
بسم الله الرحمن الرحیم

تهویه مکانیکی و کاربردهای آن

اندیکاسیون و
انواع مدهای تهویه مکانیکی

دکتر ابراهیم علیجان پور

Mechanical ventilation

- Indication
- Classification
- Modes of ventilation
- Setting
- Alarms
- Complication
- Weaning

Mechanical Ventilation Definition:

- Use of *positive pressure* to physically transport gases into and out of lungs

  (earlier ventilators used negative pressure)
- Usually performed via ETT -TT but not always (noninvasive ventilation)

Negative Pressure Ventilation

- **Rarely** Used; for **neuromuscular diseases.**
- Thoracic cage - negative pressure is applied across the chest wall.
- Generates subatmospheric pressures creating a difference in pressure gradients.
- During exhalation, negative pressure is replace by atmospheric pressure allowing the lungs to deflate.

Negative Pressure Ventilation

- Advantage:

  Lack of NTT and complication

  Improve o2 in COPD

  Decrease Work of breathing

  NO sadative and paralyse drugs

- Advers:

  Strelization

  Immobulization

  Effect of Negative pressure

  Pressure sore

Modern(ized) Iron Lung

Chest Cuirass

Intubation - Indications

1. Airway patency (obstruction)
2. Airway protection (aspiration)
3. Oxygenation (pO_2)*
4. Ventilation (pCO_2)*
5. (secretions)

4 P's:**P**ulmonary toilet

Patency, **P**rotection, **P**ositive **P**ressure,

Mechanical Ventilation Indication

*Improve Oxygenation (when ↓pO_2; ↓SaO_2):

NL.Vent-Fio2-PEEP- FLOW-Invers.Ratio

*PA02=(Bp-47)Fi02- Pc02/0.8

*Improve Ventilation (If ↑pCO_2) or hyperventilation

*Reduce work of breathing (WOB)
(i.e. asthma)

*CHF

*Hemodynamic Instability

Clinical criteria for Mech. Vent.

1. Apnea
2. hypopnea
3. Respiratory distress
4. Clinically apparent increasing work of breathing unrelieved by other interventions
5. Obtundation, Coma and need for airway protection
6. Controlled hyperventilation (in head injury).
7. Severe circulatory shock

8. Impairs the capacity of the respiratory

9. Respiratory muscles weakness , Neuromuscular disorder

10. Increases the ventilation requirements above the muscle capacity(M. hyperther)

11. Increases the workload associated to the act of breathing- Respiratory fatigue

12. Hypoventilation

13. Hypoxemia

14. Respiratory Failure

15. Mechanical Failure(cord inj)

16. Chest trauma(flail chest)

17. Cardiac surgery (6-24h)

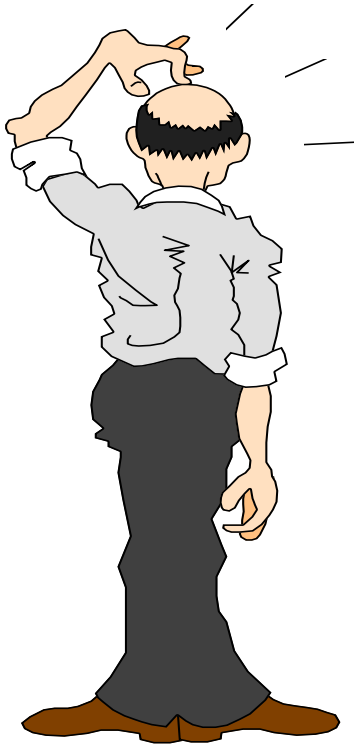
18. Exacerbation COPD

19. High ICP

20. Respiratory center supress

21. Post Cardiac arrest

22. General anesthesia



Types of support

- **Full Support - Control mode : ventilator delivers the preset TV OR Press once it is triggered regardless of patient effort (time cycle).**

1. **Volume Control** 2. **Pressure Control**

   CMV-ACMV **PCV-APCV**

- **Partial support:**

  ventilator detects inspiration by the patient and supplies an assist volume or pressure, during inspiration.

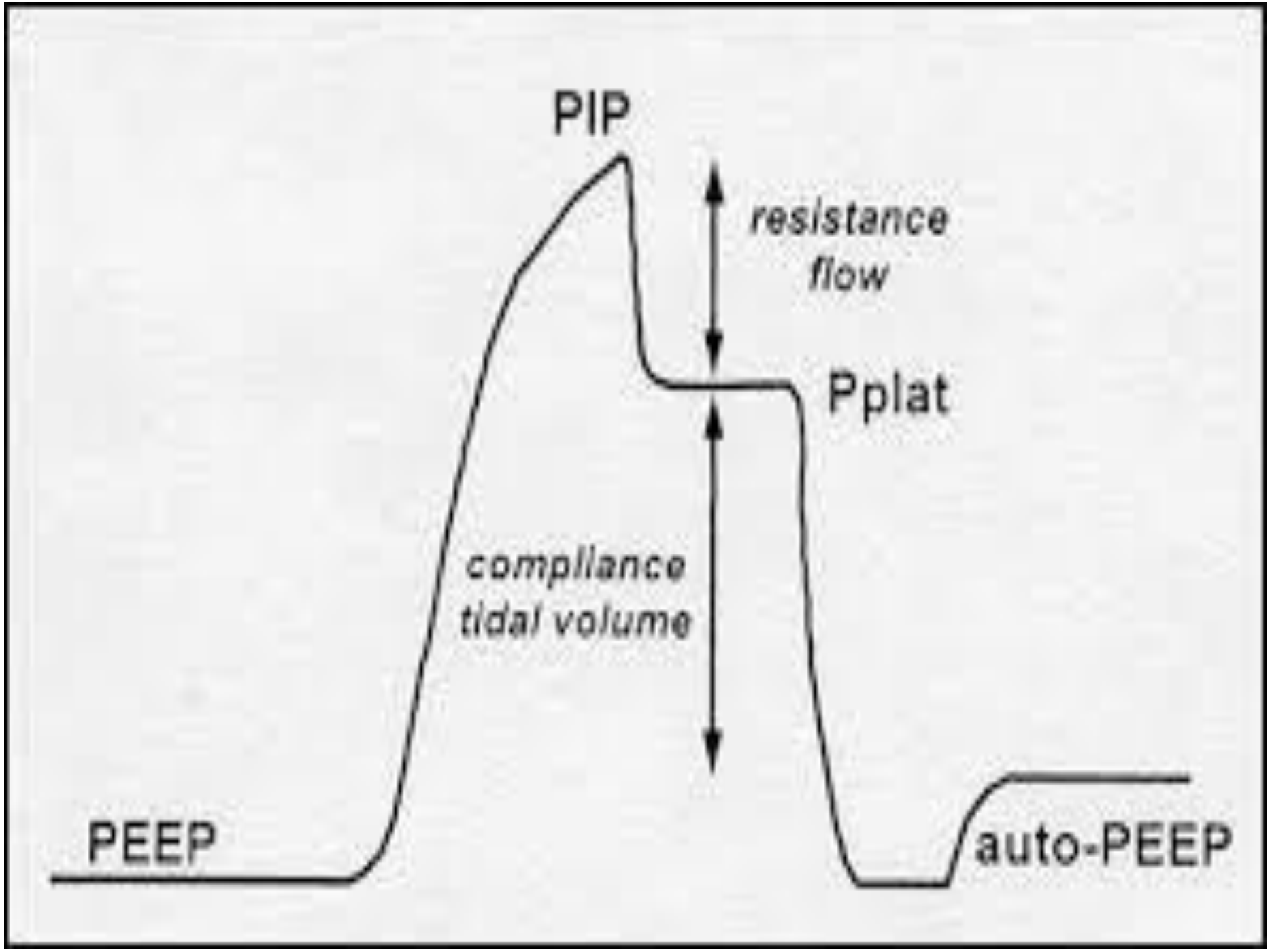
1. **Volume Mode 2. Pressure Mode**
   IMV-SIMV-SIMV+PS+PEEP
2. **PSIMV-PSIMV+PS+PEEP-PSV-ASV-PAV-BIPAP-CPAP-APRV**

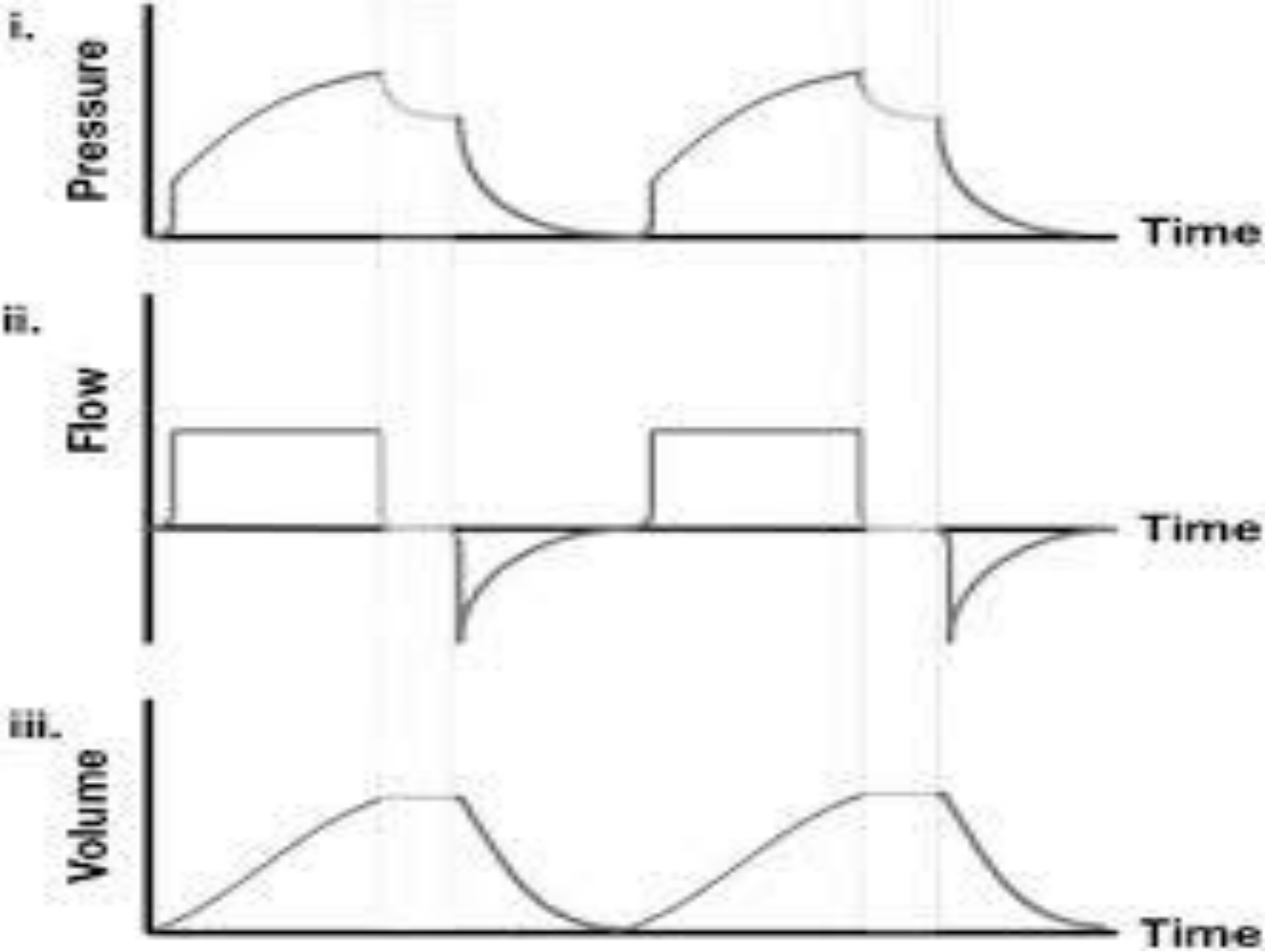
Mechanical Ventilation(criteria):

- Trigger – who/what starts a breath (pt/vent)
- Target – what the vent is trying to achieve
- Cycle – what causes the breath to end

Volume-cycled mode

- **Inhalation proceeds until a set tidal volume (TV) is delivered and is followed by passive exhalation.**
- **A feature of this mode is that gas is delivered with a constant inspiratory flow pattern, resulting in peak pressures applied to the airways higher than that required for lung distension (plateau pressure).**


PIP
resistance
flow
Pplat
compliance
tidal volume
PEEP
auto-PEEP


i.
Pressure
Time
ii.
Flow
Time
iii.
Volume
Time

Volume-cycled mode:

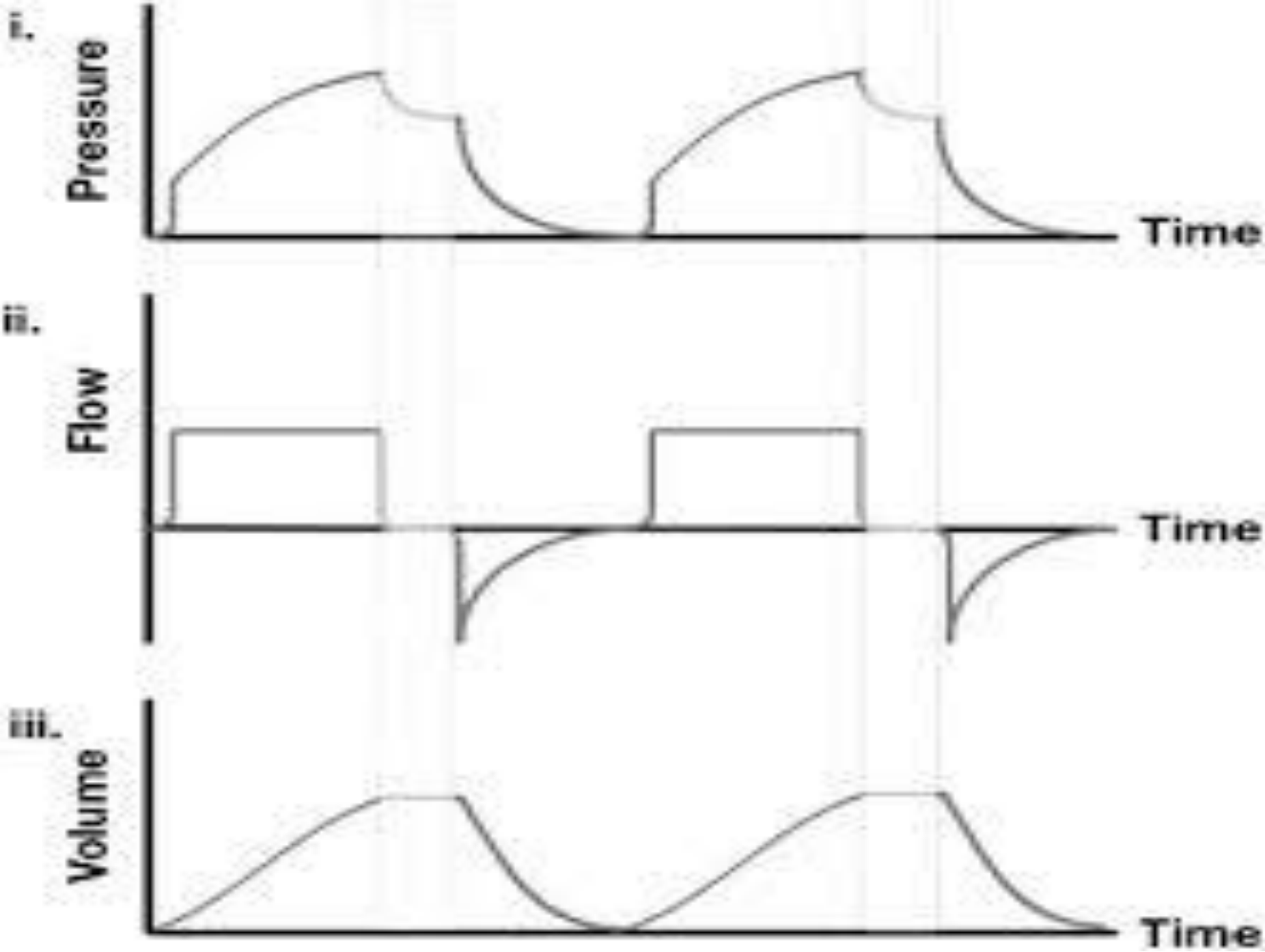
- **Because the volume-cycled mode ensures a constant minute ventilation.**
- **major disadvantage is barotrauma.**

Adverse:

- **pneumothorax**
- **leak(hypoventilation)**
- **↓Ed.VR(Hypoten)**

Volume ventilation

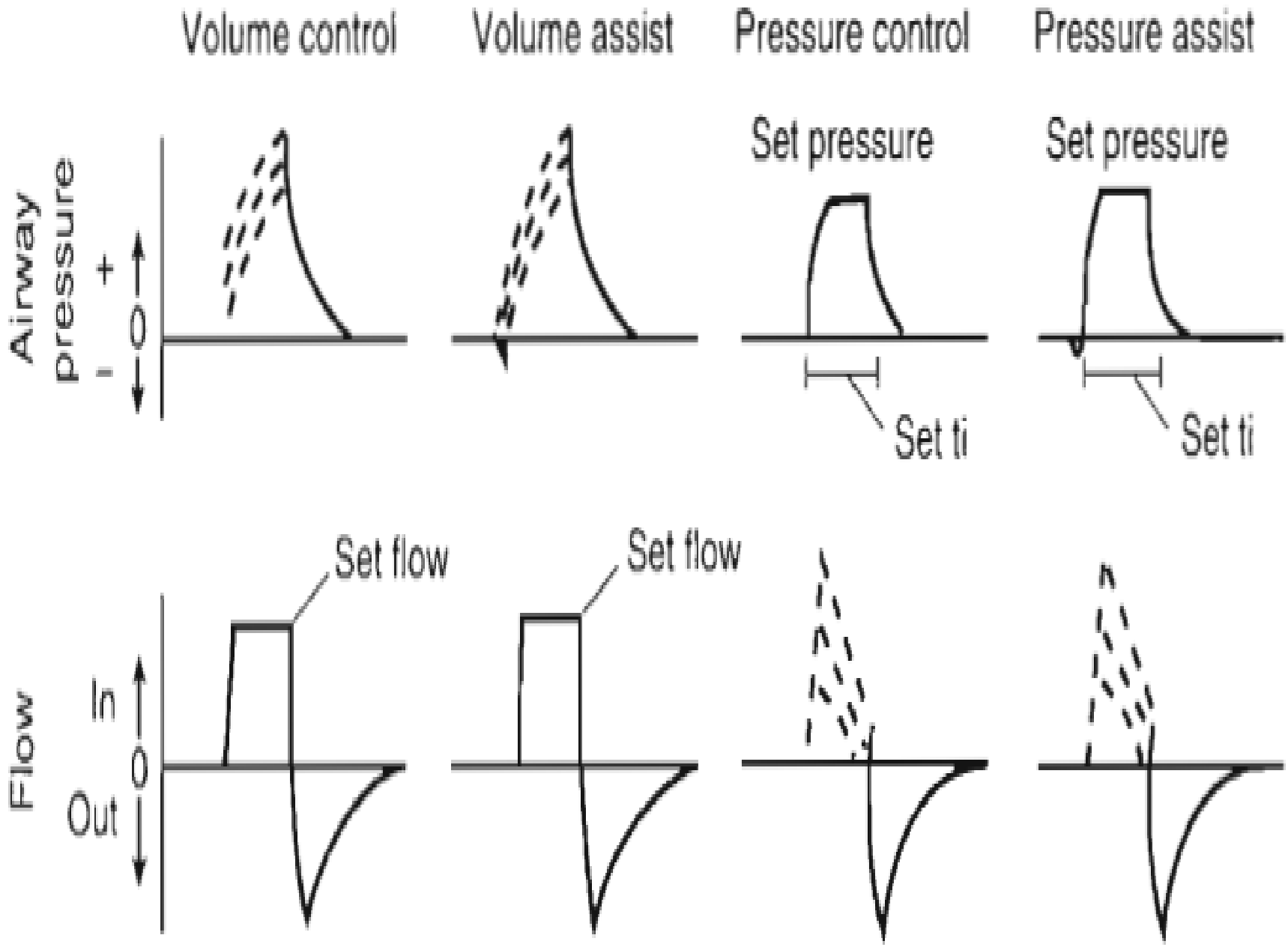
- TV : Constant-5oo
- Flow: Constant-55
- Pressure: variable(RES-COMPL)
- RR : set-12
- Time:Fix
- Pressure : limit(Alarm)-35
- Ins time: determined by ins flow, flow pattern TV-Ins.T=1.3-1.5(I/E=1/2)

