interval just prior to time triggering.
- Breath stacking is avoided as mandatory breaths are synchronized with spontaneous breaths.
- In between mandatory breaths patient is allowed to take spontaneous breath at any TV.

SIMV



SIMV
Mechanical
Breath
+
Airway
Pressure
-
Spontaneous
Ventilation
Time ⟶
IMV
Mechanical
Breath

Pressure Support Ventilation (PSV)

- Patient is spontaneously breathing
- The vent augments the patient's respiratory effort with a "pressure support"
- Tidal Volume is determined by patient's effort and respiratory system compliance
- Can set a FiO_2 PEEP and PS above PEEP
  - Can not set respiratory rate except back-up apnea rate.

What can I set

- FiO2
- Tidal Volume /Pressure
- Respiratory Rate
- PEEP
- Flow Rate
- I:E Ratio
- Trigger

What FiO2 Should I start with

- Start with FiO2 =1.0 and titrate to SpO2 >=94%
- ABG after 20-30min
- Goal -PaO2 between 60 -100 mmHg
- If FiO2 requirement is>0.5 , increase PEEP
- FiO2 =1.0, before & after suction, during bronchoscopy, & any other risky procedure

What Tidal Volume should I start with

- The tidal volume is the amount of air delivered with each breath.
- Initial tidal volumes should be 8-10ml/kg, depending on patient's body habitus.
- If patient is in ARDS consider tidal volumes between 4 - 6 ml/kg with increase in PEEP
- In Pressure-Targeted modes you'll set the Pressure High (PH) according to the delivered tidal volume

Ideal Body Weight (kg)

- Males: IBW = 50 kg + 2.3 kg for each inch over 5 feet.
- Females: IBW = 45.5 kg + 2.3 kg for each inch over 5 feet.

What Respiratory Rate should I start with

- An optimal method for setting the respiratory rate has not been established.
- 12 – 15/Min – Adult

  20+_ 3 – Child

  30– 40 – New born

On some machines you set the Inspiratory Time (T_i) and Expiratory Time (T_e)

Respiratory Rate

- Increase RR –

  Hypoxia

  Hypercapnoea / Resp. Acidosis

  Sepsis, ARDS, metabolic acidosis

- Decrease RR–

  Hypocapnoea

  Resp. Alkalosis

  Asthma / COPD

Keep in mind the Minute Ventilation

- Minute Ventilation (L/min) = RR (b/min) x Tidal Volume (liters)
- If you decrease one or both the MV will decrease resulting inHypercapnia
- Tolerated in status asthmaticus and ARDS/ALI – Called “permissive hypercapnea”

What PEEP should I start with

- A typical initial PEEP applied is 5 cmH2O.
- Adjust up by increments of 2 for marked hypoxia
- However, up to 20 cm H2O used in ARDS

- PEEP increases intra thoracic pressure and can thus decrease venous return and thus Blood Pressure

PEEP

- Improves oxygenation
- Recruits Lung in ARDS
- Prevents collapse of alveoli
- Diminishes the work of breathing

What Flow Rate should I set

- Peak flow rates of 60 L per minute
- Higher rates are frequently necessary in Asthma or those with air hunger
- An insufficient peak flow rate is characterized by dysnoea, spuriously low peak inspiratory pressures, and scalloping of the inspiratory pressure tracing
- Pressure-Targeted modes allow patient to dictate the flow rate that they want

Inspiratory Time: Expiratory Time Relationship (I:E Ratio)

- During spontaneous breathing, the normal I:E ratio is 1:2.
- If exhalation time is too short "breath stacking" occurs resulting in an increase in end-expiratory pressure also called auto-PEEP.
- Asthma/COPD 1:3, 1:4, …
- Severe hypoxia ARDS 1:1, 2:1,

Inspiratory Pause (0.5-1 sec)

- Most frequently used to obtain an estimate of Plateau pressure and static compliance
- Patient should not be actively breathing
- When used with each breath, improves distribution of air, V/Q ratio.

Trigger

- **Pressure triggering** -1to -2cm H_2O

  Ventilator-delivered breath is initiated if the demand valve senses a negative airway pressure deflection greater than the trigger sensitivity.

