
IN GOD WE TRUST

Ventilator Modes

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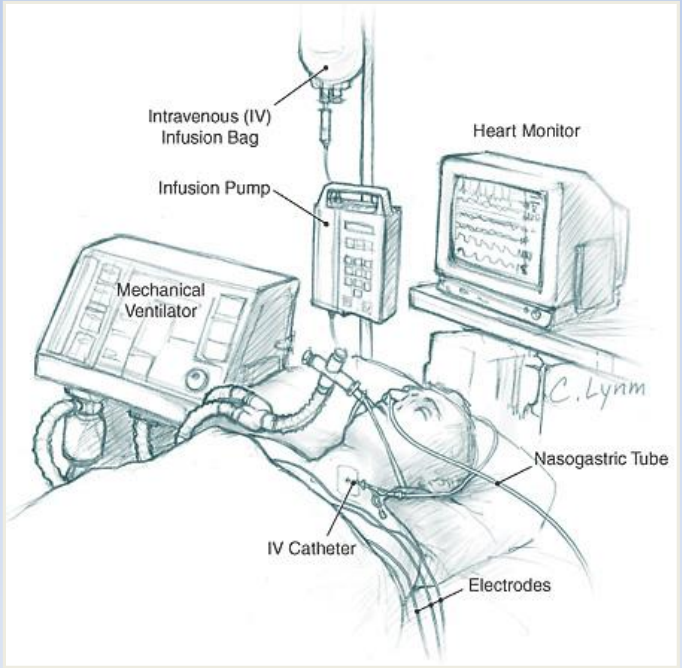
Indication

Indication

- Hypoxic respiratory failure
- Hypercapneic respiratory failure
- Protect airway
- refractory shock
- Reduction of ICP
- GA



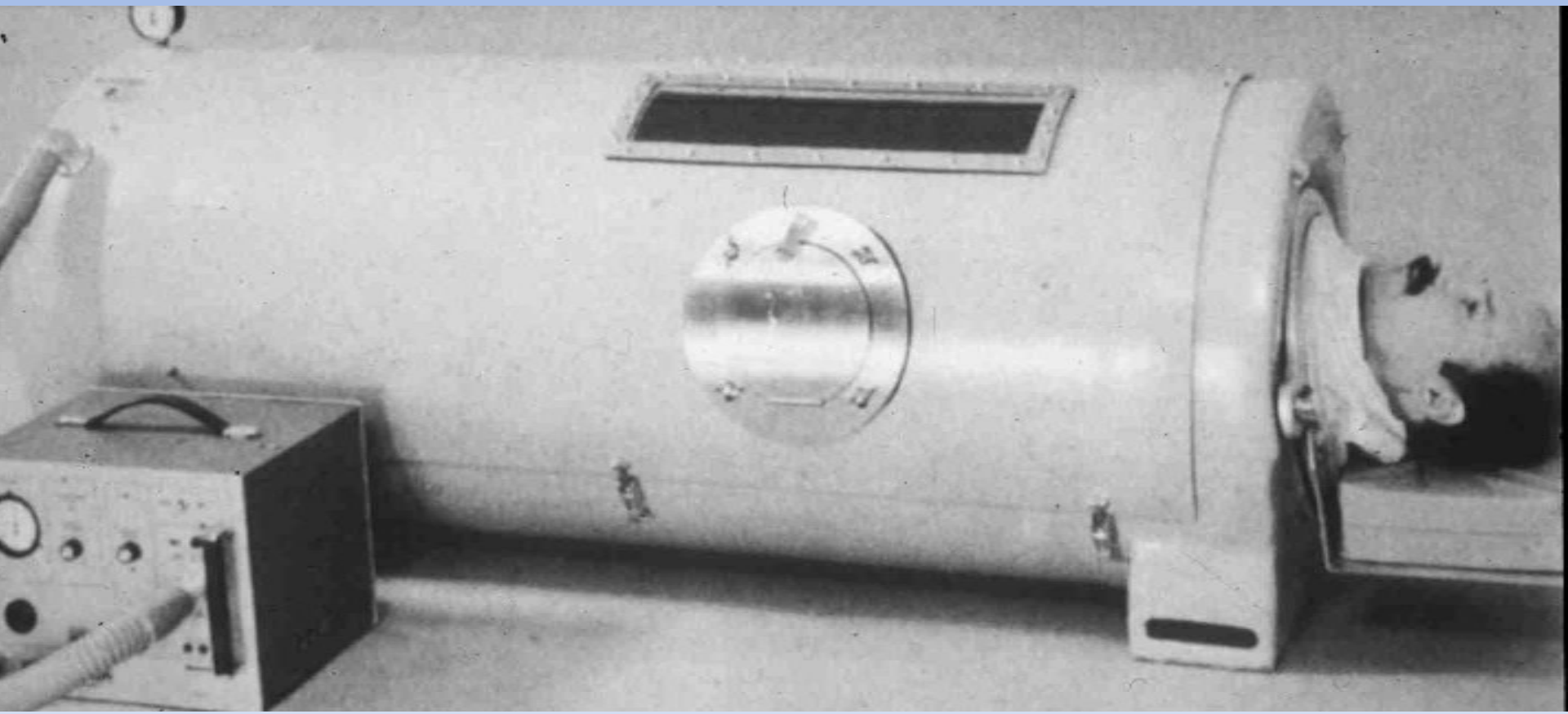
Classification

Classification

1. **Negative-pressure ventilators ("iron lungs")**
   - **Non-invasive ventilation first used in Boston Children's Hospital in 1928**
   - **Used extensively during polio outbreaks in 1940s – 1950s**

   "Iron Lung"
   Cuirass (breastplate) ventilators
   Physiological but impractical
2. **Positive-pressure ventilators**
   - **Invasive ventilation first used at Massachusetts General Hospital in 1955**
   - **Now the modern standard of mechanical ventilation**

   Unphysiological but practical



Iron lung polio ward at Rancho Los Amigos Hospital in 1953.