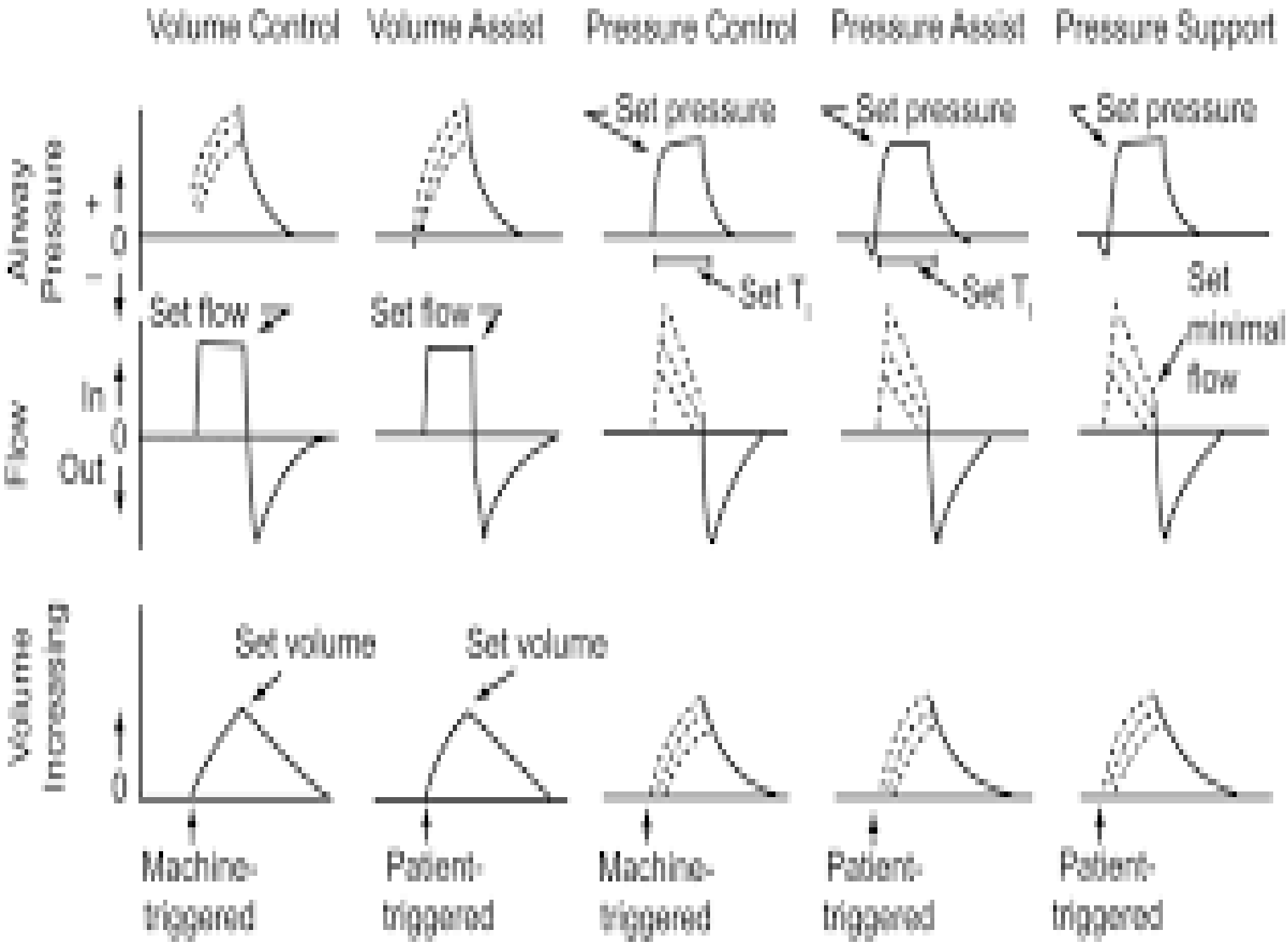

i.
Pressure
Time
ii.
Flow
Time
iii.
Volume
Time

Pressure Ventilation

- PIP &Plateau pressure -- constant
- TV -- -Invers ratio to compliance-resistanc(Variable)
- Flow –variable(decelerating)
- Time—fix
- Pressure—fix
- RR-- fix

- prevent ventilator-associated lung injury
- Improve patient-ventilator synchrony


Volume control
Volume assist
Pressure control
Pressure assist
Airway pressure
+
0
-
Set pressure
Set pressure
Set ti
Set ti
Flow
In
0
Out
Set flow
Set flow


Volume Control
Volume Assist
Pressure Control
Pressure Assist
Pressure Support
Airway Pressure
+
0
−
Set pressure
Set pressure
Set pressure
Set T_i
Set T_i
Set flow
Set flow
Set minimal flow
Flow
In
0
Out
Volume Increasing
0
Set volume
Set volume
Machine-triggered
Patient-triggered
Machine-triggered
Patient-triggered
Patient-triggered

Modes of ventilation:V vs P

Volume :

- **Controlled mechanical ventilation (CMV)**
- **Assist-control ventilation (A/CMV)**
- **Intermittent mandatory ventilation (IMV)**
- **Synchronized Intermittent mandatory ventilation: (SIMV-SIMV+PS+PEEP)**

Modes of ventilation

Pressure:

- **Pressure control ventilation: (PCV)**
- **PSIMV-PSIMV+PS+PEEP-ASV**
- **Dual positive airway pressure: (Du PAP)-BIPAP-BILEVEL**
- **Airway pressure-release ventilation: (APRV)**
- **Spontaneous Ventilation :(spont)-CPAP-PSV-PAV-ASV**

Positive Pressure Ventilators

	Volume	Pressure	Flow	I-time
Spontaneous	variable	variable	variable	variable
CMV	FIXED	variable	FIXED	FIXED
PCV	variable	FIXED	variable	FIXED
PSV	variable	FIXED	Variable	variable

تهویه مکانیکی حجمی، فشاری و مدهای SIMV+PS

دکتر سید حسین حمیدی

CMV: Continuous mandatory ventilation

RR-VT-Fio2-PEEP-Ins.Tim-Peak.P(Alarm)-Flow

- Breaths are delivered at preset intervals, regardless of patient effort.
- This mode is used most often in the paralyzed or apneic patient . it can increase the work of breathing if respiratory effort is present.
- Many ventilators do not have a true CMV mode and offer ACMV instead.(Trigger)

CMV: Controlled Mechanical Ventilation

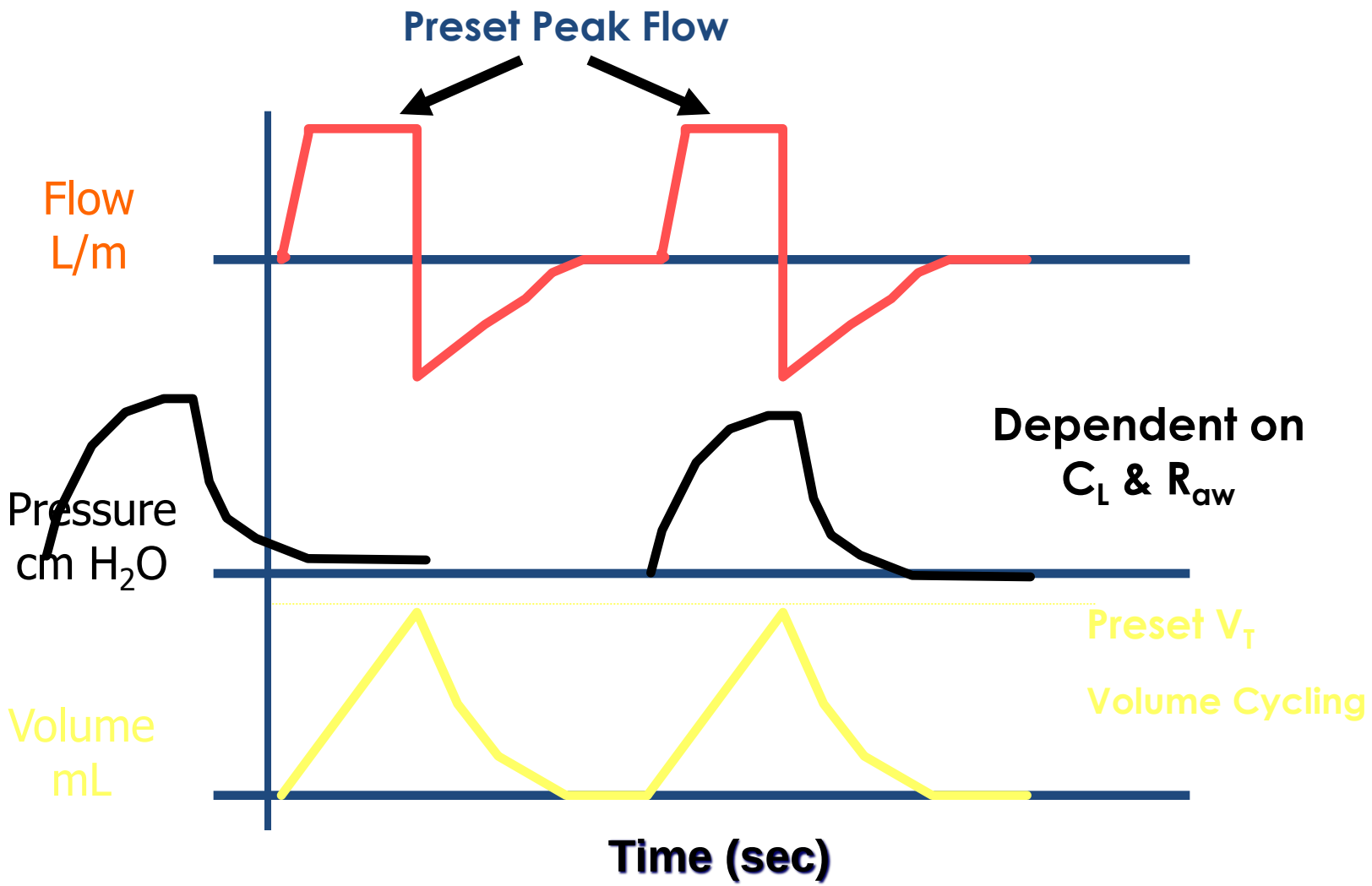
- Vt: preset
- RR: Preset
- Trigger: time
- Limit: pressure(Alarm)

- Spontaneous breathing: block
- Fighting
- No synchrony
- RR=15 Vt=600 Fio2=50% Ins.t=1.3-1.5 (I/E) PIP=35
- Flow=55

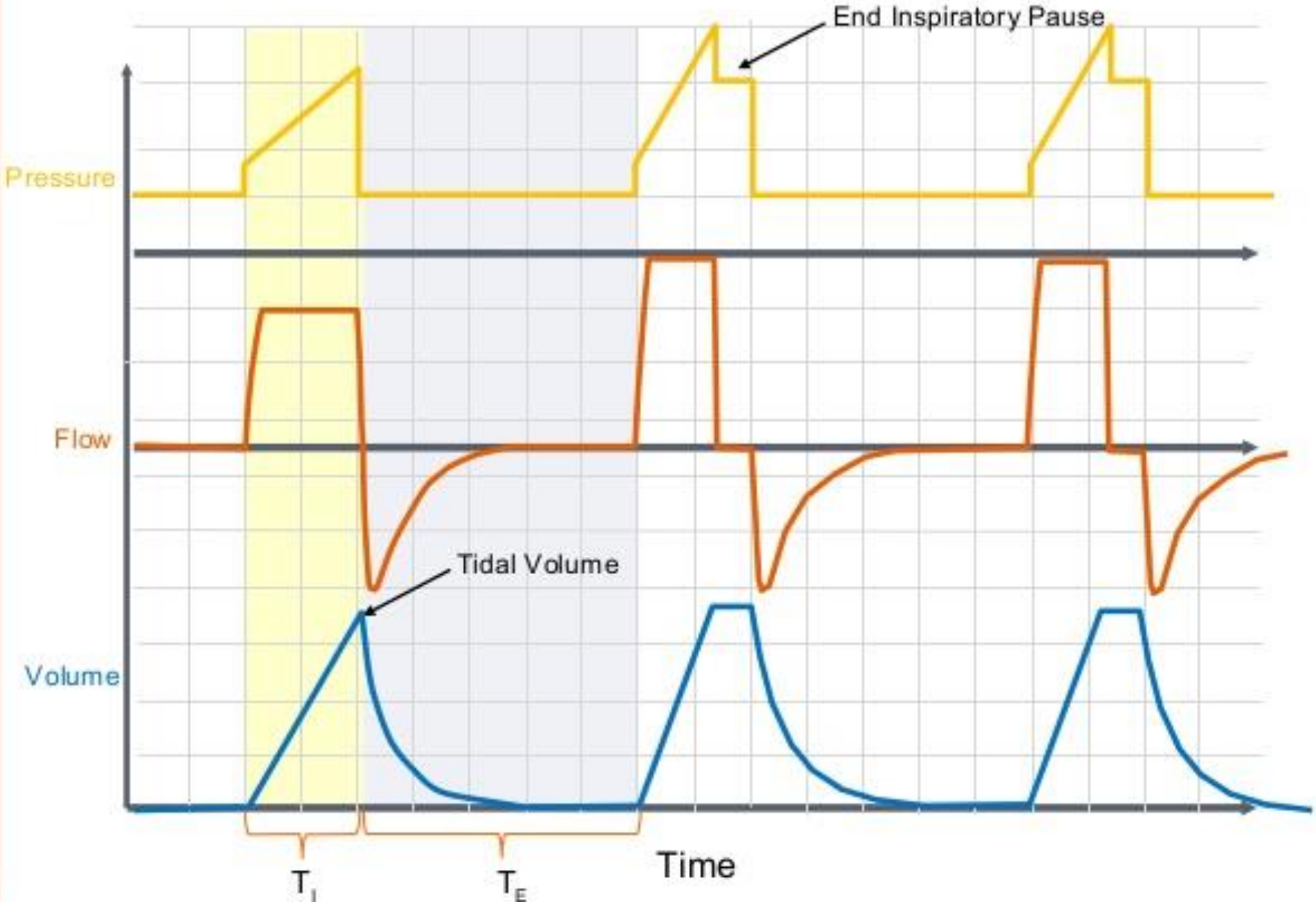
Controlled Mode

(Volume- Targeted Ventilation)

Time triggered, Flow limited, Volume cycled Ventilation



VOLUME CONTROL WITH END-INSPIRATORY PAUSE



ACMV: Assist-Control Ventilation

RR-Vt-Fio2-INS.T-PEEP-Trig-Peak.P-FLOW

- **ACMV delivers the preset volume or pressure in response to the patient's own inspiratory effort, but will initiate the breath if the patient does not do so within the set amount of time.**
- **RR=10- Monitor RR=16(10+6)**
- **ALL Vt=FIXED**
- **RR=10 Vt=650 Fio2=60% I/E=1/2**

PEEP=8 Trig=4 PIP=40 Flow=50

ALL.Vt=650

Modes of Ventilation

ACMV:

- Trigger – machine(time) and patient
- (Pres-Flow)

– Target – volume

– PIP = variable

e.g. vent gives 10 bpm @ 700cc each

pt initiates 6 bpm – vent provides 700cc(ALL Vt=700)

Modes of Ventilation

ACMV:

- Advers: Fighting - sedation- paralysis?