- **Flow triggering** 1 to 3 L/ min (preferred)

  Continuous flow of gas through the ventilator circuit is monitored. A ventilator delivered breath is initiated when the return flow is less than the delivered flow

Sedation

- different medications for sedation.
- Opiates (morphine, fentanyl)

Benzodiazepines (Midazolam)

- Propofol
- Less is sometime more

Long Term Chemical Paralysis

- Paralysis without sedation = Torture

  Atracurium,Vecuronium can be used

- All one needs in this situation is chemical weakening…

Appropriate Alarms

- Low pressure,
- High pressure limit and alarm
- Volume alarm(low TV, high and low minute ventilation)
- High respiratory rate alarm
- Apnea alarm and apnea values
- High/low temperature alarm
- I:E ratio limit and alarm

Complications of positive pressure ventilation

Increase in positive airway pressure

- High intrathorasic pressure
- this pressure transmitted to airway,alveoli,as well as mediastinum and great vessels
- Compression of great vessels
- Decreased venous return

Decreased strock volume and

cardiac output

decreased GFR

decreased urine output

Weaning

The process of withdrawing mechanical ventilatory support and transferring the work of breathing from the ventilator to patient.

Readiness To Wean

- Improvement of the cause of respiratory failure
- Absence of major system dysfunction
- Appropriate level of oxygenation
- Adequate ventilatory status
- Intact airway protective mechanism (needed for extubation)

Rapid Shallow Breathing Index

- Failure of weaning may be related to the development of a spontaneous breathing pattern that is rapid (high frequency) and shallow (low tidal volume).

- The rapid shallow breathing index (RSBI) or f/VT index has been used to evaluate the effectively of the spontaneous breathing pattern.

- Favourable RSBI is < 105

Methods of weaning

- No one or method of weaning has been definitely found to be superior;
- Spontaneous Breathing Trial
- Pressure Support Ventilation
- Other Modes of Partial Ventilatory Support
- SIMV
- Volume support (VS) and volume-assured pressure support (VAPS)
- Mandatory minute ventilation (MMV)
- Airway pressure-release ventilation (APRV)

PROCEDURE	Steps
PSV	1. PSV may be used in conjunction with spontaneous breathing or SIMV mode;
	2. Start PSV at a level of 5 to 15 cm H_2O (up to 40 cm H_2O) to augment spontaneous VT until a desired VT (10 to 15 mL/kg) or spontaneous frequency (<25/min) is reached;
	3. Decrease pressure support (PS) level by 3 to 6 cm H_2O intervals until a level of close to 5 cm H_2O is reached;
	4. If patient tolerates step (3), consider extubation when blood gases and vital signs are satisfactory.

What after weaning

- Oxygen therapy
- Close monitoring: ABGs evaluation, Pulse oximetry
- Bronchodilator therapy
- Chest physiotherapy
- Adequate nutrition, hydration, and humidification
- Incentive spirometry

- Trouble Shooting

Management of the tube

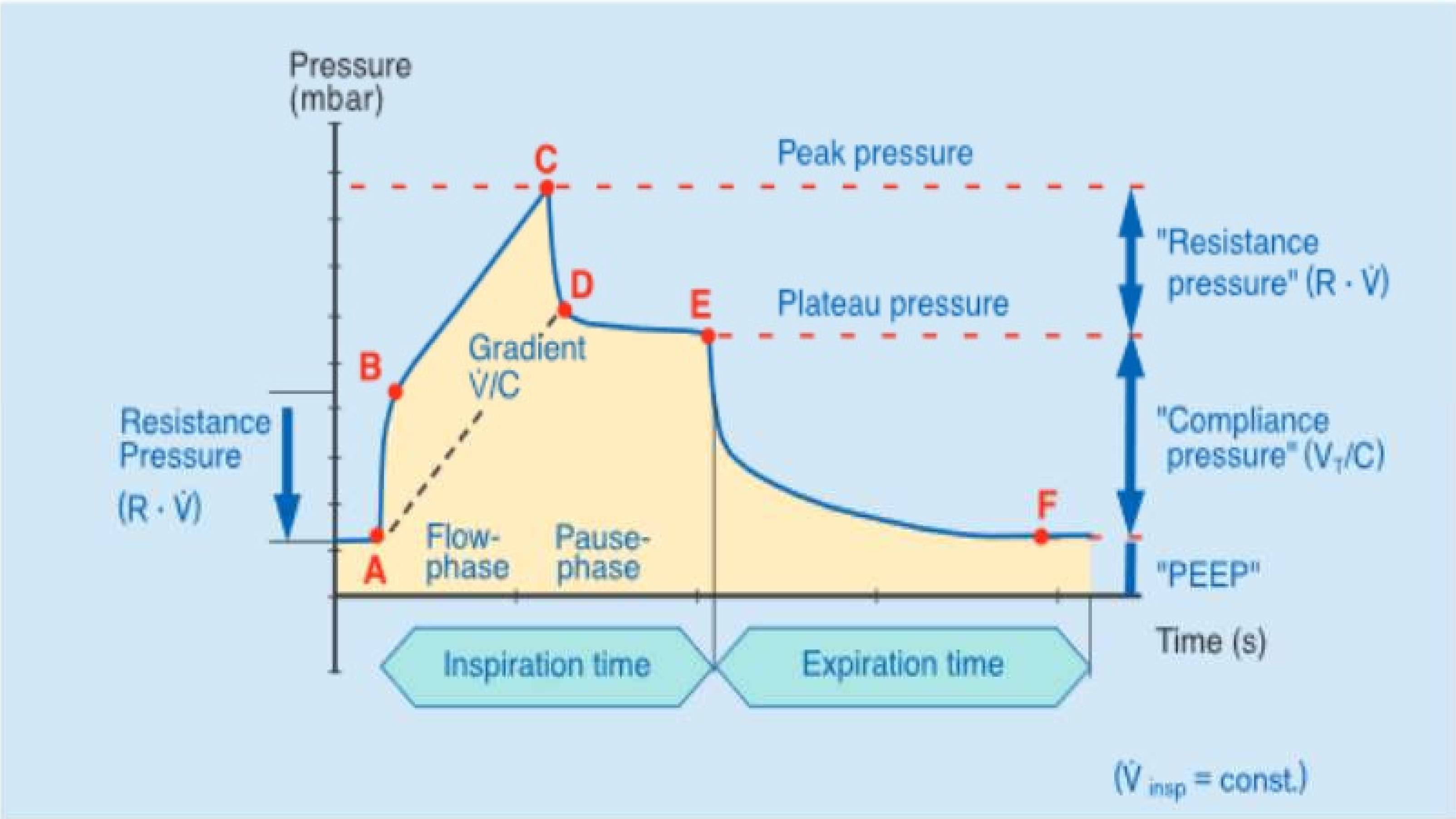
- The ETT must be repositioned and re-secured at least once a shift to prevent tissue breakdown
- Mouth care needs to be performed routinely
- Cuff pressure needs to be assessed once a shift
- Sometimes a higher pressure is needed to seal (ETT is too small, anatomical differences)
- Check for proper inflation, determine the location of the leak, assess the integrity of the pilot line
- Suctioning