Classification

1. Invasive ventilation
   - applied through a endotracheal tube or a tracheotomy
2. Non invasive ventilation (NIPPV)
   - applied to patient's mouth or nose
   - Advantages: less patient discomfort, reduced need for sedation, and a lower incidence of ventilator associated pneumonia and sepsis

Classification

- **Total ventilatory support**
- *Patient's own* breathing pattern is totally replaced by the ventilator (sedation and respiratory muscle paralysis)
- **Partial ventilatory support**
- *The ventilator* provides a partial amount of minute ventilation

Classification

- ***Conventional***
  1. deliver a VT higher than the dead space volume
  2. apply a positive pressure at the airway opening
- ***Unconventional***
  - application of a VT lower than the dead space volume (1-3 mLlkg)
  - use of external gas exchangers that bypass the lung and the heart
  - High-Frequency Ventilation
  - High-Frequency jet ventilation
  - High-Frequency osilatory Ventilation *(active expiration)*
  - Extracorporeal Membrane Oxygenation
  - Extracorporeal Carbon Dioxide Removal
  - Liquid Ventilation (perfluorocarbons)

Classification

- **Volume-cycled modes**
  - **deliver a fixed volume at variable pressure**
- **Pressure-cycled modes**
  - **deliver a fixed pressure at variable volume**
- **Dual**
  - **deliver a fixed pressure & volume**

Volume ventilation

- حجم جاری بدون توجه به مقاومت وکمپلیانس ریه ثابت
- فلوی دمی ثابت
- فشار راه هوایی متغیر
- Pressure limitبرای جلو گیری از پنوموتوراکس
- ارجح در افزایش ICP

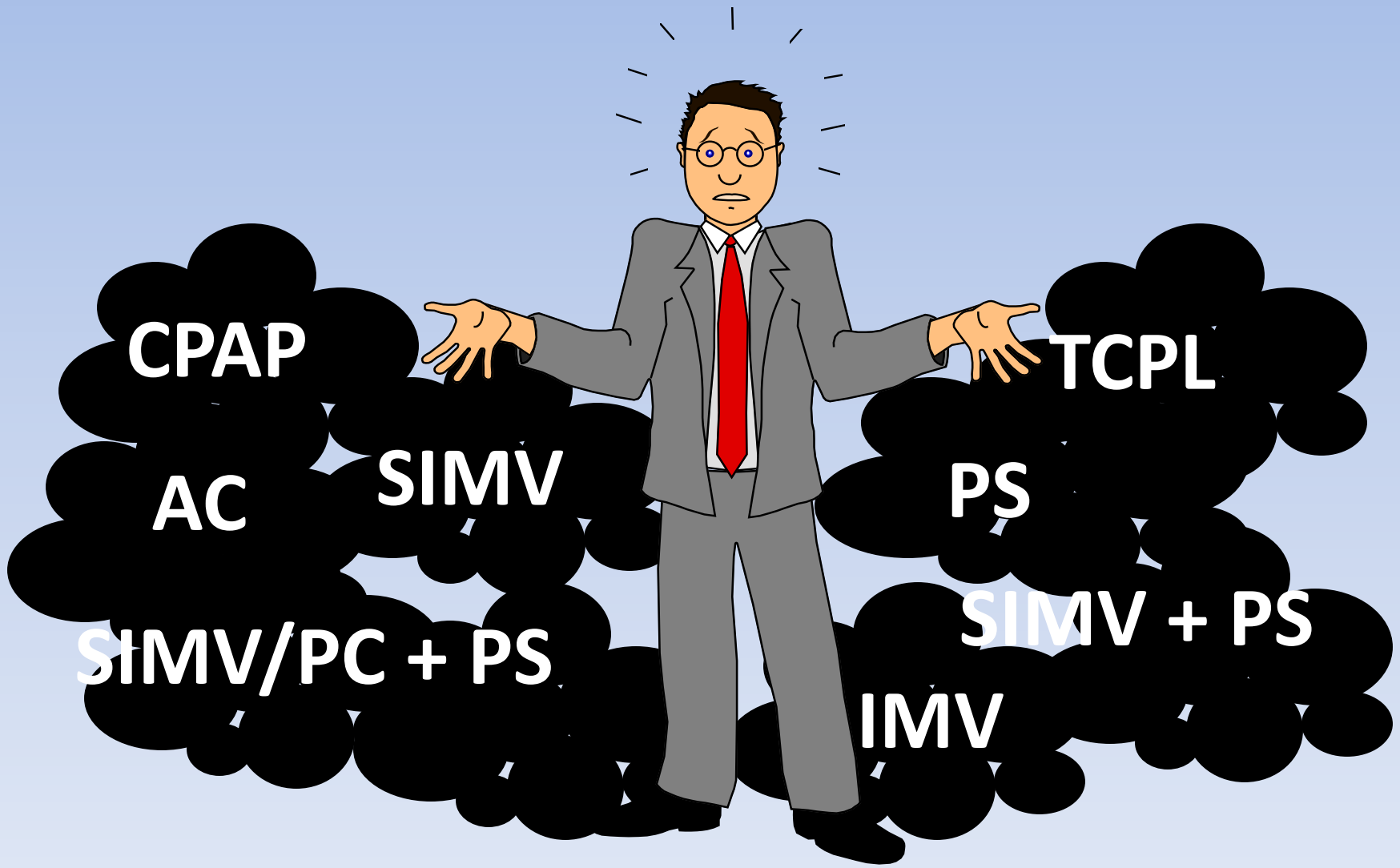
Pressure Ventilation

- PIP &Plateau pressure are constant
- TV is variable
- خطر افزایش فشار راه هوایی و پنوموتوراکس کم
- Flow is decelerating