  Hyperventilation- Respiratory Alkalosis

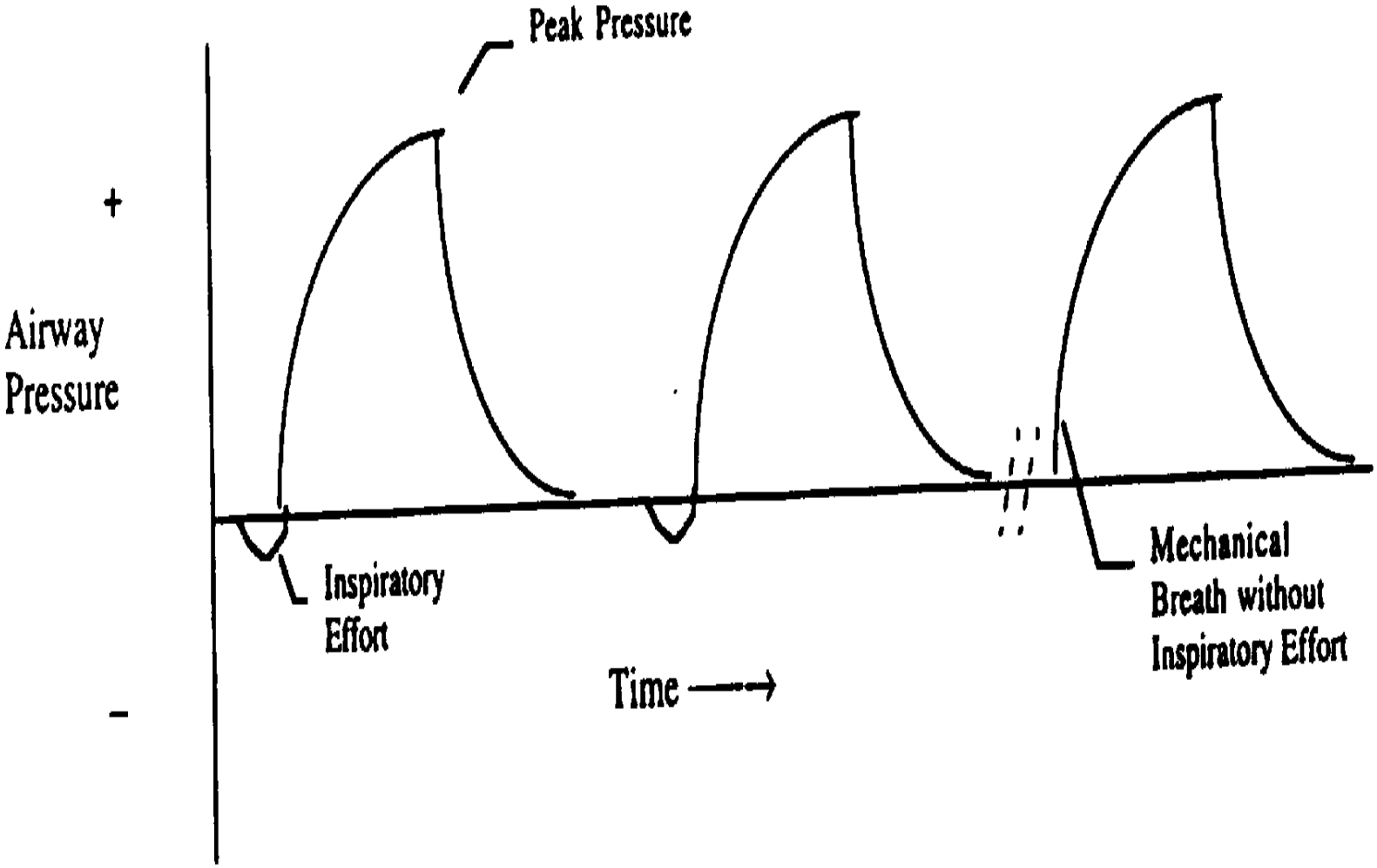
  Auto-PEEP

  Hypotension

- Advantage: used muscles
- Indication: patient with spontaneous breathing

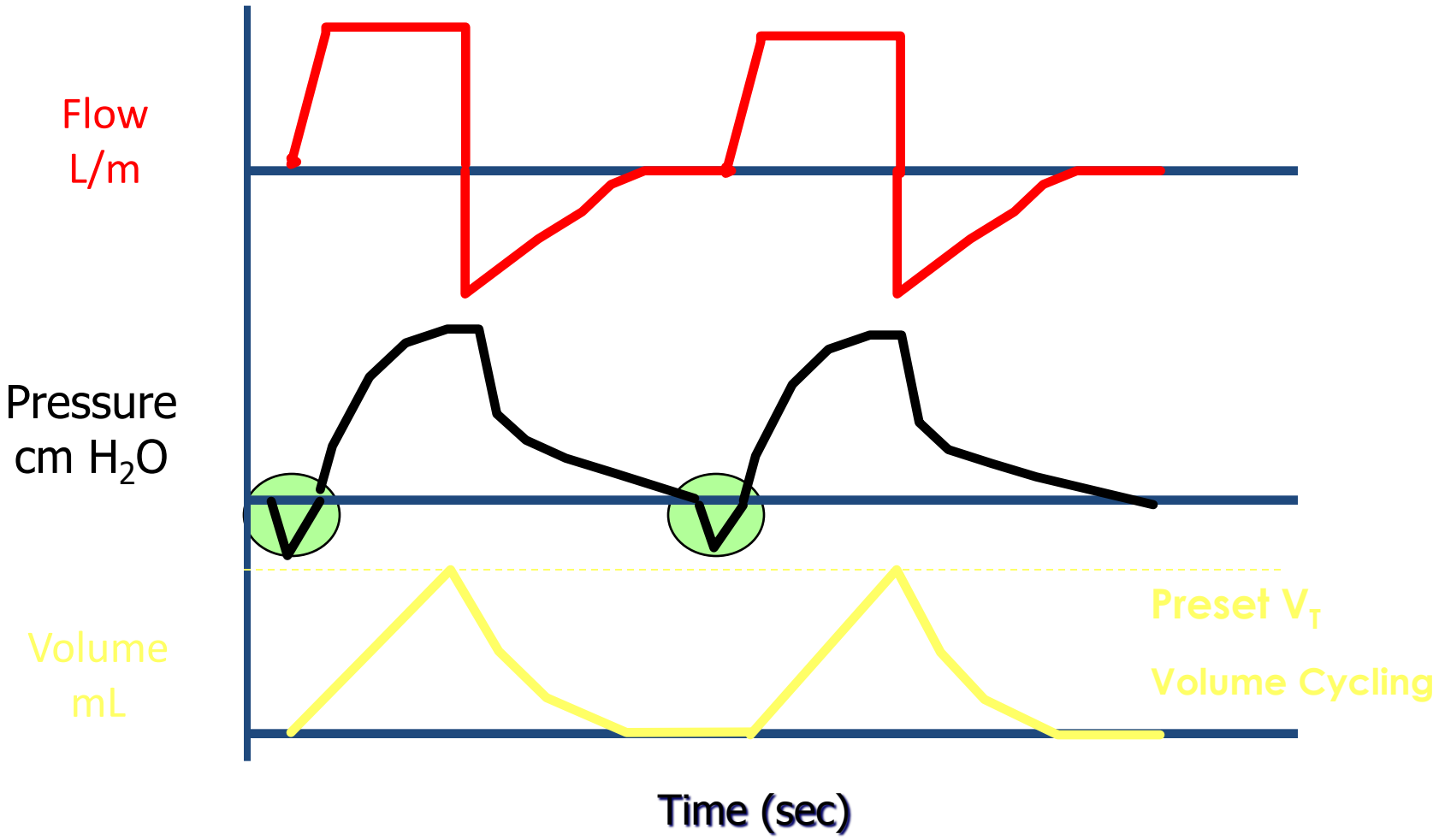
  But with muscle weakness

Assist-Control Ventilation (ACMV)

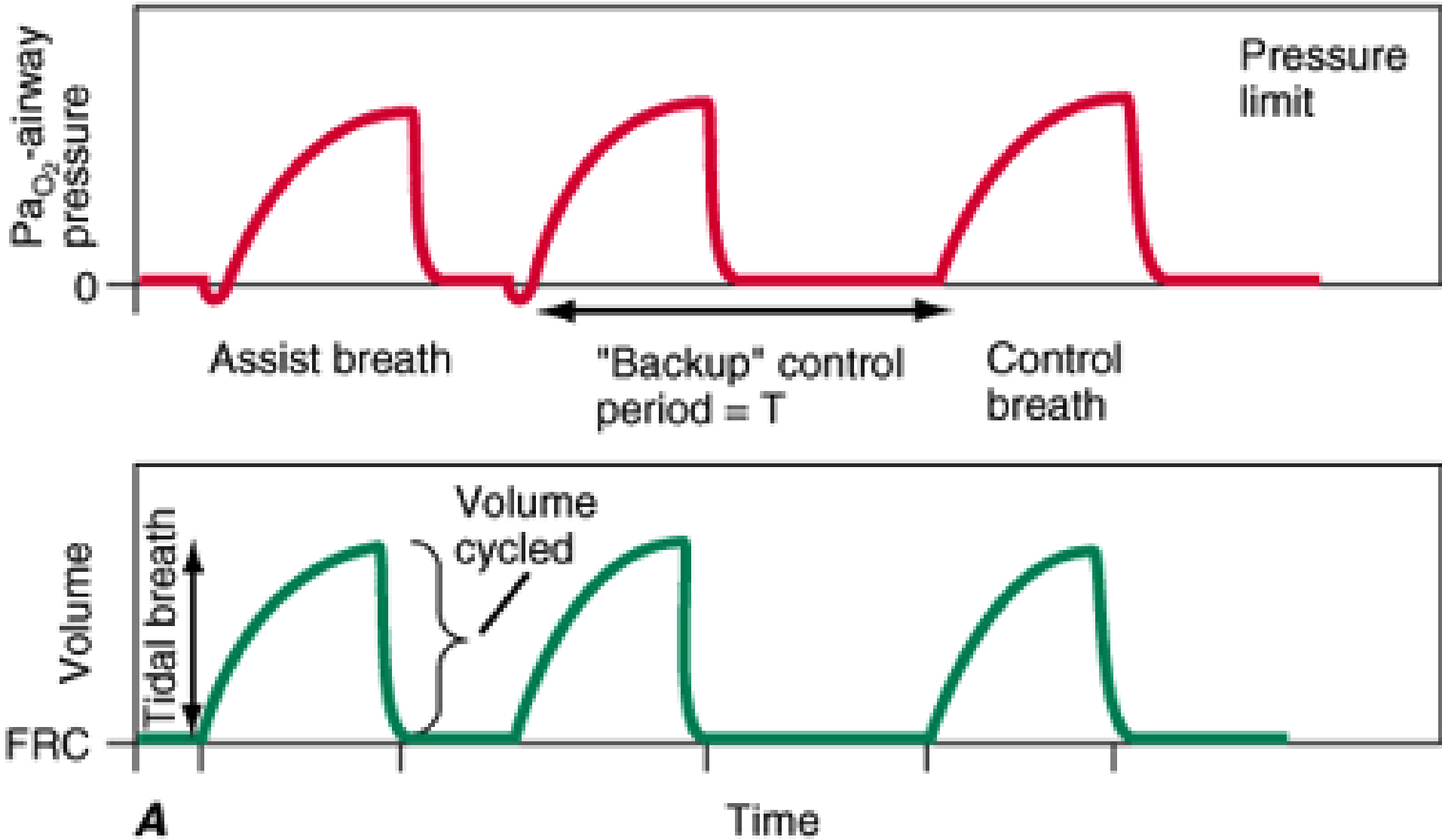


Assisted Mode
(Volume-Targeted Ventilation)

Patient triggered, Flow limited, Volume cycled Ventilation



ACMV


Pa$_{O_2}$-airway pressure
0
Pressure limit
Assist breath
"Backup" control period = T
Control breath
Volume
Tidal breath
Volume cycled
FRC
A
Time

Intermittent Mandatory Ventilation (IMV)

- **With intermittent mandatory ventilation (IMV), breaths are delivered at a preset interval, and spontaneous breathing is allowed between ventilator-administered breaths.**
- **RR=12 Vt=600 Fio2=50%**
  Ins.t=1.7(I/E=1/2) PEEP=5 Trig=time
  Vt=Variabl
  with spontaneous venti

Intermittent Mandatory Ventilation (IMV)

- **Volume cycle**
- **Vt: preset**
- **RR: preset**
- **Trigger: time**

- **Spontaneous breathing: No block unless…**
- **Asynchrony**
- **Fighting: Exhale on Inspiration**

Modes of Ventilation

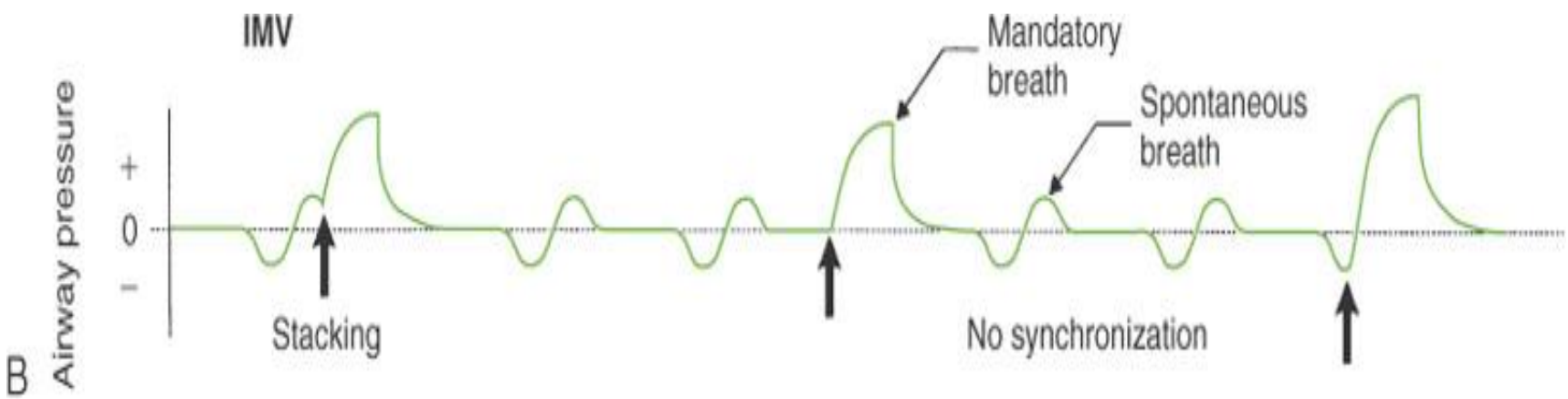
IMV-Intermittent Mandatory Ventilation

Complications

When used for weaning, may be done too quickly and cause muscle fatigue

Mechanical rate and spontaneous rate may **asynchronous** causing "stacking"

May cause barotrauma or volutrauma



(From Dupuis Y: *Ventilators: theory and clinical application*, ed 2, St Louis, Mosby, 1992.)

Synchronous Intermittent Mandatory Ventilation (SIMV)

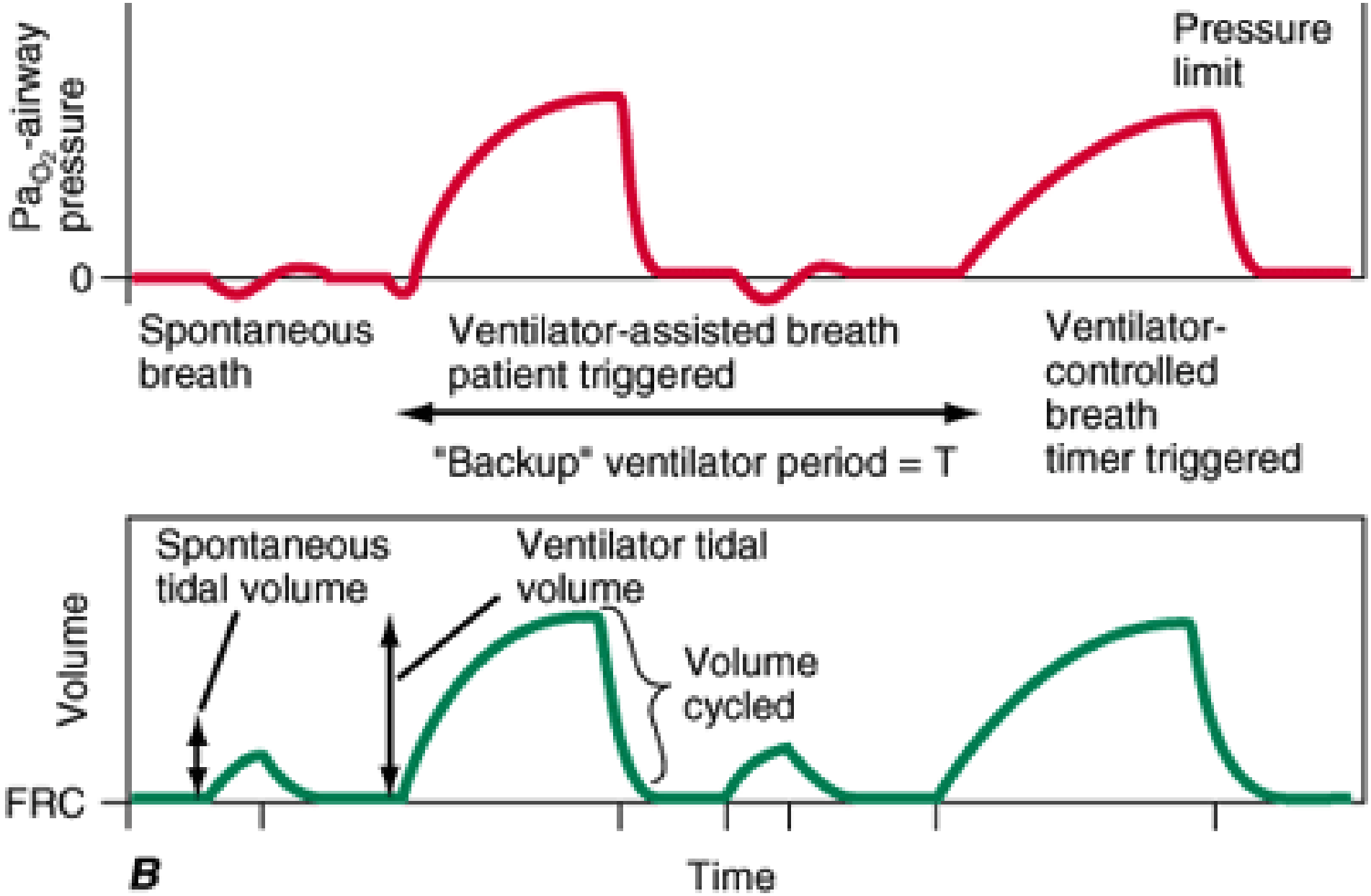
- **SIMV delivers the preset volume or pressure and rate while allowing the patient to breathe spontaneously in between ventilator breaths.**
- **Is used as a primary mode of ventilation, as well as a weaning mode.**

MODE of Ventilation SIMV

Synchronized Intermittent Mandatory Ventilation:

