RESPIRATORY REFERENCE

Invasive Positive Pressure Ventilation

Introduction

Invasive Positive Pressure Ventilation (IPPV) provides ventilatory support through an artificial airway. Depending on the patient's condition, ventilation may be delivered as Full Support or Partial Support to ensure adequate gas exchange while reducing the work of breathing.

The mode of ventilation is determined by

1- Breath Type

- Mandatory
- Spontaneous
- Assisted

2- Control Variable

- Volume
- Pressure

3- Breath Timing

- CMV
- IMV
- CSV

Mode	Mandatory Breaths	Spontaneous Breaths
CMV	All	None
IMV	Some	Some
CSV	None	All

Breath Type	Triggered by	Controls by
Mandatory	Patient or Ventilator	Ventilator
Spontaneous	Patient	Patient
Assisted	Patient	Patient + Ventilator

Volume Control (VCV)	Pressure Control (PCV)
Fixed VT	Fixed Pressure
Pressure varies	VT varies
Better CO2 control	Better lung protection
Higher risk of high airway pressure	Lower risk of barotrauma

RESPIRATORY REFERENCE

Assist/Control (A/C)

Overview

- Assist/Control (A/C) ventilation is a full-support mode in which every breath is delivered by the ventilator. Breaths may be patient-triggered or time-triggered, but each receives the preset tidal volume or inspiratory pressure.

Breath Mechanism

Trigger
- Flow
- Pressure
- Time

Control
- Volume
- Pressure

Cycle
- Time
- Pressure

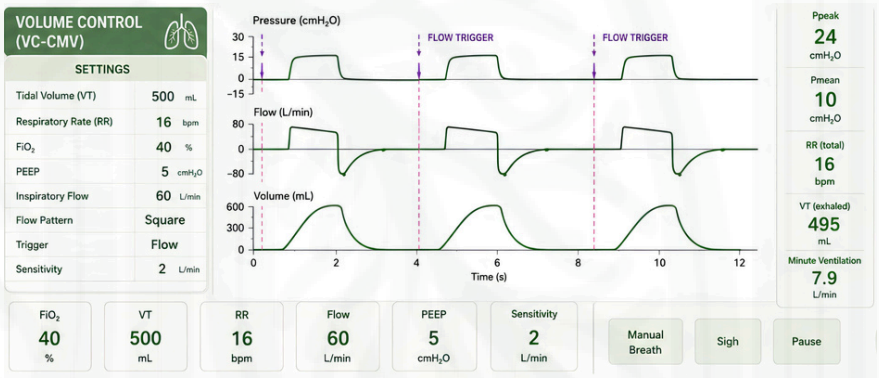
Assist Control / Volume Control

indication
Preferred when maintaining a consistent tidal volume and stable minute ventilation is the primary goal, particularly in patients who require reliable CO_2 control regardless of changes in lung mechanics.

Advantages
- Guaranteed tidal volume
- Better CO_2 control

Disadvantages
- High airway pressure if compliance ↓
- Flow mismatch → Patient–ventilator asynchrony

Management
- Ventilation problem (↑ $PaCO_2$) → Increase VT or RR.
- Oxygenation problem (↓ PaO_2) → Increase FiO_2 and/or PEEP.
- High PIP → Check compliance, airway resistance, and airway obstruction.



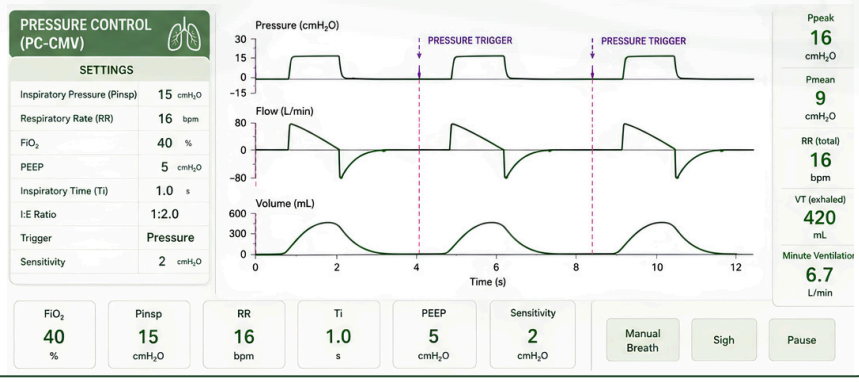
Assist Control / Pressure Control

indication
Preferred when limiting airway pressure and protecting the lungs are the primary goals, particularly in patients with ARDS, reduced lung compliance, or an increased risk of barotrauma.