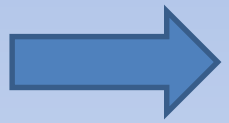
Table 75–6 Characteristics of volume-targeted ventilation (VTV) and pressure-targeted ventilation (PTV)

Variable	VTV	PTV
Trigger	Patient or Time	Patient or Time
Limit	Flow	Pressure
Cycle	Volume	Time or Flow
Tidal Volume	Constant	Variable
Peak Pressure	Variable	Constant
Modes	Assist/Control (synchronized) intermittent Mandatory ventilation	Assist/Control (synchronized) intermittent Mandatory ventilation Pressure support

What MODE??



Modes of ventilation

Which mode  which patient

Which mode you are familiar

Variables of ventilation:

1. How it initiates a breath *(trigger)*
2. How it sustains a breath *(Target or Limit)*
3. How it terminates a breath *(cycle)*

Triggers

1. Time trigger
2. Pressure trigger
3. Flow trigger

Which one is better?

MODES

1. CMV Continuous MandatoryVentilation
2. A/C Assist/Control ventilation
3. IMVIntermittent mandatory ventilation
4. SIMV synchronized IMV
5. MMV Mandatory minute ventilation

MODES

6. PCV pressure control ventilation
7. PSV pressure support ventilation
8. PAV Proportional-Assist Ventilation
9. BIPAP Bilevel positive airway pressure
10. APRV Airway Pressure-Release Ventilation

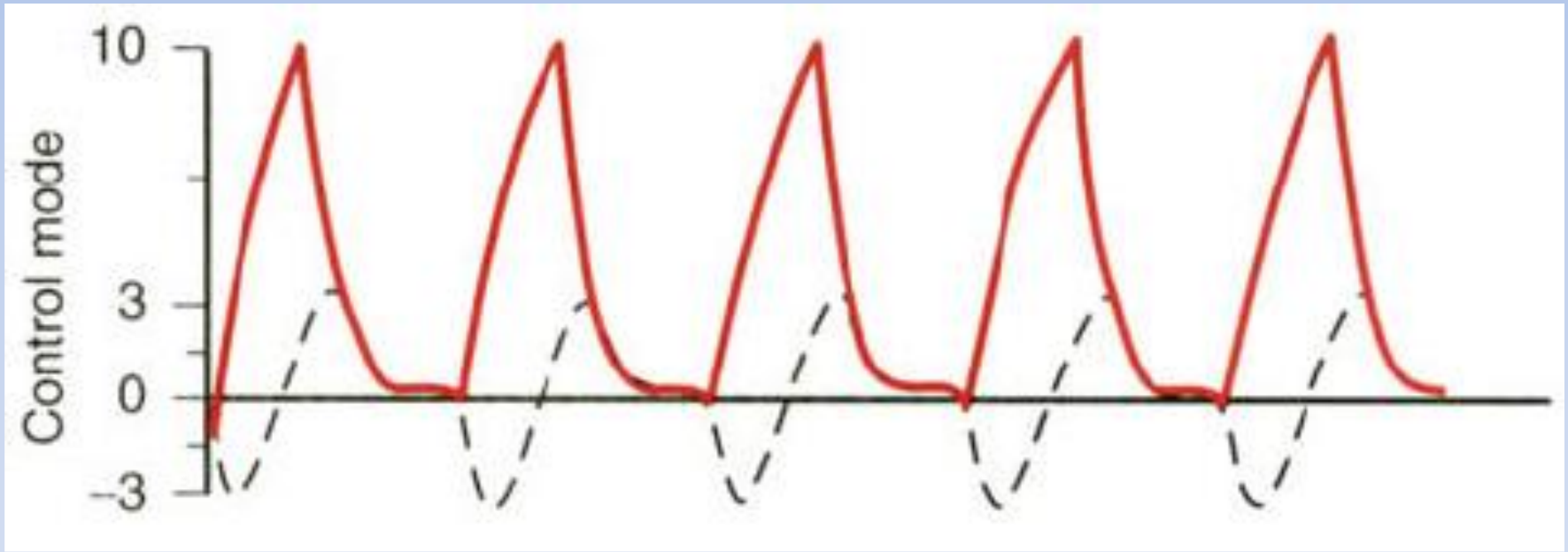
MODES

11.ASV Adaptive Support Ventilation

12.NAVA Neurally adjusted ventilatory assist

13.PRVC pressure regulated volume control

ContinuousMandatoryVentilation (CMV)