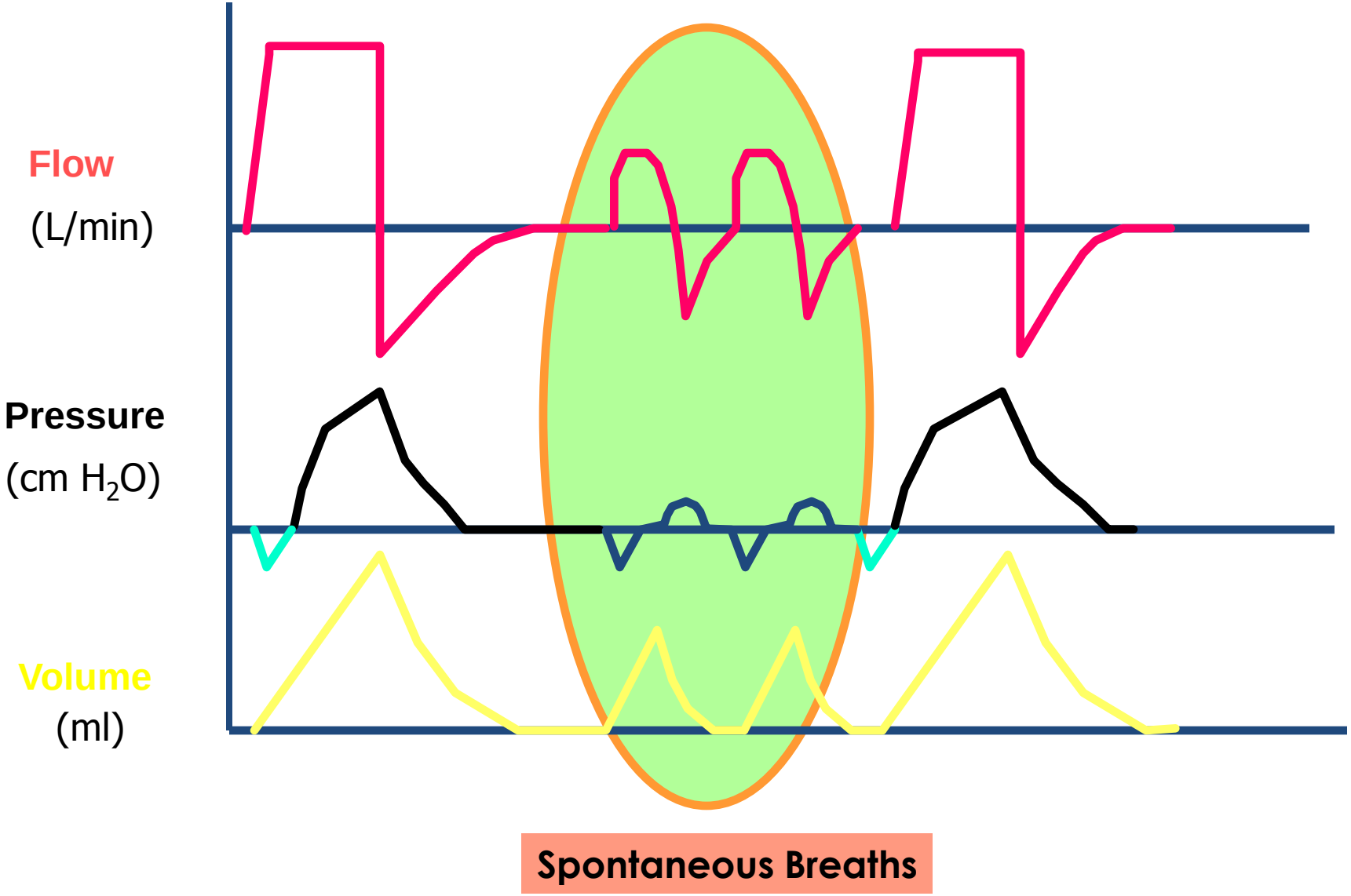
- *Control: TV = Set- If Pt :variable(compl-res-force-PS)
  RR =Set -patient
- *Spontaneous ventilation(patient):
  TV--RR Variable
- A/CMV + Demand valve
- Synchronized
- SIMV+PSV+PEEP
- RR=10 Vt=600 Fio2=60% PEEP=8 Ins.t=1.5(I/E=1/3)
- Trig=3 PIP=35 Flow=55 PS=15
  Pt.Vt=Variable(Res-compl-force-PS)

SIMV


Pa$_{O_2}$-airway pressure
0
Pressure limit
Spontaneous breath
Ventilator-assisted breath patient triggered
Ventilator-controlled breath timer triggered
"Backup" ventilator period = T
Volume
FRC
Spontaneous tidal volume
Ventilator tidal volume
Volume cycled
B
Time

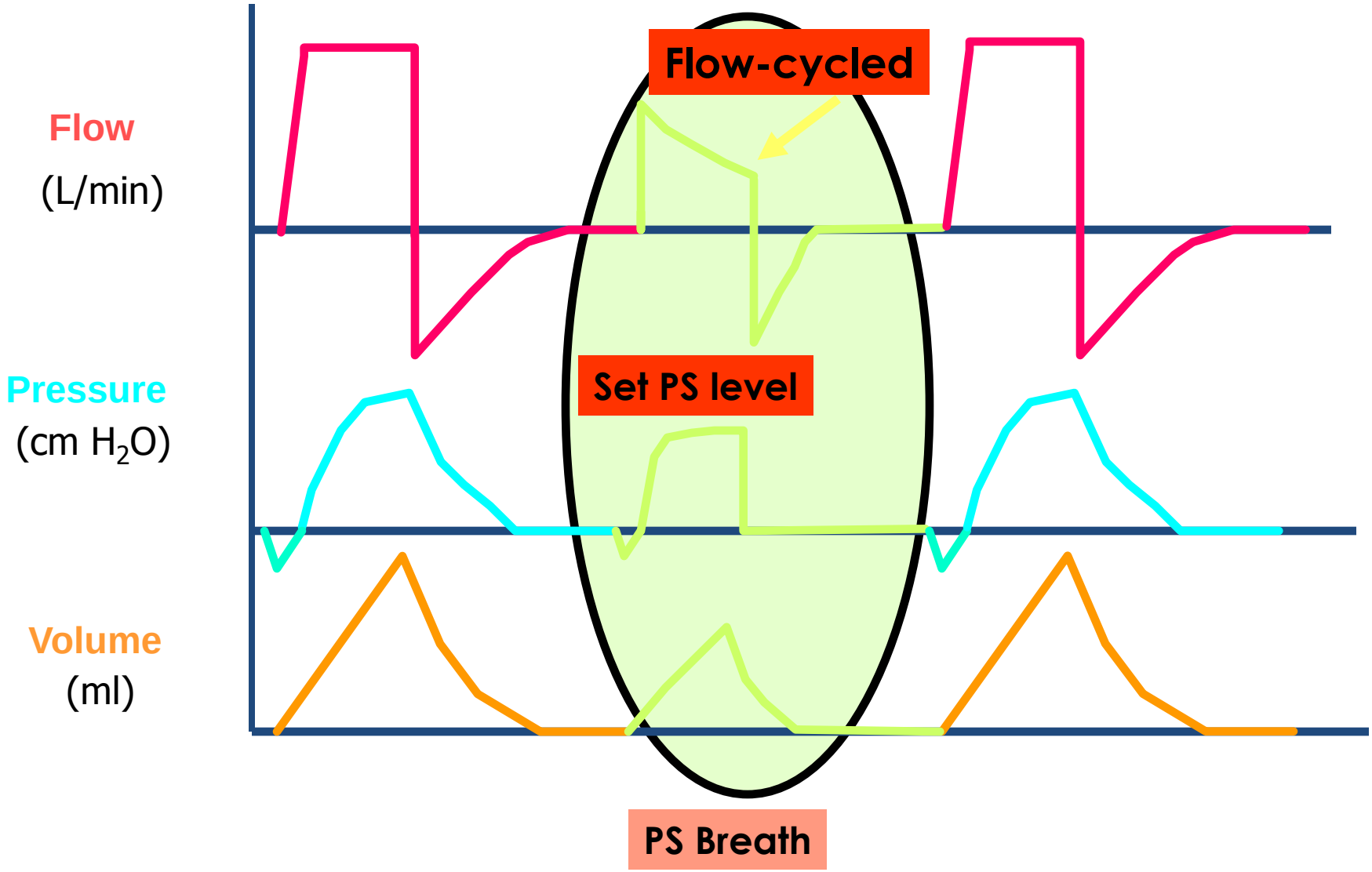
SIMV

(Volume-Targeted Ventilation)



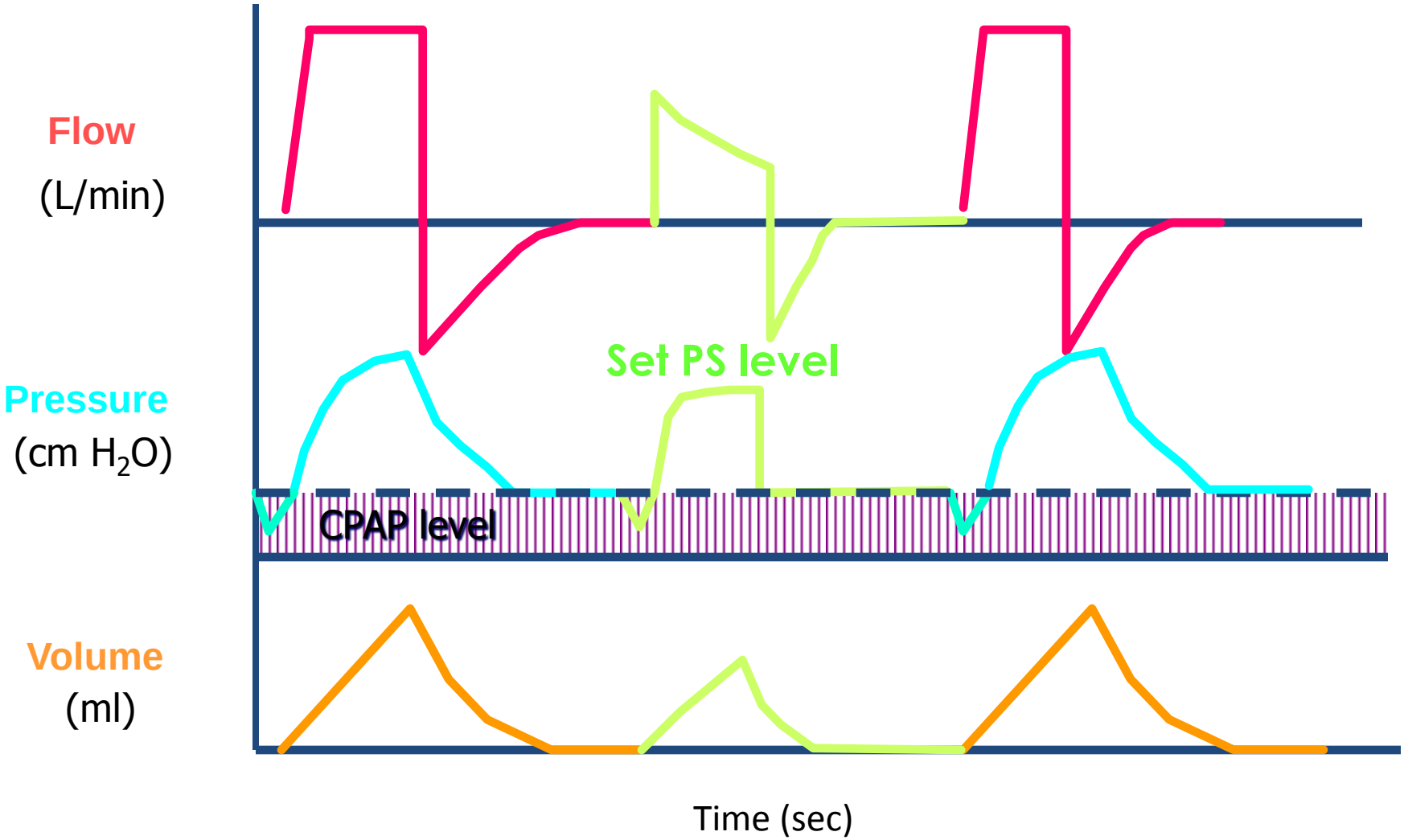
SIMV+PS

(Volume-Targeted Ventilation)



SIMV+PS + PEEP

(Volume-Targeted Ventilation)



Modes of Ventilation:

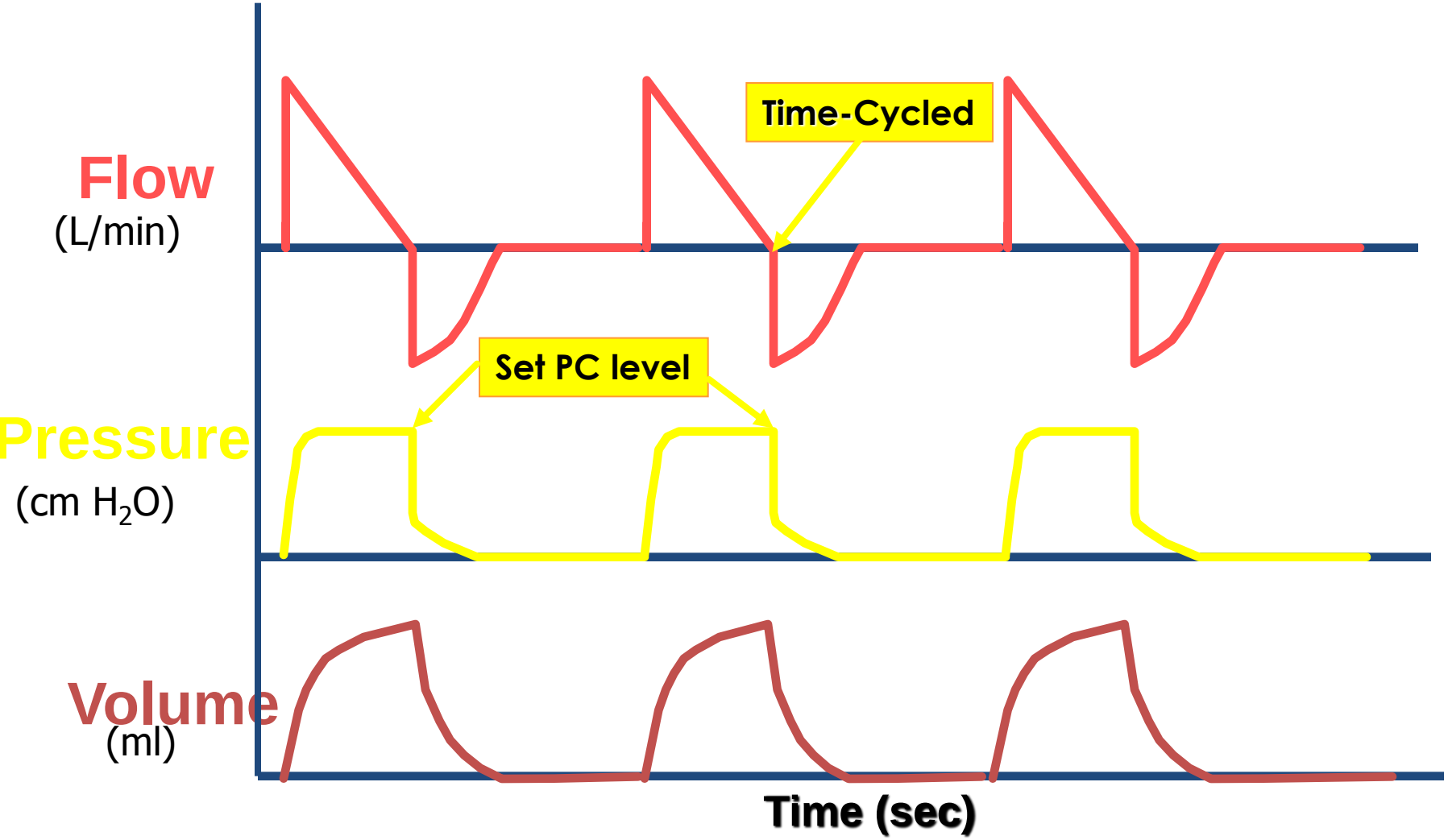
Pressure Control (PC)

- **PC&pressure assist control**
- RR =set-Pt Trig(P or F)
- Air wayPressure(PIP)=Fix(plat.p)
- Time =Fix
- TV =variable(PIP-RR-Ins time-compl-Resis)
- Flow =variable
- Trigger =pt.
- I/E Ratio=Fix

RR=12 PIP=20 Fio2=50% PEEP=5 Ins.t=1.4 Trig=3
(Vt=600---Plat.P=PIP)

Pressure-Targeted Ventilation
(PCV)

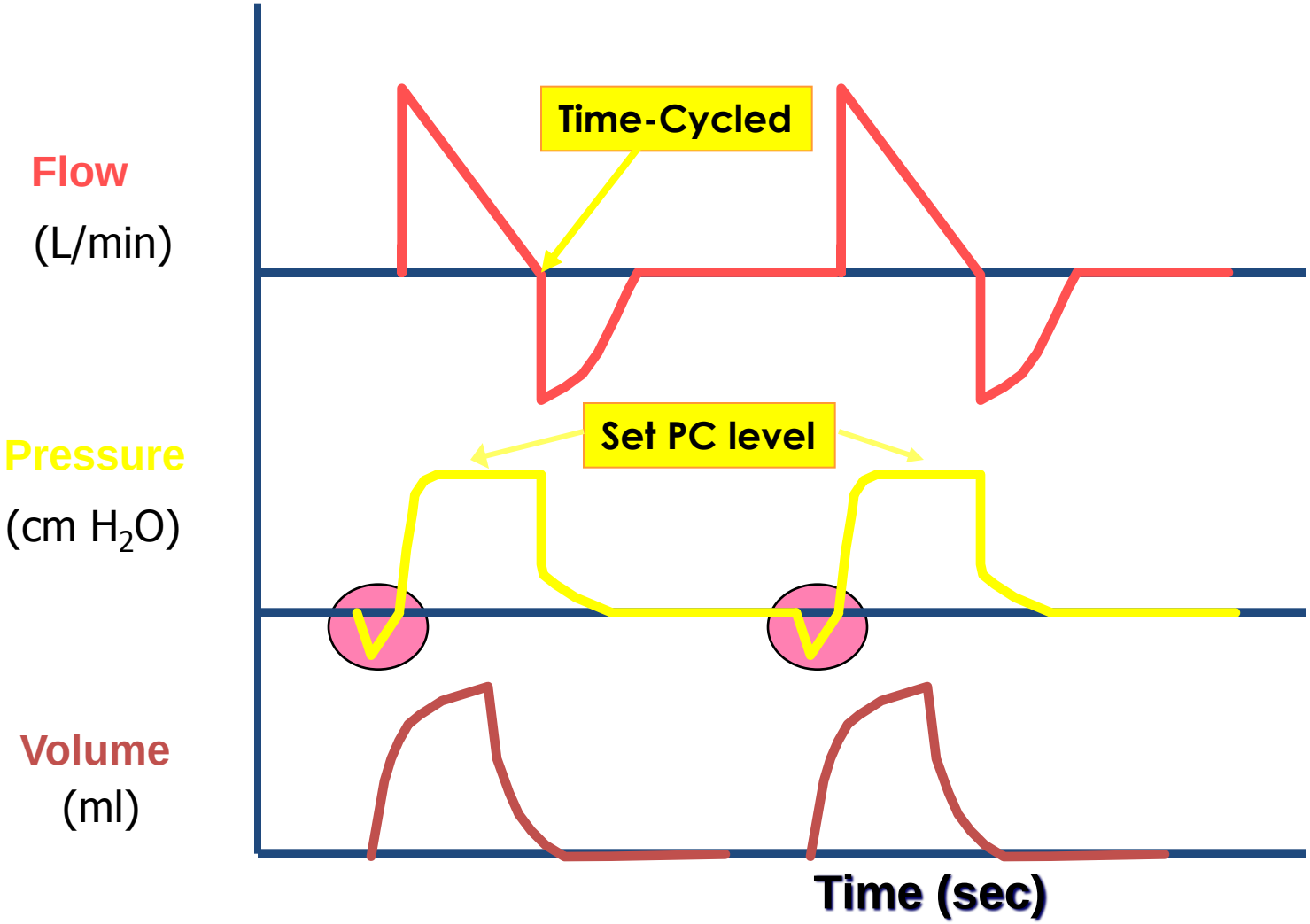
Time Triggered, Pressure Limited, Time Cycled Ventilation