Evaluating for Leaks

- Every ventilator check must include assessing the circuit integrity
- PIP and Vt measurements are lower than previous measurements
- Start at the patient connection and work back to the ventilator
- May need to disconnect the patient and provide manual ventilation while testing the circuit

If peak pressures are increasing

- Check plateau pressures by allowing an inspiratory pause (this gives you the pressure in the lung itself without the addition of resistance)
- If peak pressures are high and plateau pressures are low then you have an obstruction
- If both peak pressures and plateau pressures are high then you have a lung compliance issue



Pressure (mbar)
Peak pressure
C
D
E
Plateau pressure
B
Gradient V̇/C
"Resistance pressure" (R · V̇)
Resistance Pressure (R · V̇)
"Compliance pressure" (V_T/C)
F
A
Flow-phase
Pause-phase
"PEEP"
Time (s)
Inspiration time
Expiration time
(V̇ insp = const.)

Trouble Shooting the Vent

- High peak pressure differential:

High Peak Pressures Low Plateau Pressures	High Peak Pressures High Plateau Pressures
Mucus Plug	ARDS
Bronchospasm	Pulmonary Edema
ET tube blockage	Pneumothorax
Biting	ET tube migration to a single bronchus
	Effusion

Trouble Shooting the Vent

- Increase in patient agitation and dis-synchrony on the ventilator:
  - Could be secondary to overall discomfort
    - Increase sedation
  - Could be secondary to feelings of air hunger
    - Options include increasing tidal volume, increasing flow rate, adjusting I:E ratio, increasing sedation

Mechanical Ventilation in Asthma

- Early use of NPPV
  - Prepare and expect hypotension during intubation – IVF bolus
- Mechanical Ventilation Strategy – Permissive Hypercapnia
  - Ventilator maneuvers that prolong I:E – Low tidal volumes, low respiratory rates, square wave forms, high flow rates.

Mechanical Ventilation in Asthma

- Tidal Volumes: 6-7 ml/kg (IBW)
- Respiratory Rate: 8-10 bpm
- Flow Rate: 80-100 L/min
- Square Wave forms
- SEDATION: propofol,fentanyl
- Last resort: chemical weakening
- Expect high peak pressures

Mechanical Ventilation in ARDS

- Lung Protective Strategy
- Low-Tidal Volumes
- Start at 6 mL/kg IBW
- Goal of 4-6 mL/kg IBW
- Low Plateau Pressures – Less than 30
- High PEEP
- Permissive hypercapnia

THANK YOU