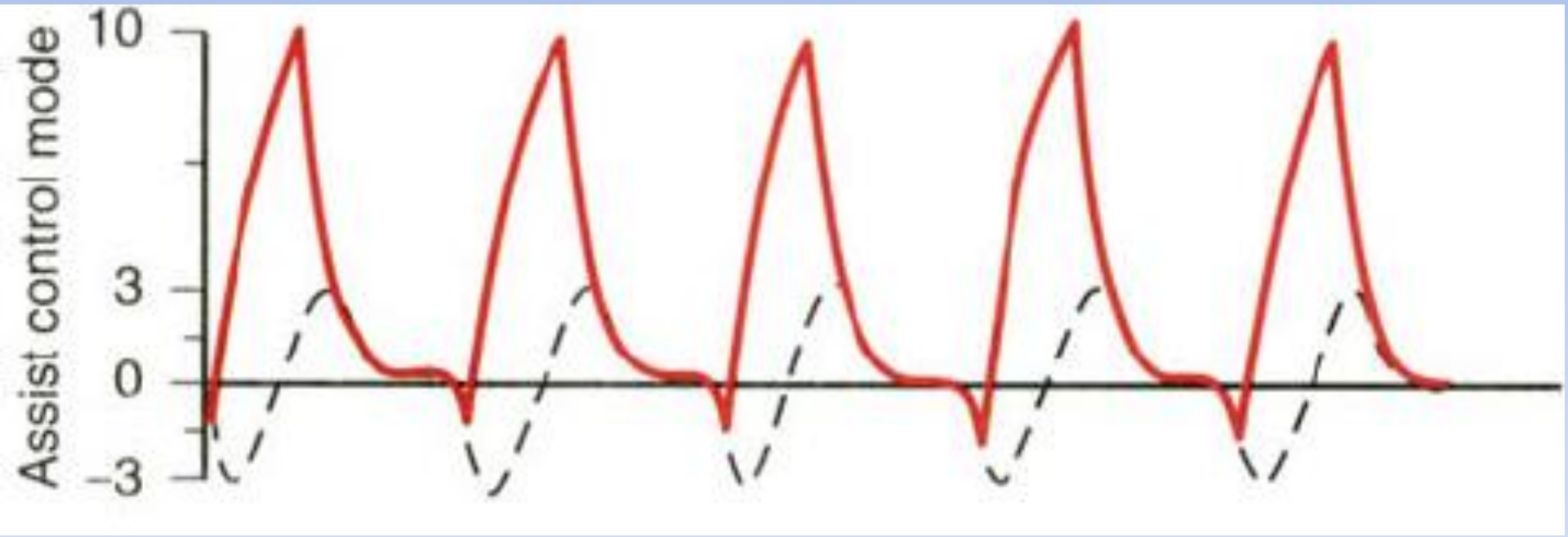


Continuous MandatoryVentilation (CMV) /IPPV

MODE	trigger	limit	cycle
CMV	Time	Volume	Time

- ICP GA, GBS, Deep sedation
- Fighting
- Sedation
- Muscular atrophy
- Syncنبودن
- Flow بین تنفس های دستگاه وجود ندارد

Assist/Control ventilation



Assist/Control ventilation

MODE	trigger	limit	cycle
A/C	patient	Volume	time

- Fighting &sedation
- Indication: برای بیمارانی که تنفس ارادی دارند ولی ضعف عضلانی دارند

❑ Disadvantages

- Dys-synchrony
- Respiratory alkalosis
- Dynamic hyperinflation
- Auto-PEEP & Hypotension

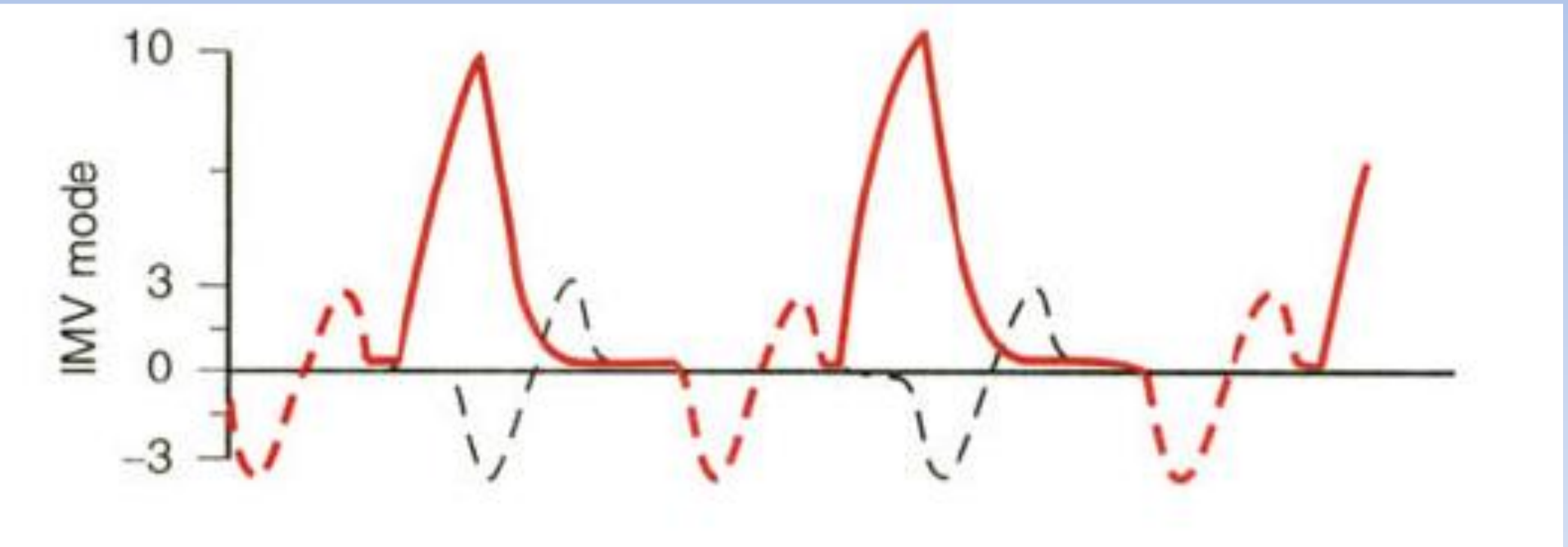
- Patient 70 kg
- A/C , TV:700 cc, Rate: 10/min
- Patient RR=0

  Vent RR = 10
- Patient RR=10

  Vent RR = 10
- Patient RR=20

  Vent RR = 20

Intermittent mandatory ventilation (IMV)