Assisted Mode

(Pressure-Targeted Ventilation)

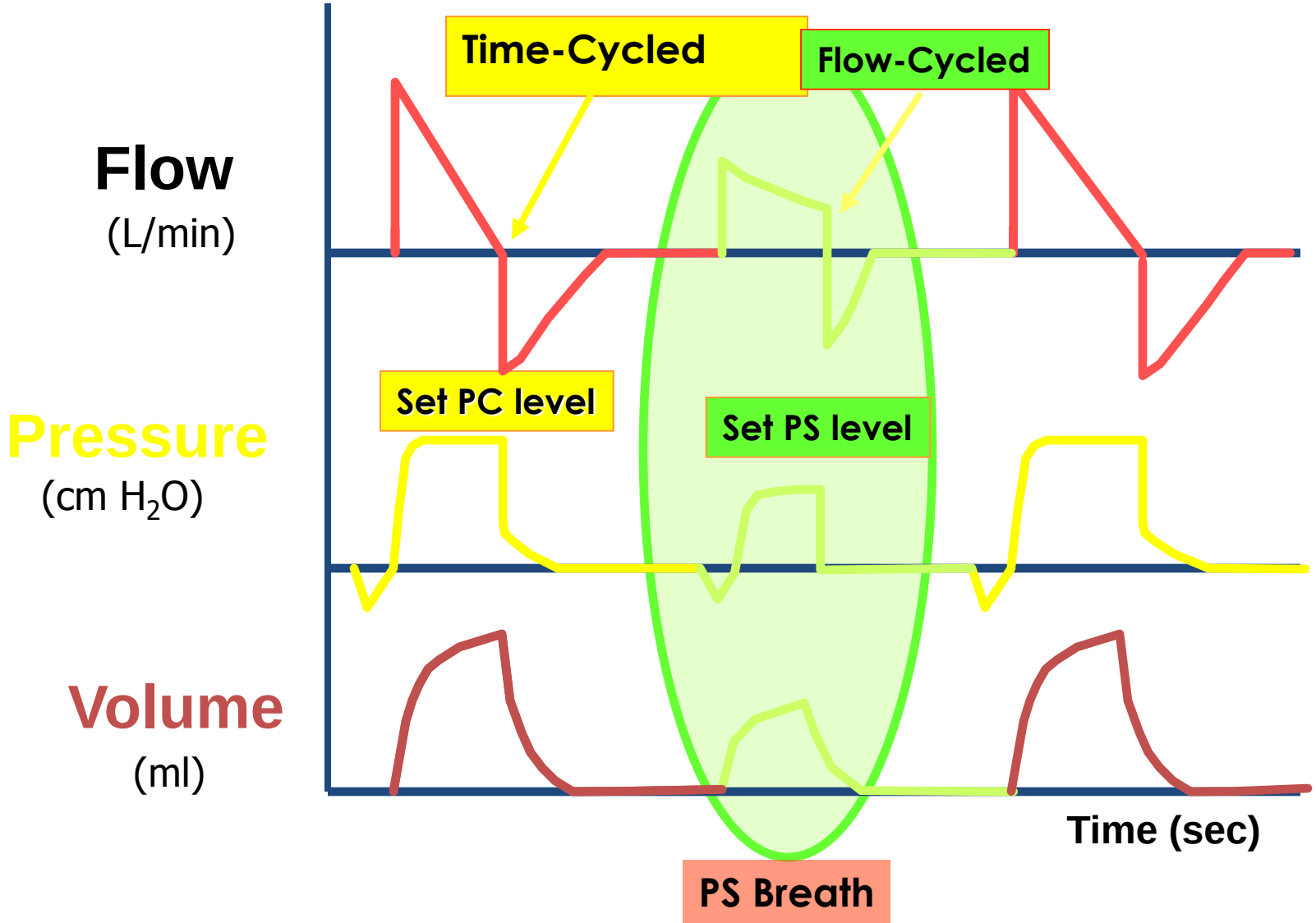
Patient Triggered, Pressure Limited, Time Cycled Ventilation



PSIMV:

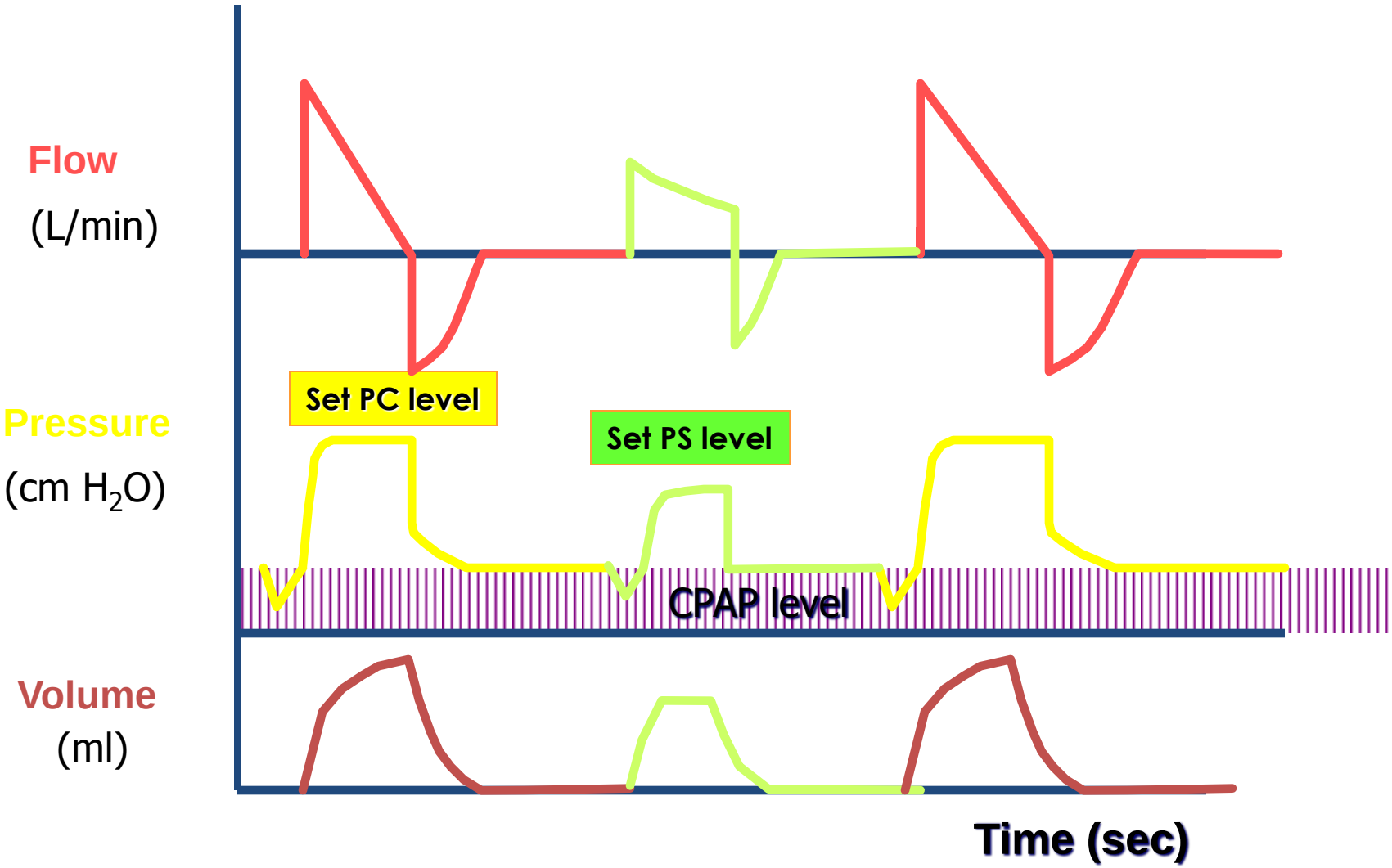
- **Pressure-Targeted Ventilation**
- **SIMV delivers the preset pressure and rate while allowing the patient to breathe spontaneously in between ventilator breaths.**
  RR-fix PIP=fix Vt=variable
- **RR=12 PIP=22 Fi02=60% PEEP=5 Trig=3 PS=12**

PSIMV+ PS:
Pressure-Targeted Ventilation



SIMV + PS + PEEP

(Pressure-Targeted Ventilation)



Spontaneous ventilation:

INVASIVE&NON INVASIVE

(Spont.V=CPAP-PSV-BiPAP)

PSV=Ps -PEEP-Fio2-Trig

CPAP=Pres-Fio2-(T-tube ?)-BiPAP:Ins PAP&Exp PAPA

- **CPAP:patient dependant mode**
- **Trigger: Patient**
- **Machin=No Vt or Pressure and RR----Fio2: preset**
- **Monitoring, Alarm, Backup**

PSV=S.MODE

- **Spont.M = PEEP + PS+Fio2**
- **PS=12 PEEP=5 Trig=3 Fio2=40%**

MODE of Ventilation

PSV

- Trigger – patient only(Pres-Flow)
- Target - pressure
- Cycle – patient flow decrease
- TV- **variable**(effort-ps-compliance-Resistanse)
- Insp.End:=Insp.Flow is ¼ peak flow(5 L/min)

SettingS – Mode: PS = 14 cm H20

O FIO2 0.4; PEEP 5-Trig=4

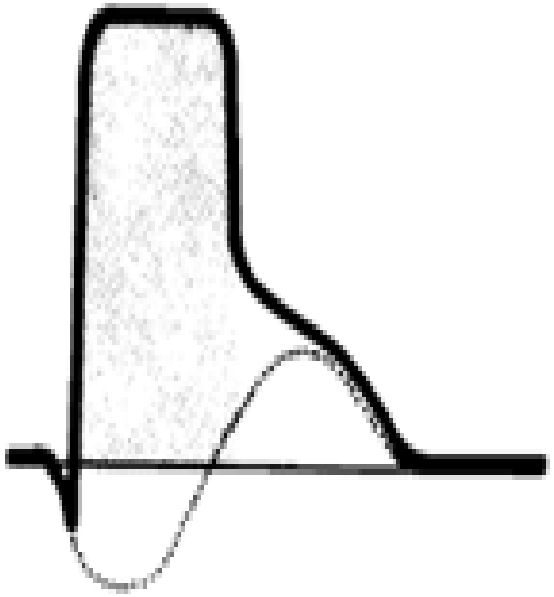
e.g. pt takes 18 bpm @ Vt = 500cc(variable)

machine gives zero breaths

MODE of Ventilation

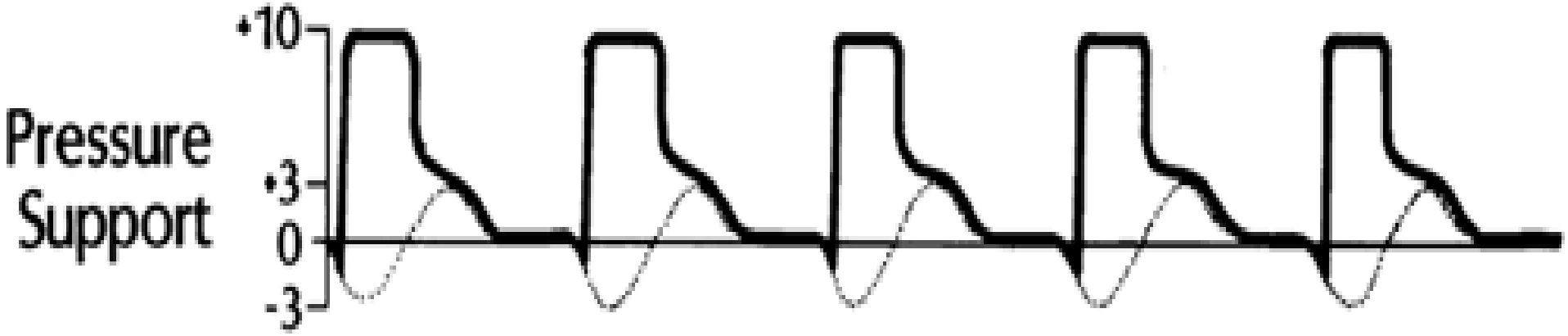
psv

- PSV: High level(PSVMax-8-10 ml/kg)
  Low level(5-8ml/kg)
- If PEEP used:
- Peak inspiratory pressure(PIP)-PS above PEEP
- Advers: TV variable-Apnea
- Advantage: Muscle weakness-loss
  WoB-loss
- Indication: weaning
  Long used



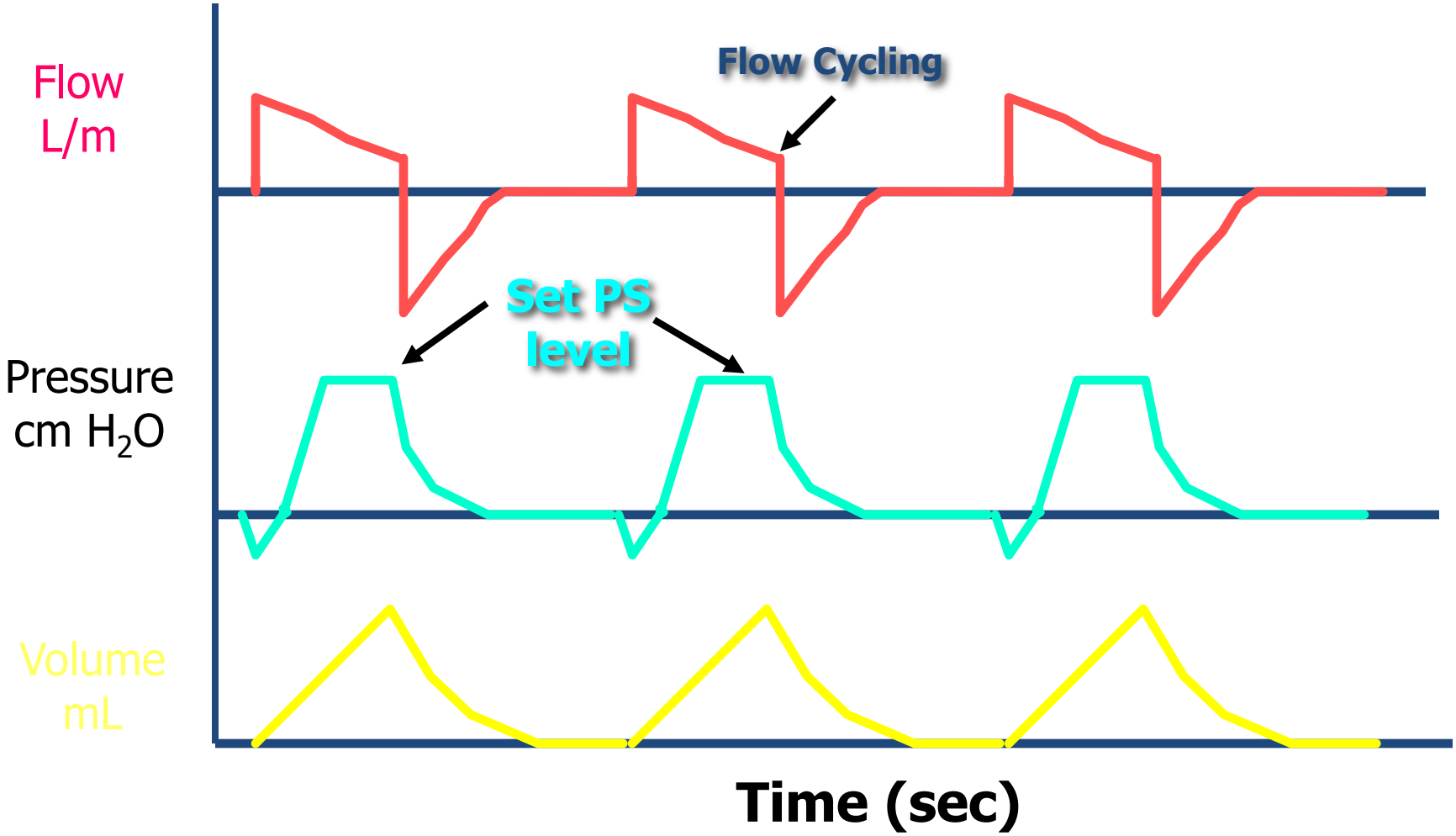
[IN][LIM][CYC]

Pres. Pres. Flow

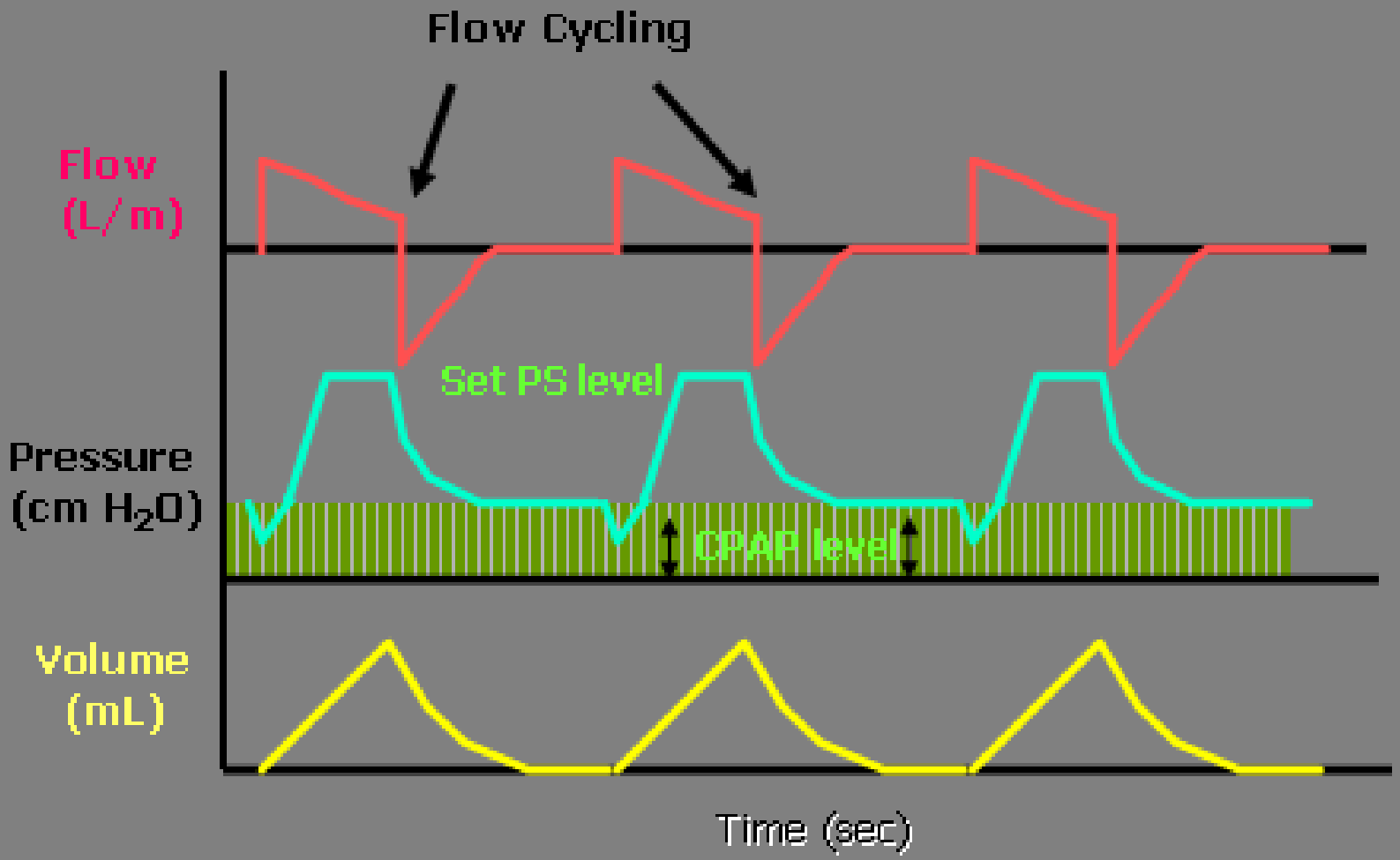


PSV

Patient Triggered, Flow Cycled, Pressure limited Mode



CPAP + PSV


Flow Cycling
Flow
(L/m)
Set PS level
Pressure
(cm H_2O)
CPAP level
Volume
(mL)
Time (sec)