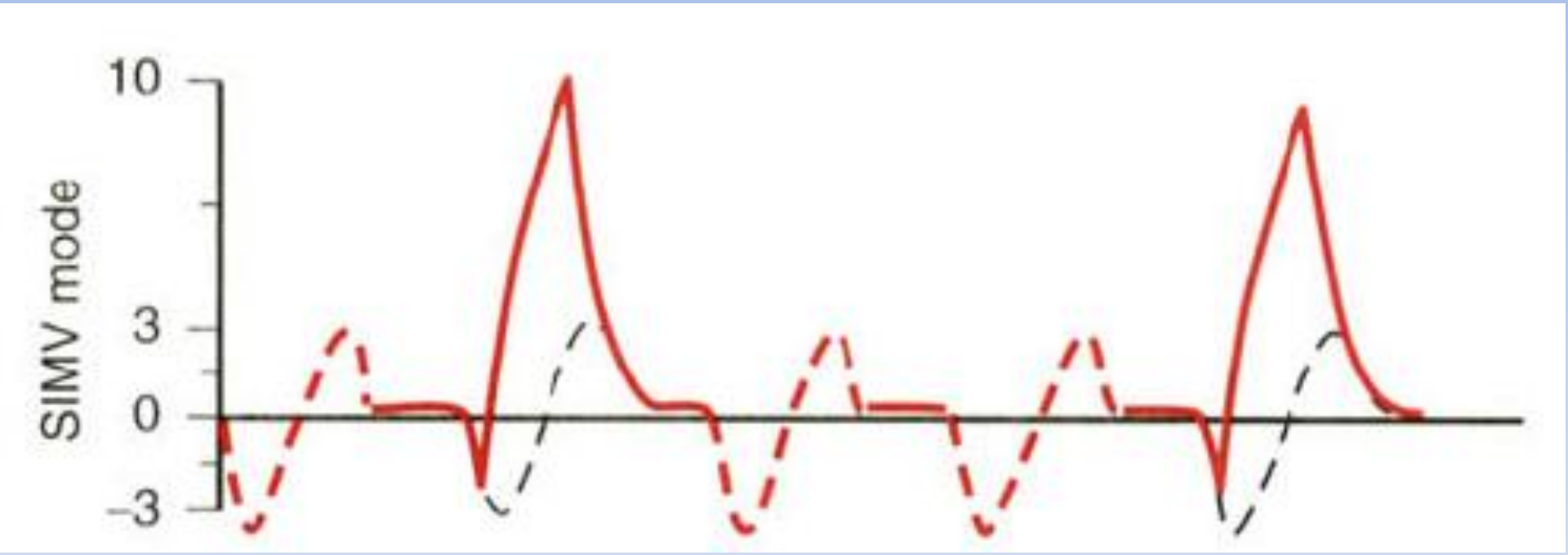


Intermittent mandatory ventilation (IMV)

MODE	trigger	limit	cycle
IMV	Time	Volume	Time

- CMV + Continuous FGF
- Spontaneous ventilation
- Indication: Weaning

SIMV

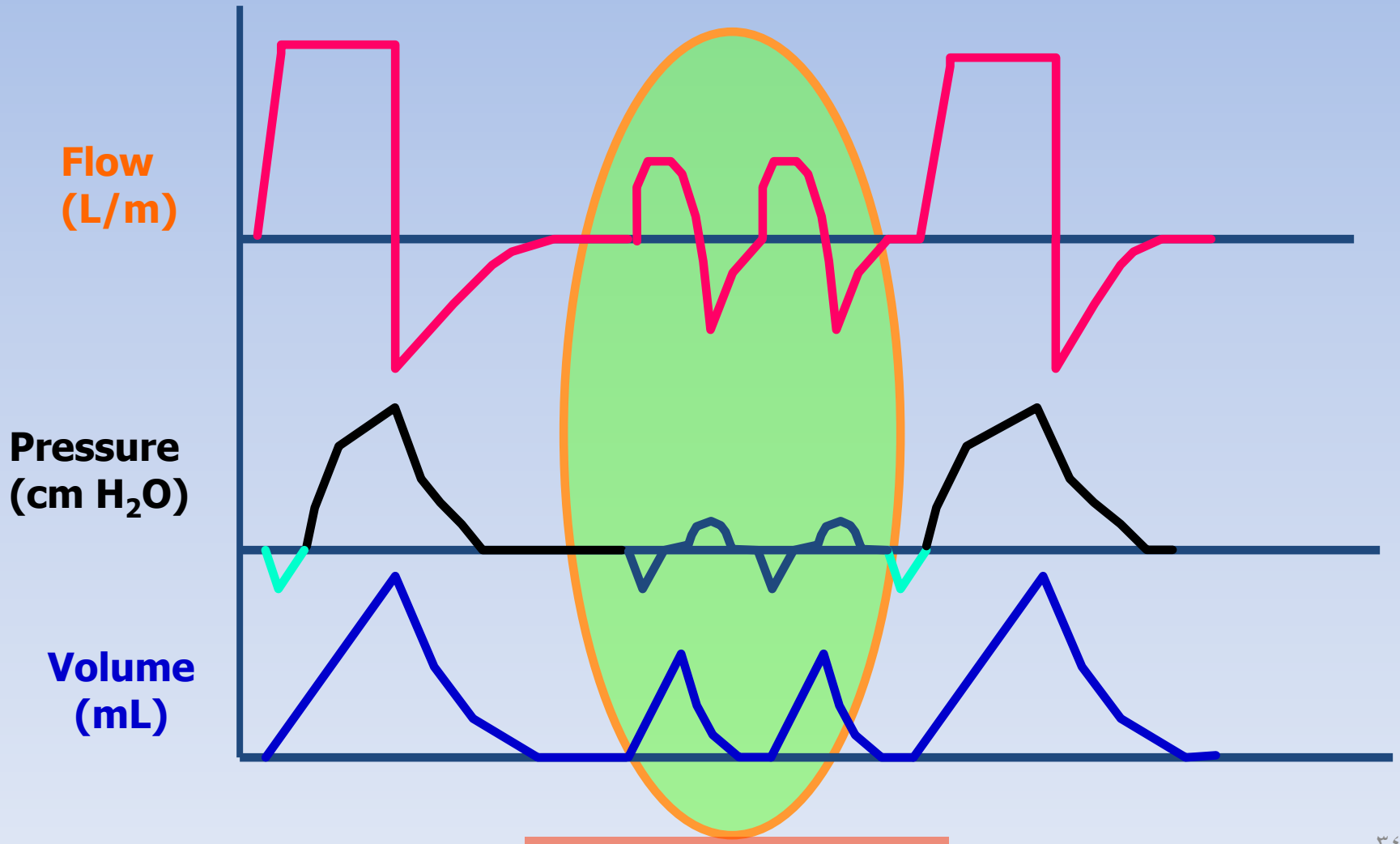


SIMV

MODE	trigger	limit	cycle
SIMV	Patient	Volume	Time

- A/CMV + Demand valve
- Synchronized
- Fighting
- Sedation

SIMV
(Volume-Targeted Ventilation)



- چرا در SIMV بمدت طولانی بیمار خسته می شود ولی در IMV بمدت طولانی بیمار خسته نمی شود؟

- IMV FGF
- SIMV Demand Valve

MMV
Mandatory minute ventilation

MODE	trigger	limit	cycle
MMV	Patient	Volume	Time

- **Dräger**
- minute ventilation is set
- Weaning mode in which the ventilator delivers mandatory breaths only when the pt's spontaneous minute ventilation falls below a preset target.

MMV

- Disadvantage :

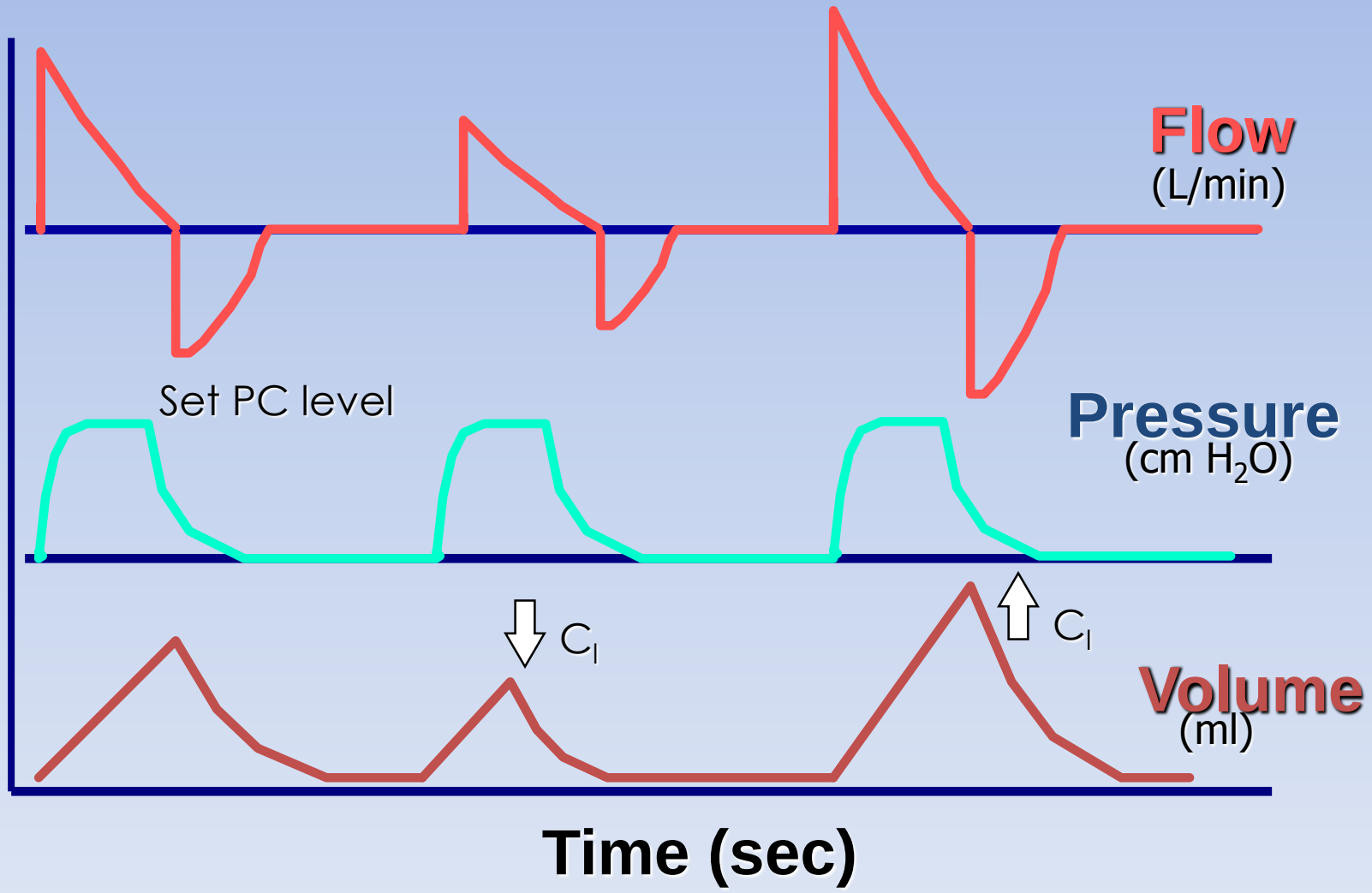
- TV=500 RR=10 MV=5000
- TV=250 RR=20 MV=5000
- TV=100 RR=50 MV=5000