Modes of Ventilation

CPAP: (Invasive&Noninvasive)

Pres-Fio2-

- Trigger – patient(?)
- Cycle – patient effort ceases
- PS:Constant
- Settings: CPAP 5; FIO2 0.4

- e.g. patient takes 24 bpm @ 250 **cc each(Variable)**

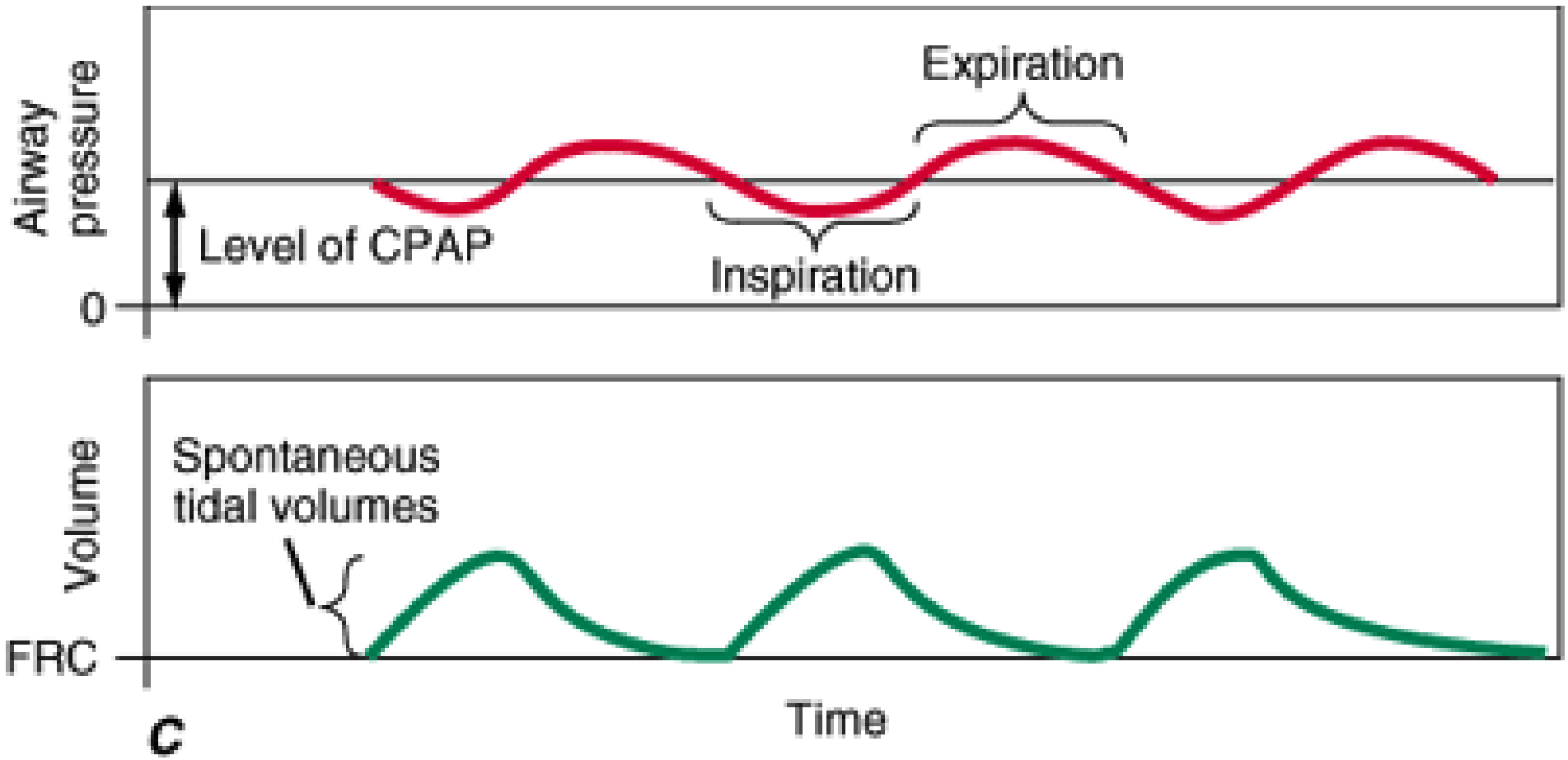
Mechanical Ventilation

CPAP

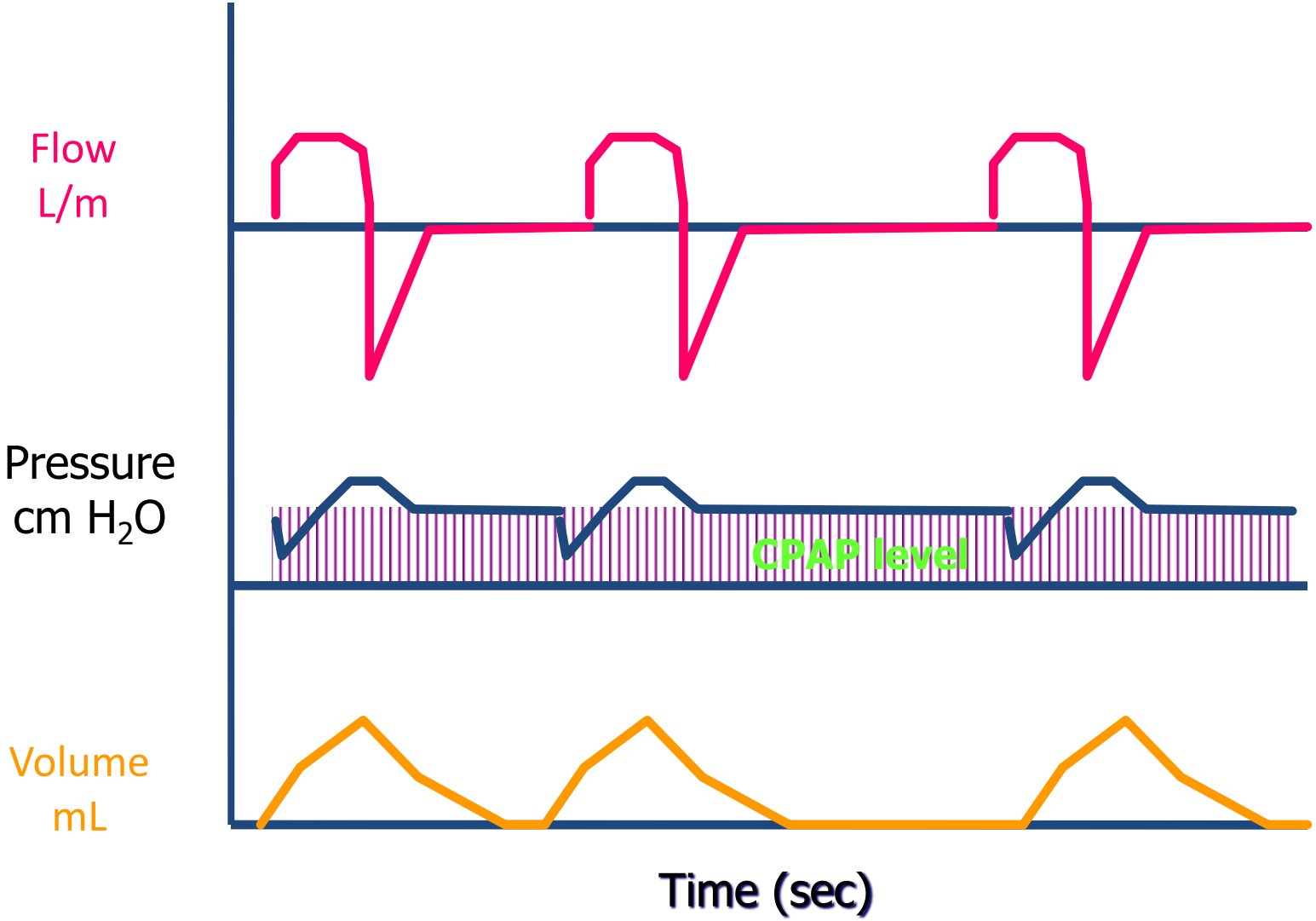
- Advantages
  - Takes advantage of the ventilator alarm systems providing psychological security of the ventilator being there Increase FRC- Pao2

- Disadvantages
  - Patient may sense resistance as he breathes through the ventilator tubing

CPAP


Airway pressure
Expiration
Level of CPAP
Inspiration
0
Volume
Spontaneous tidal volumes
FRC
Time
c

CPAP



Positive End Expiratory Pressure (PEEP)

- **PEEP is positive pressure that is applied by the ventilator at the end of expiration.**
- **Do not deliver breaths, but is used as an adjunct to other mode to improve oxygenation by opening collapsed alveoli at the end of expiration.**
- **Complications from the increased pressure can include decreased cardiac output, pneumothorax, and increased intracranial pressure.**

TABLE 65-1. PEEP-FiO_2 ALGORITHM

FiO_2	.30	.40	.40	.50	.50	.60	.70	.70	.70	.80	.90	.90	.90	1.0	1.0	1.0	1.0
PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	18	20	22	24

مدهای تنفسی خود به خودی و پیشرفته

دکتر سید حسین حمیدی

BIPAP Ventilation Mode

- **BIPAP Vent: Invasive&NON Invasive**

* نوع تهاجمی از طریق لوله تراشه یا تراکوستومی.

* نوع غیرتهاجمی از طریق ماسک صورت و بینی یا بینی.

* بیشترین کاربرد در نارسایی حاد تنفسی-شدید حاد بیماری انسدادی ریه-اپنه در خواب.

* تنفس: خودبخودی-ونتیلاتور یا ترکیب هردو.

* اگر بیمار نتوانست تهویه دقیقه ای را جبران کند یا اپنه طولانی داشته باشد-ونتیلاتور تنفس می دهد.

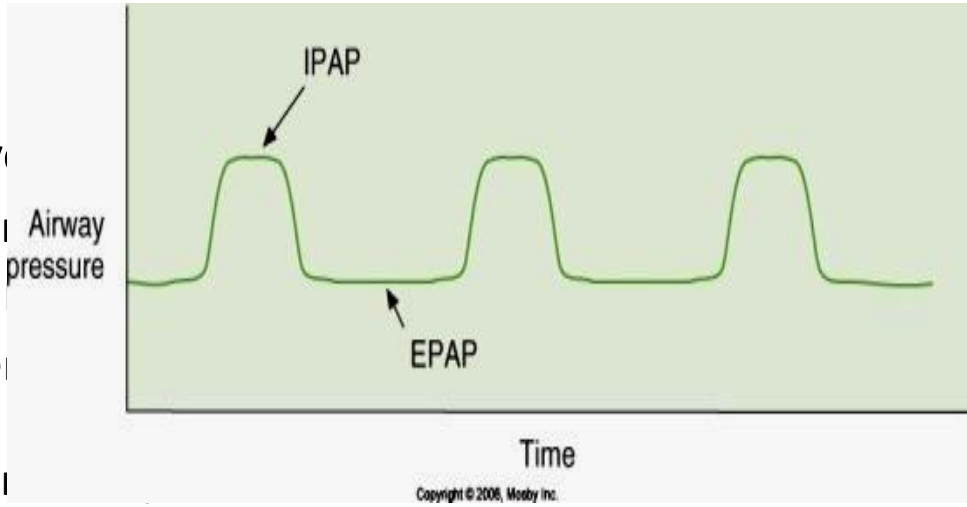
* دستگاه فشار را در دو سطح دمی و باز دمی اعمال می کند.

Modes of Ventilation

Spontaneous Modes

Bilevel Positive Airway Pressure (BiPAP)

Commonly patient triggered but can be time triggered, pressure targeted, flow or time cycled



The operator sets two pressure lev

IPAP (Inspiratory Positive Airway Pr

IPAP is always set higher than

Augments V_T and improves ve

EPAP (Expiratory Positive Airway Pr

Prevents early airway closure and alveolar collapse at the end of expiration by increasing (and normalizing) the functional residual capacity (FRC) of the lungs

Facilitates better oxygenation

Modes of Ventilation

Spontaneous Modes

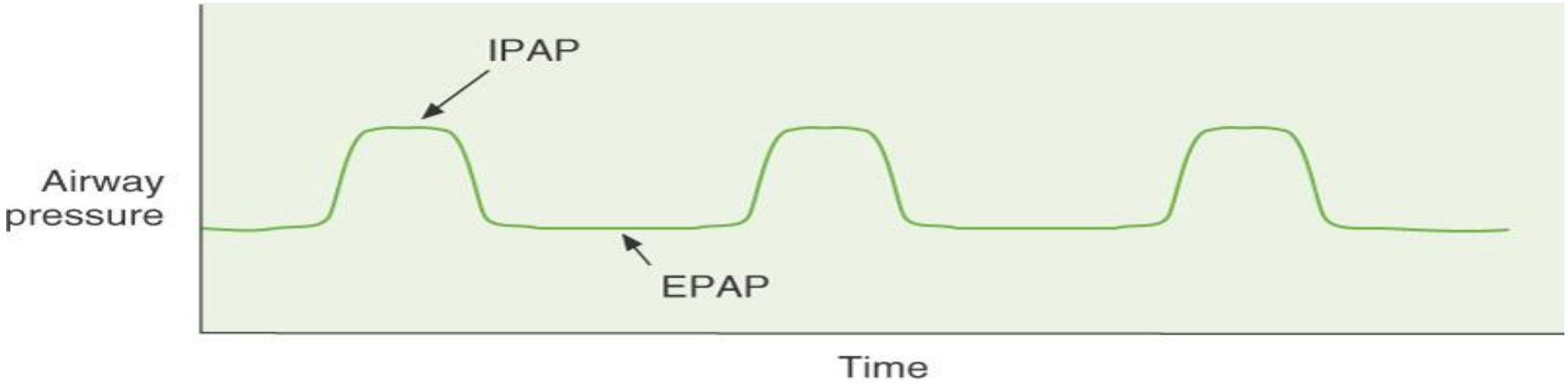
Bilevel Positive Airway Pressure (BiPAP)

The operator sets two pressure levels

-IPAP(PIP)

-EPAP(PEEP)

NOTE: The pressure difference between IPAP and EPAP is ***pressure support***



Adaptive support ventilation(ASV)

- یک روش تهویه ای با **مد فشاری** است.
- تنفس خود به خودی بیمار با حمایت فشاری تریگر می شود.
- این مد سازگاری خوبی با بیمار دارد.
- نیاز به سدیشن کمتر است وبرای جداسازی مناسب است.
- این مد برای بیمارانی که خطر اتوپیپ دارند مناسب است. (بیماری انسدادی ریه)
- در بیمارانی که خطر آپنه سنترال دارند روش خوبی است.

Adaptive support ventilation(ASV)

نحوه مدیریت در این مد

- اپراتور میزان وزن ایده آل بدن IBW و T.SIZEرا وارد می نماید. سپس ونتیلاتور با توجه به الگوریتم خود میزان حجم دقیقه ای را محاسبه می نماید .
- با محاسبه چند تنفس **(100 ml|kg|min)** ونتیلاتور میزان کمپلیانس سیستم، مقاومت و auto-PEEP بیمار را اندازه گیری می نماید.
- 1- اگر بیمار هیچ تلاش تنفسی خود به خودی نداشته باشد ونتیلاتور تعداد تنفس، حجم جاری و محدود کننده فشار مناسب تنظیمی را به صورت یک تنفس اجباری Mandatory به ریه بیمار منتقل می نماید.
- 2- اگر بیمار شروع به تنفس خود به خودی بنماید، تعداد تنفس اجباری کاهش می یابد و ونتیلاتور به PS با همان سطح فشار سوئیچ می شود.

Adaptive support ventilation(ASV)

- در ASV اگر بیمار تنفس نداشته باشد مانند PCV Pressure control Ventilation کار می کند.
- اگر تعداد تنفس خودبخودی کمتر از تعداد تنفس هدف باشد. مانند مد **PSIMV**فشاری عمل می نماید.
- اگر تعداد تنفس خودبخودی مناسب باشد مانند مد PSV عمل خواهد کرد.
- درواقع ترکیبی از مد های **PSIMV-PCV-PSV** است.
- نسبت دم به بازدم و زمان دم توسط ونتیلاتور به طور مستمر بهینه شده تا از بروز auto-PEEP جلوگیری نماید.