Pressure Control Ventilation

MODE	trigger	limit	cycle
PCV	Time	Pressure	Time

- **Disadvantage**
  - Requires frequent adjustments to maintain adequate V_E
  - Pt with noncompliant lungs may require alterations in inspiratory times to achieve adequate T_V

Pressure Control Ventilation



Pressure-support ventilation (PSV)

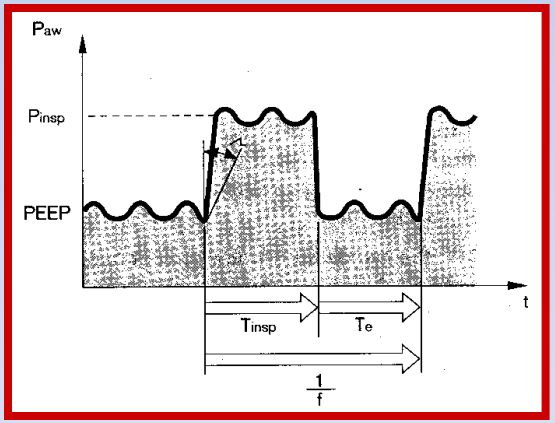
MODE	trigger	limit	cycle
PSV	Patient	Pressure	Flow

- Pressure support levels in excess of 10 cmH2O may be needed to overcome the resistance of an endotracheal tube, particularly with small (<7 mm) endotracheal tubes.
- At higher levels of pressure support (>10 cmH2O), tidal volume is augmented and respiratory rate slows.
- Usually used during recovery phase of respiratory failure as a weaning mode
- not appropriate for ***apneic pt's***
- **مود مستقل نمی باشد.**

BiPAP

MODE	trigger	limit	cycle
BiPAP	Patient	Pressure	Time

- BiLevel (PCV+)
- Preset RR, IT,
- Typical settings are an IPAP of 8 to 20 cm H2O and an EPAP of 4 to 5 cm H2O.
- The IPAP should be titrated to give an expiratory tidal volume of about 7 ml/kg and a respiratory rate of less than 25.



PAV & PAV+
Proportional assist ventilation

MODE	trigger	limit	cycle
PAV	Patient	Pressure	Flow

- the ventilator generates pressure in proportion to patient-generated flow and volume

Airway Pressure Release Ventilation (APRV)

- **Advantages**
  - Lower peak airway pressures
  - Recruitment and stabilization of collapsed alveoli(intrinsic PEEP due to short expiratory phase)
  - Reduced deadspace ventilation
  - Allows spontaneous breathing
- **Disadvantages**
  - Tidal volume varies with changes in the resistance and compliance properties of the lung
  - Synchrony ↖ airway pressure release is not synchronized with spontaneous breathing

ASV
Adaptive Support Ventilation

MODE	trigger	limit	cycle
ASV	Patient	Pressure	Time

- It response to changes in both respiratory impedance (elastance and resistance) and the patient's spontaneous efforts.
- the operator enters the patient's body weight and sets the desired percentage of minute ventilation.
- adjusts inspiratory pressure, inspiratory-expiratory time ratio, and mandatory respiratory rate to maintain the target minute ventilation and respiratory rate.

NAVA
Neurally adjusted ventilatory assist

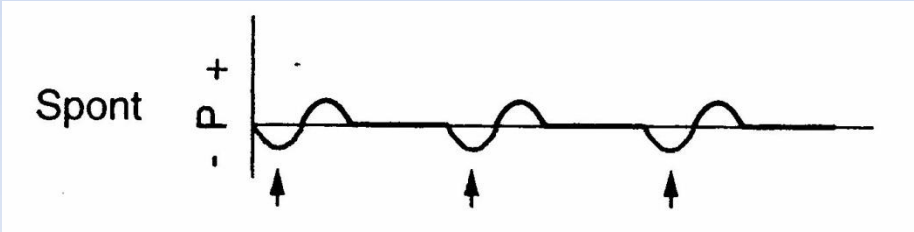
- electrical activity of the diaphragm is measured by means of an electrode array inserted into a nasogastric tube and placed in the lower esophagus; this information is then used to control the ventilator to generate flow, volume, and pressure
- Not routine use
- Not available in most ventilators
- Servo I

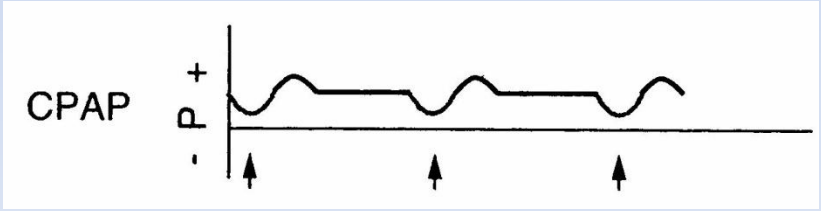
CPAP

Continuous Positive Airway pressure

is a spontaneous breath mode, with the baseline pressure elevated above zero.

- ❑ Advantages
  - Improves oxygenation by increasing FRC
  - Decreases physiological shunting
  - Improved oxygenation will allow the FIO2 to be lowered
  - Increased lung compliance
- ❑ Disadvantages
  - Increased incidence of pulmonary brotrauma
  - Potential decrease in venous return
  - Increased work of breathing
  - Increased intracranial pressure





PEEP
Positive End Expiratory Pressure

PEEP is the application of positive pressure to change baseline variable during CMV, SIMV, IMV and PCV. PEEP is primarily used to improve oxygenation in patients with severe hypoxemia.