Adaptive Support Ventilation(ASV)

موارد استفاده:

- پشتیبانی کامل یا نسبی از تهویه بیمار
- بیماران که نیاز به جریان متغیر یا بالا دارند.
- بیمارانی که تنفس خودبخودی خوبی ندارند.
- بیمارانی که نوسان در میزان کمپلیانس و مقاومت راه هوایی دارند.
- تسهیل جهت جداسازی از ونتیلاتور

Adaptive Support Ventilation(ASV)

مزایای استفاده:

- 1- تضمین ارائه حجم جاری و تهویه دقیقه ای
- 2- حداقل WOB بیمار
- 3- ونتیلاتور خود را با بیمار سازگار می نماید
- 4- جداسازی Weaning به طور مداوم و اتوماتیک انجام می شود.
- 5- آنالیز تنفس به تنفس بیمار

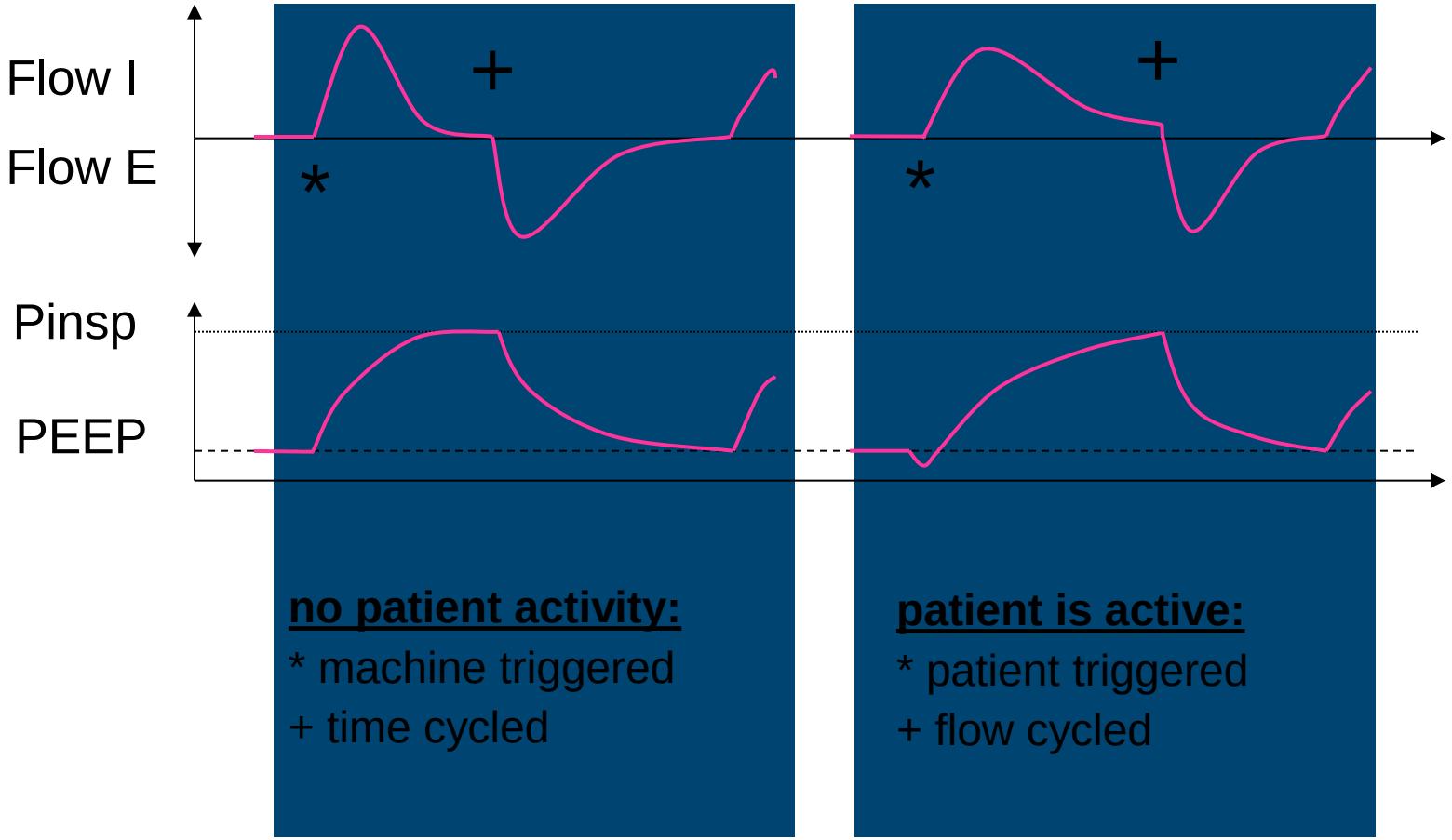
ASV (Adaptive Support Ventilation)

- Advantages
  - Guaranteed V_T and $\dot{V}_E$
  - Minimal patient WOB
  - Ventilator adapts to the patient
  - Weaning is done automatically and continuously
  - Variable $\dot{V}$ to meet patient demand
  - Decelerating flow waveform for improved gas distribution
  - Breath by breath analysis

ASV (Adaptive Support Ventilation)

- Disadvantages and Risks
  - Inability to recognize and adjust to changes in alveolar V_D
  - Possible respiratory muscle atrophy
  - Varying mean airway pressure
  - In patients with COPD, a longer T_E may be required
  - A sudden increase in respiratory rate and demand may result in a decrease in ventilator support

ASV: Principle mode of ventilation



From Hamilton Medical

Bi-level Ventilation: Duo PAP

•It mixes spontaneous and mandatory breath types

.The mandatory breaths are pressure controlled and the spontaneous breaths can be pressure supported.

RR=10 high.P=12 low.p=4(PEEP)

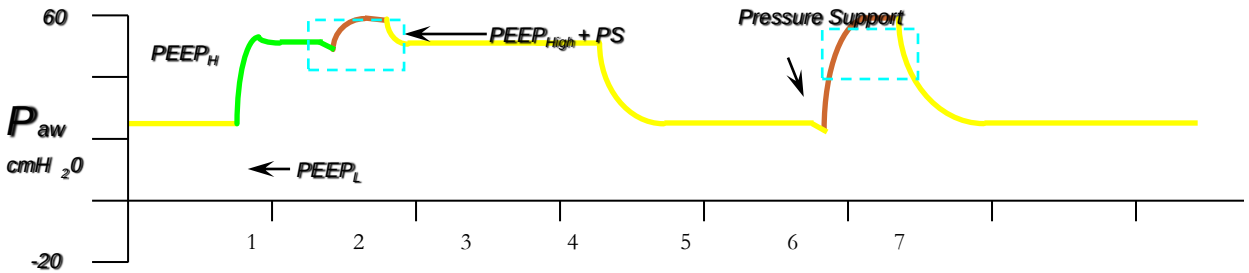
T.high=2 T.low=4 Fio2=40%

PS=15

BiLevel Ventilation

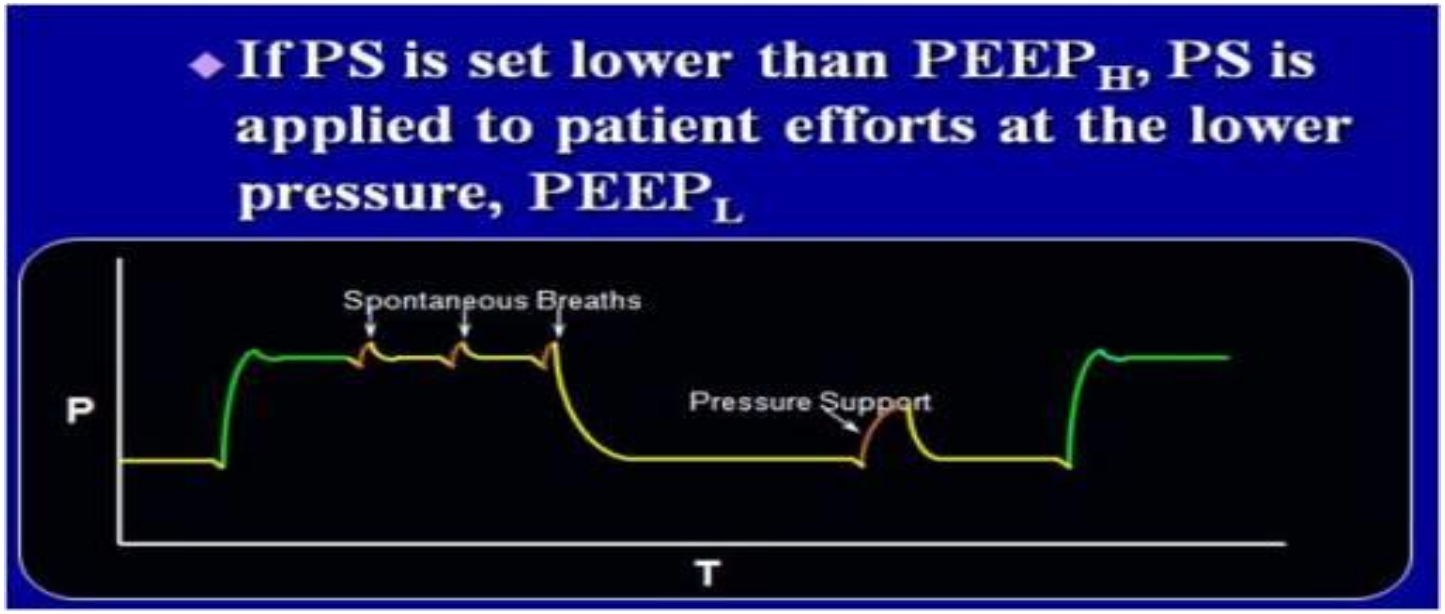
در هر دو سطح فشار, بیمار خود به خود می تواند تنفس کند

- تنفس خود به خودی ممکن است توسط PS پشتیبانی (میتوانیم PS تنظیم تماییم)
- میزانPS باید 4 تا از فشار تعیین شده بالایی وپایین بیشتر باشد
- اگر PS بالاتر از فشار یا PEEP H تنظیم شود PS از تنفس خود به خودی در فشار بالا پشتیبانی خواهد کرد



BiLevel Ventilation

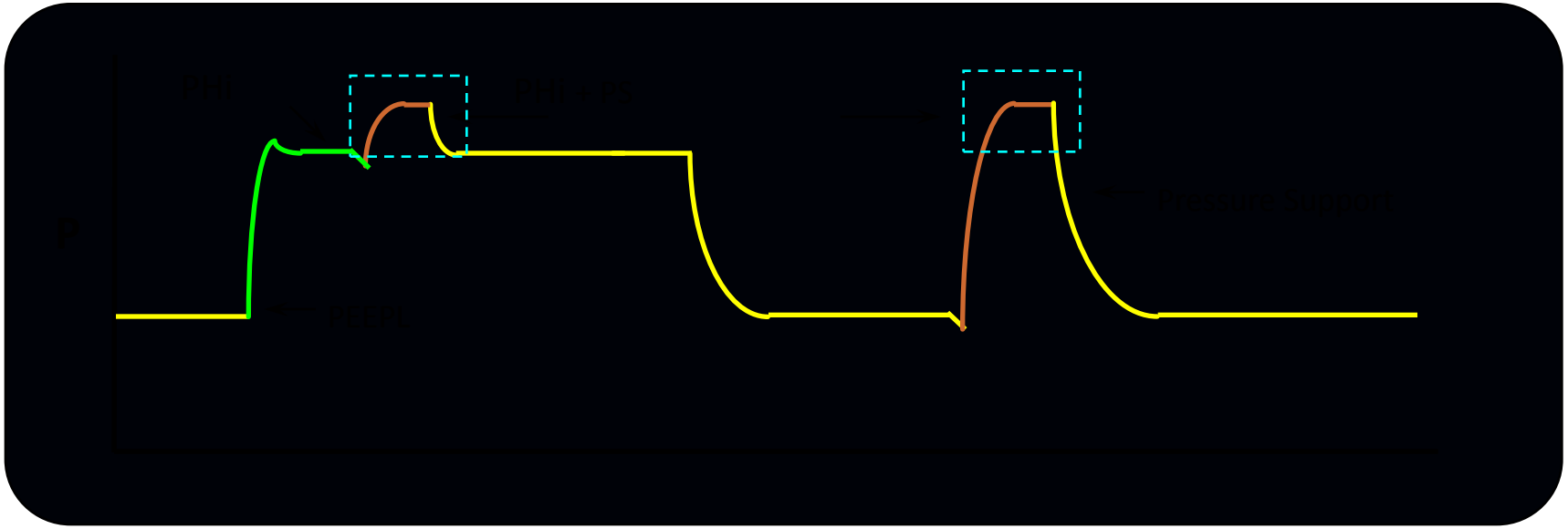
در صورتی که میزان ساپورت فشاری تنظیمی کمتر از پیپ بالا باشد، ساپورت فشاری موثر بر تنفس بیمار در پیپ پایین ظاهر خواهد شد.



BiLevel Ventilation:

Pressure support may be applied at both pressures during a spont. breath

If PS is set higher than P_H, the PS pressure is applied to a spontaneous effort at upper pressure



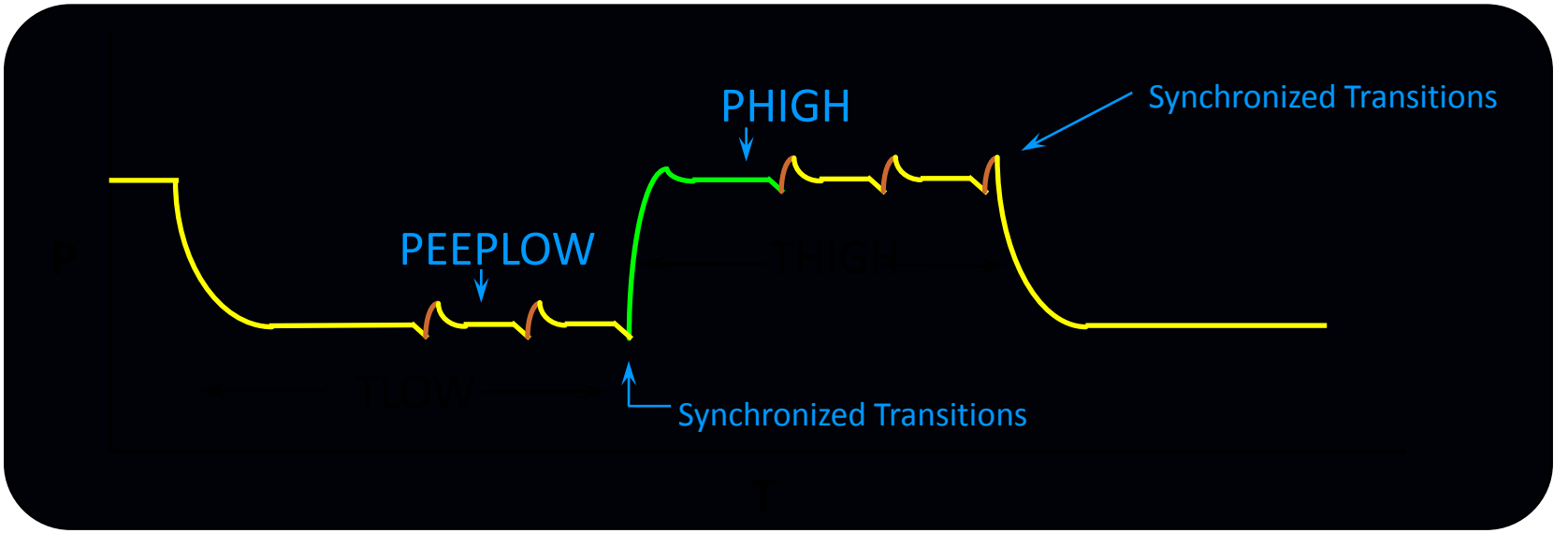
From PB product lit.

BiLevel Ventilation:

Uses 2 pressure levels for 2 time periods

P_{low}& P_{high} $T_{high}$and T_{low}

Patient triggering & cycling can change phases



From PB product lit.

Modes of Ventilation

APRV - Principle of Operation

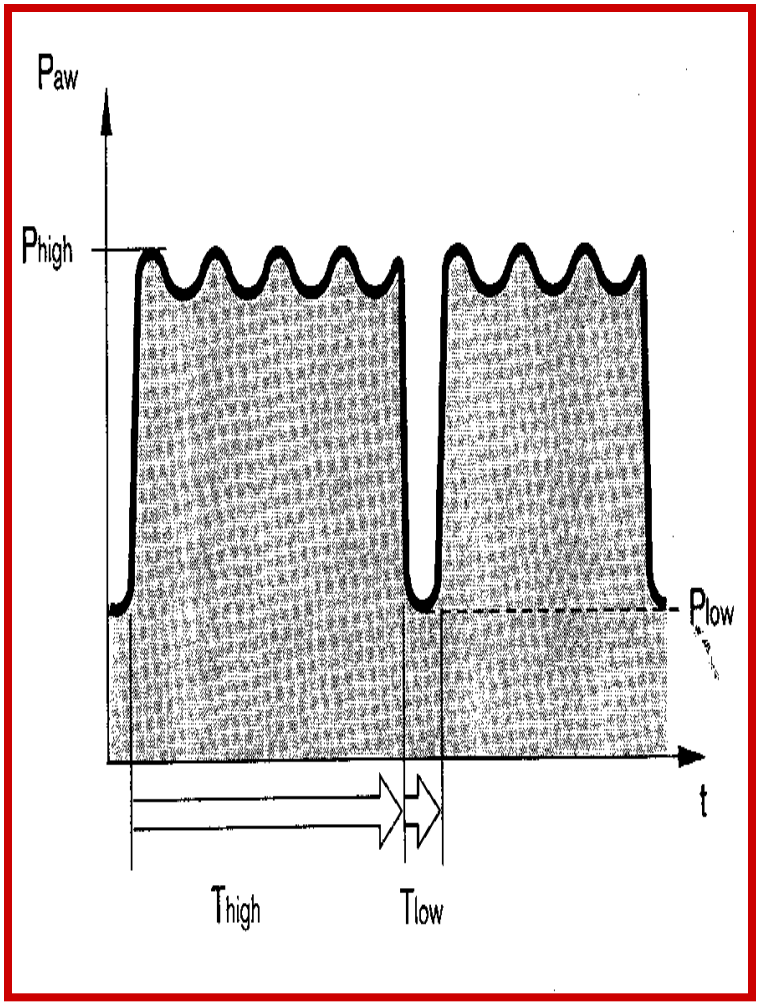
Preset $T_{high(5)}$, $T_{low(1)}$,

$P_{high(20-30)}$ & $P_{low(3-5)}$

Switches between P_{high} & P_{low}

based on set time intervals.

Pt can spontaneus breathing



Airway Pressure Release Ventilation - APRV

- این مد روش مناسبی برای تهویه معکوس است.IRV
- فشارLow بین 0-5 و فشار High کمتراز 30 سانتی متر اب (20-24) تنظیم می شود. طوری که حجم بیمار 6-8 ml|kg شود.
- تعداد تنفس باید بین 8-12 تعیین گردد و هرگز بالاتر از 12 نباشد.
- زمان دمی 4-6 ثانیه و نسبت دم به بازدم I/E 5 به 1 باشد.
- مدت فشار پایین کوتاه 0.8 ثانیه باشد.

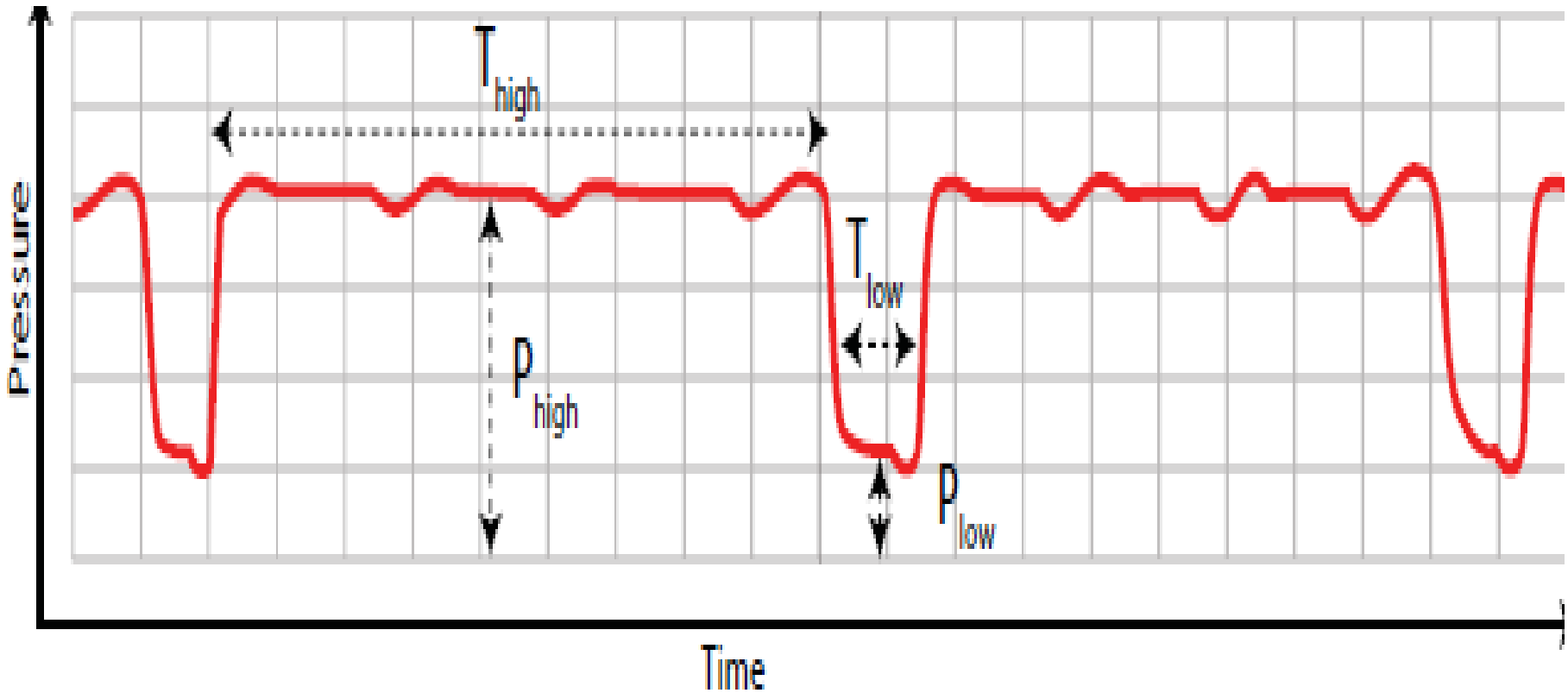
Airway Pressure Release Ventilation- APRV

3-زمان بازدم را بر روی 0.4 تا 0.6 ثانیه تنظیم می کنیم تا حجم جاری هدف خود را (بین 4 و ml/kg6) در نظر بگیرید.

- مدت زمان بازدم متغیر کلیدی است.
- تعداد تنفس باید 8 تا 12 تنفس در دقیقه باشد نه بیشتر.
- درواقع تعداد تنفس تعیین نمی شود بلکه زمان دم وبازدم را مشخص می کنیم.
- اگر حجم جاری بیشتر از 6ml/kg بود ، فشار بالایی را کاهش می دهیم.
- اگر حجم جاری کمتر از 4ml/kg بود ، فشار بالایی را افزایش می دهیم.

APRV(Airway pressure release ventilation)

T.high=5 T.low=1 P.high=20-30 P.low=3-5 PS=18 Fio2=60% Trig=5



تنظیم دستگاه تهویه مکانیکی و جداسازی آن

دکتر ابراهیم علیجان پور

Ventilator Setting :Mode

Volume(ACMV-SIMV)	Pressure(PCV-PSIMV)
• RR • TV • I/E ratio • Flow • flo2 • Trigger (ACMV,SIMV) • PIP alarm • PS(SIMV) • PEEP	RR **Pressure** **I time** Fio2 Trigger(APCV-PSIMV) PEEP PS(PSIMV)

Ventilator Setting:Montoring

- RR Pco2
- TV 1- P pla. 2- P peak 3- Pco2 4- Po2
- Flow 4×mv or 60/min or TV/ I time × 60
- PEEP 1- Po2 2- Fio2 3- compliance
- PSV 1- RR 2- TV 3- Pco2
- Trigger 1-flow 2-Pres
- I time I/E Ratio
- Mod total partial spontaneous

Key Terms in Mechanical Ventilation

- Minute Ventilation (VE)
  - The total amount of volume moving in and out of the lung in one minute.
- Fractional Inspired Oxygen (Fi2O)
  - (21%-0.21; 100%-1.0)
  - Avoid :100%>12h 80% >24h 60% >36h
- Inspiratory:Expiratory Ratio (I:E ratio)
  - Normal I:E ratio 1:2 (1-3 in COPD)
  - Inverse I/E 1-1 2-1 (ARDS)

Key Terms in Mechanical Ventilation

- Tidal Volume (Vt)
  - The volume of air inhaled and exhaled
  - IBW=(Hight\cm-100)*91%
  - Vt:NL Lung=8-10,--COPD=6-8,--ARDS=4-6\cc\Kg
  - adult=8-10 children=6-10ml/kg)
- Breaths per Minute (RR=frequency)
  - Adult=12-15 neonatal=30 /min
- Positive End Expiratory Pressure (PEEP)
  - Maintenance above atmospheric pressure in exp.
  - 3-20 cmH2o

Inspiratory Trigger

- Normally set automatically
- 2 modes:

Airway pressure (-2 - -5 cm H2o)

Flow triggering(flow)(0.5 - 5 Lit /min)

Inspiratory flow

- Varies with the Vt, I:E and RR
- Normally about 60 l/min

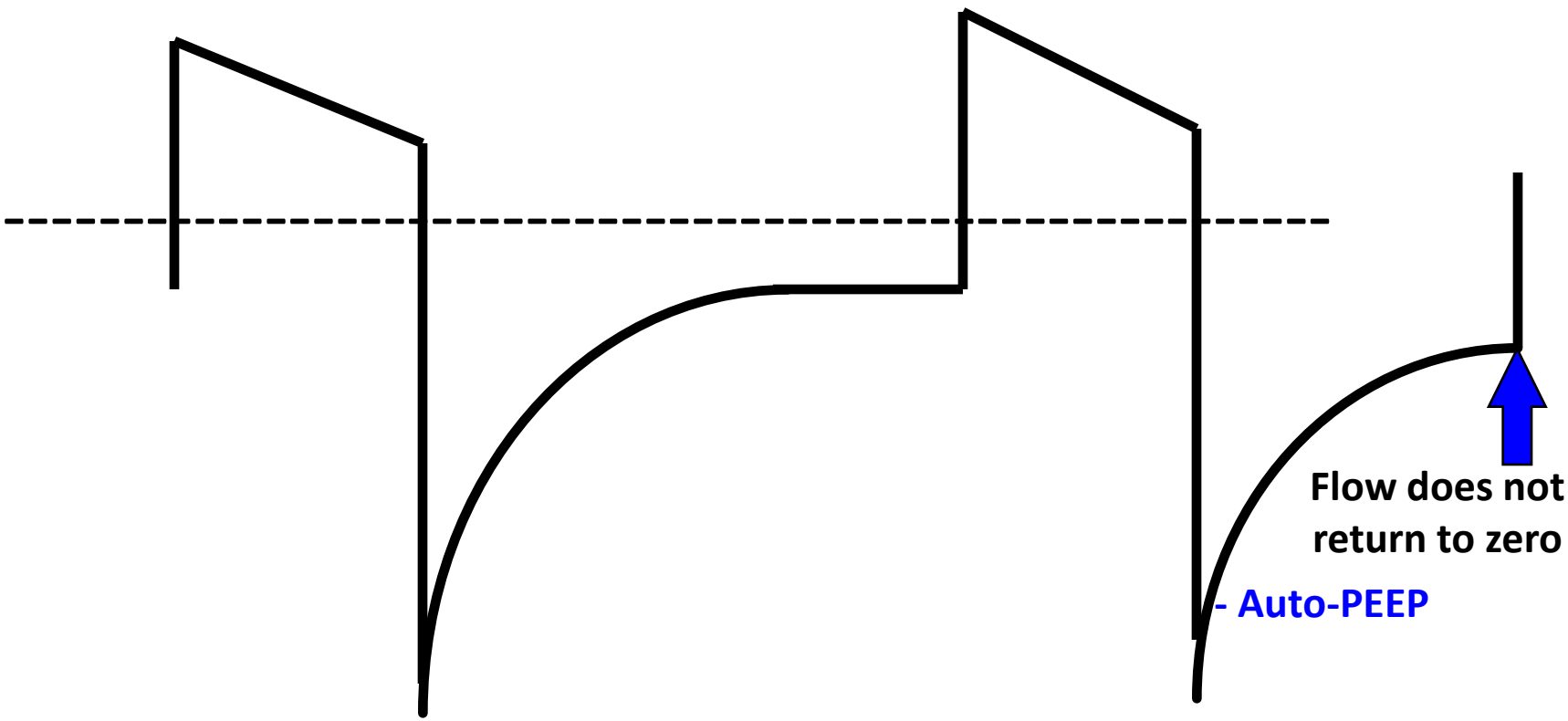
  or >4 *MV
- Can be majored to 100- 120 l/min

  in ARDS, COPD, Asthma

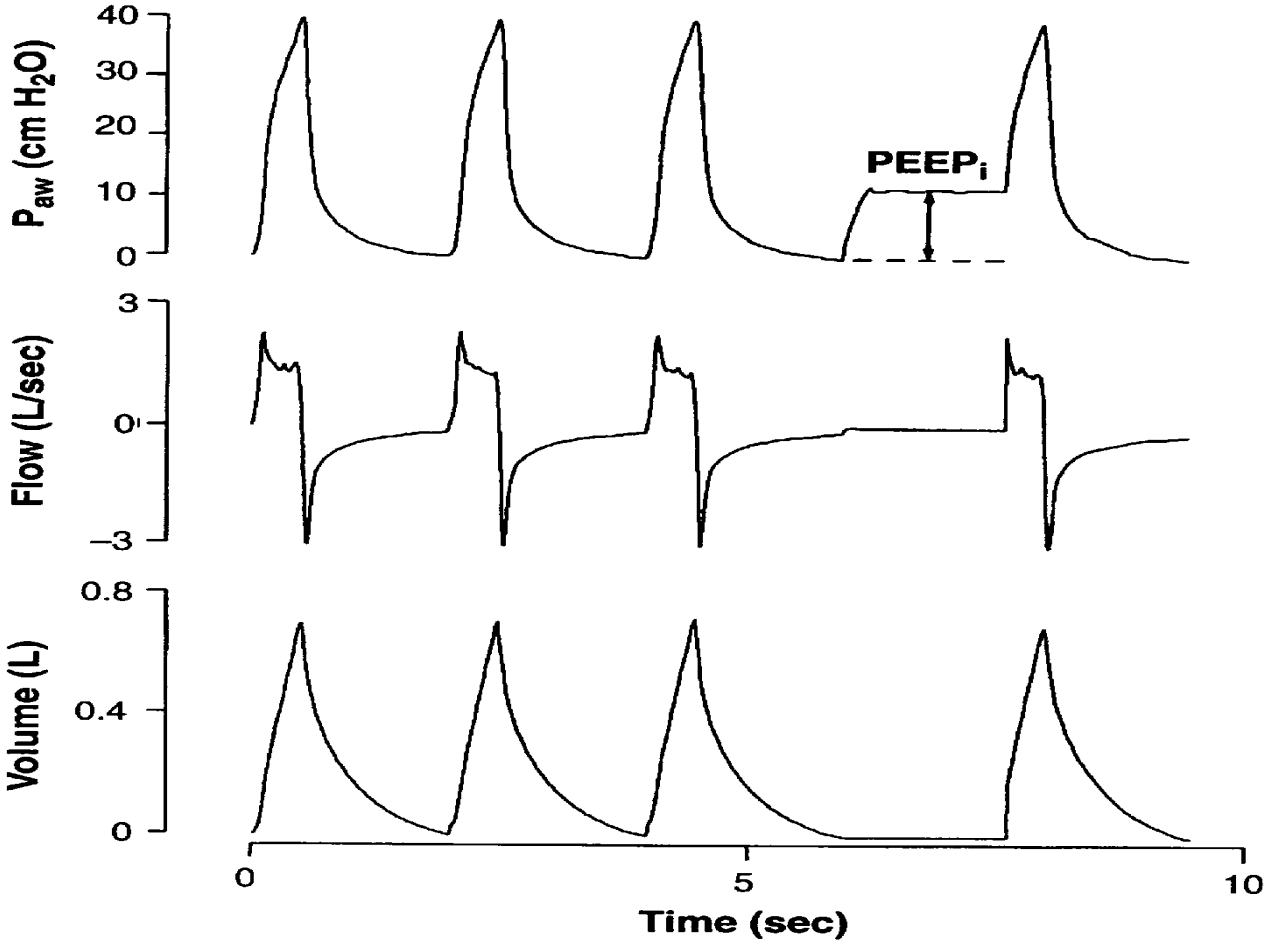
Flow=Tv(lit)/Ti * 60

Auto-PEEP Detection via the Flow Waveform

Normal



Auto-PEEP


40
30
20
10
0
P_{aw} (cm H_2O)
PEEP$_i$
3
0
–3
Flow (L/sec)
0.8
0.4
0
Volume (L)
0
5
10
Time (sec)

Initial Ventilator Settings

- Normal mechanics and gas exchange:

  -CMV with large Vt (8-10cc/kg);

  – f = 8-12; Flow = 60L/min

  – FiO_2 = 0.5; PEEP 5-8

  – CMV with small Vt 5-7cc/kg;

  – f = 16-36; Flow = 60L/min, square wave

  – FiO_2 = 1.0; PEEP 5-20

❑WEANING

❑Definition :

Period of transition from ventilatory support to spontaneous breathing

❑Success in discontinuing Weaning :

Ventilatory workload

Oxygenation status

Cardiovascular function

Psychologic

D/C Infusion sedation

(Bolus dose)

weaning

- **Subjective criteria**
- Resolution of disease acute phase
- Adequate oxygenation(Gas exchange)
- Stable cardiovascular systemHemodynamics
- A febrile
- Adequate mentation (no continuous infusion)
- Stable metabolic status (Na,K, Ca, Mg , BS,….)

weaning

- **Subjective criteria**:

Diaphoresis

Increased WoB
accessory resp. muscle use

Discomfort

Fatigue

Agitaion

Mental status
new or excessive somnolence, anxiety,
thoracoabdominal paradox
new or worsened dyspnea
pain

weaning

- **Objective criteria**
- $FiO_2 \leq 0.4$-0.5
- $PaO_2 > 60$
- PaO_2/FiO_2 ratio > 300
- $PaCO_2 < 50$
- pH > 7.35 and <7.45
- RSBI <80- 100 (RR/Tv=good)
- MV >5 and <10L/min
- TV >5ml/kg
- VC >10—15ml/kg
- PIP >-20 cmh2o
- RR < 35/min
- Cs >25 ml/cmh20

Weaning

1-Simple

No difficulty

2-Difficult

Require to 3 time SBT

or 7 day from SBT to weaning

3-Prolonged

Least >3 time weaning attempts

or require >7 day

Difficult weaning

1-Respiratory pump failure

2-Cardiovascular Dysfunction

- CHF-MI
- Nutrition imbalance
- Steroids
- Hypomagnesaemia
- Hypothyroidism
- Sleep disorder
- Electrolytes imbalance-overload

Chest. x.Ray

EKG

Echo.

Alb/total pro.

TSH,..

Na,K, Ca,Mg ,Po4

Weaning

- **Methods**
- 1- spontaneous breathing trials (SBT)

  T- Piece
- 2- CPAP
- 3- SIMV weaning-delay weaning
- 4- SIMV+(PS)Pressure support
- 5- NIPPV

Weaning Modes Tested

- **SBT :**
- **Spontaneous -24h**
- T-piece up to 2h /d

  initate5-15min

  post 30-60 min 2-6 /day

Tolerate 2h unassisted breathing

Spontaneous Breathing Trials

- **Failed SBT Criteria**
  - **RR > 35 for >5 min**
  - **S_aO_2 <90% for >30 sec**
  - **HR > 140**
  - **Systolic BP > 180 or < 90mm Hg**
  - **Sustained increased work of breathing**
  - **Cardiac dysrhythmia**
  - **pH < 7.32**

Spontaneous Breathing Trials

SBTs do not guarantee that airway is stable or pt can self-clear secretions

Causes of Failed SBTs	**Treatments**
Anxiety/Agitation	Benzodiazepines or haldol
Infection	Diagnosis and tx
Electrolyte abnormalities (K^+, PO^{4-})	Correction
Pulmonary edema, cardiac ischemia	Diuretics and nitrates
Deconditioning, malnutrition	Aggressive nutrition
Neuromuscular disease	Bronchopulmonary hygiene, early consideration of trach
Increased intra-abdominal pressure	Semirecumbent positioning, NGT
Hypothyroidism	Thyroid replacement
Excessive auto-PEEP (COPD, asthma)	Bronchodilator therapy

Spontaneous Breathing Trials**(CPAP)**

- **Settings**
  - **CPAP= 5-8**
  - **FiO_2 < 40%**
  - **Breathe independently for 30 – 120 min**
  - **ABG obtained at end of SBT**

Weaning Modes Tested

- SIMV: Delay to weaning

  Initial :10/min

  reduced at least 2 RR /D

  by 4-6 RR/min
- SIMV: Tolerate 5 breaths/min for 2h

Weaning Modes Tested

- PSV:
- Only or with SIMV
- Initial: 18cmH_2O

  reduced at least 2-5 x/d

  by 6-8 CmH2O

Tolerate PSV 5 for 2h

Weaning Modes Tested

- **PSV :(15-18) on RR =20-25**
- **If RR >25-30 PS-Increase to 20**
- **If RR > 30-35 ps –unsuitable**

Change to other mode


سپاس از توجه شما