- Advantages
  - Improves oxygenation by increasing FRC
  - Decreases physiological shunting
  - Increased lung compliance
- Disadvantages
  - Increased incidence of pulmonary brotrauma
  - Potential decrease in venous return
  - Increased work of breathing
  - Increased intracranial pressure

PEEP

- ***Physiologic PEEP***: A small amount of applied PEEP (3 to 5 cmH2O) to overcoming the decrease in FRC caused by bypass of the glottic apparatus during endotracheal intubation.
- ***Supraphysiologic PEEP***: (>5 cm H2O) is applied most often in three settings, for the following reasons:
  - In patients with obstructive airways disease and dynamic hyperinflation, to offset the effects of auto-PEEP.
  - In hypoxemic respiratory failure with acute lung injury, to improve oxygenation and prevent worsening lung injury .
  - In patients with cardiogenic pulmonary edema, to improve oxygenation and improve cardiac performance.

Contraindications

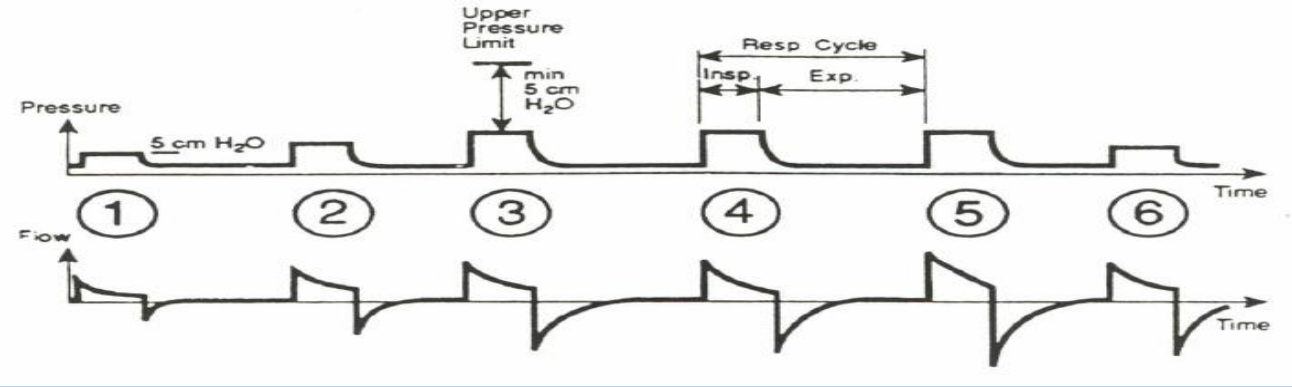
- No absolute contraindications
- Relative contraindications:
  1. intracranial abnormalities
  2. unilateral lung disease
  3. hypotension
  4. Hypovulemia
  5. pulmonary embolism
  6. bronchopleural fistula

DUAL MODES

Table 75–7 Partial list of available dual-control modes of positive-pressure ventilation

Adaptive Pressure Ventilation (APV)	Volume-Assured Pressure-Support Ventilation (VAPSV)
Auto-Flow	Volume Control Plus (VC+)
Pressure Augmentation	Volume Support
Pressure-Regulated Volume Control (PRVC)	
Variable Pressure Control	

PRVC
pressure regulated volume control



- the clinician sets a target tidal volume and maximum pressure level. The ventilator attempts to achieve the volume target using a pressure-control format at the lowest possible airway pressure
- If the target volume is exceeded, the pressure limit is decreased by 1-3 cmH20 on each breath until the target tidal volume is reached

Setting

• Volume	•pressure
• RR • TV • I/E ratio • Flow • flo2 • Trigger (ACMV,SIMV) • PIP alarm • PS(SIMV) • PEEP	•RR •Pressure •Ins time •Fio2 •Trigger •PEEP

SETTING

- ***Tidal volume***
- 10 mL/kg for patients who do not have lung disease
- less than 10 mL/kg In patients with lung disease (obstructive airways disease, fibrotic lung disease, post lung resection).
- In (ALI) or (ARDS), an initial 6 mL/kg ideal body weight
- ***Respiratory rate***
- Initiate between 12 and 16 breaths/minute
- In ALI or ARDS begin between 18 and 22 breaths/minute
- Once the desired tidal volume has been determined , incrementally increase (or decrease) the respiratory rate to achieve our pH and $PaCO_2$ goals.
- Other approaches
  - during SIMV adjust the RR to achieve at least 80 percent of the patient's minute ventilation
  - During A/C ventilation, the RR may be set four breaths per minute lower than the patient's spontaneous rate

SETTING

- ***Flow rates*** of 60 L/min are often sufficient; however, higher rates of inspiratory flow are frequently necessary to produce adequate gas exchange, especially in patients with obstructive airways disease
- ***trigger*** sensitivity of -1 to -3 cmH2O or 1-3 L/min
- ***FiO2: initiate 100%***
- ***PEEP: 5 cmH2O***
- ***I:E Ratio: 1:2***
- ***PS: 10-15***
- **Sigh**
  - a breath that has a greater volume than the preset V_T , usually 1.5 to 2.0 times the V_T
  - <u>No longer routinely used</u>

Suggested guidelines for mechanical ventilation

- Maintain plateau pressure < 30 cm H2O
- Avoid dynamic hyperinflation (auto-PEEP).
- Use PS during spontaneous breaths.
- Use lowest FIO2 to maintain acceptable arterial PaO2.
- Keep patient comfortable.
  - Anxiety, pain, WOB (RR < 20-30)


Any question?