Advantages
- Limits airway pressure.
- Lung protective (↓ barotrauma).
- Reduces WOB.

Disadvantages
- VT is not guaranteed.
- VT decreases if compliance worsens.
- Requires close VT monitoring.

Management
- Ventilation problem (↑ $PaCO_2$ / ↓ VT) → Increase Inspiratory Pressure or RR.
- Oxygenation problem (↓ PaO_2) → Increase FiO_2, PEEP.
- Low VT → Reassess compliance, resistance, and pressure settings.



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Synchronized Intermittent Mandatory Ventilation (SIMV)

Overview

- SIMV is a mode of mechanical ventilation that synchronizes mandatory breaths with the patient's inspiratory effort while permitting spontaneous breaths between mandatory breaths, providing partial ventilatory support.

Breath Mechanism

Trigger	Control	Cycle
• Flow • Pressure • Time	• Volume • Pressure	• Time • Pressure

Mechanism

- Preset synchronized mandatory breaths.
- Synchronization window aligns mandatory breaths with patient effort.
- Spontaneous breaths are allowed between mandatory breaths (± PSV).

Management

- Ventilation (↑ $PaCO_2$): Increase RR or VT/Pinsp.
- Oxygenation (↓ PaO_2): Increase FiO_2 and/or PEEP.

Indications

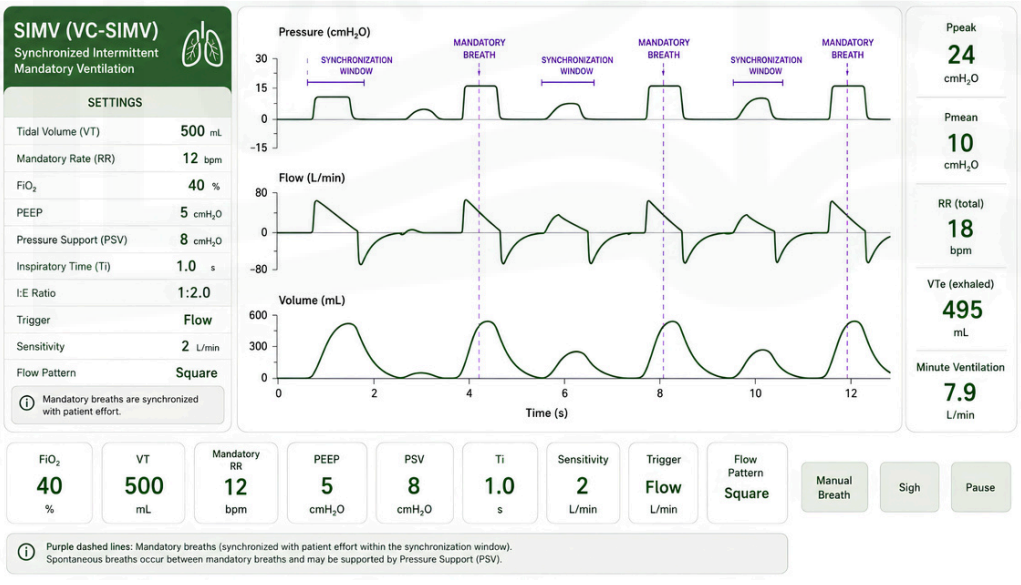
- Partial ventilatory support.
- Patients with spontaneous respiratory drive.
- Weaning from mechanical ventilation.

Advantages

- Preserves spontaneous breathing.
- Maintains respiratory muscle strength.
- Reduces breath stacking.
- PSV decreases WOB.

Disadvantages

- Increased Work of Breathing (WOB).
- May prolong weaning if mandatory rate is set too high.
- Inadequate support may lead to fatigue.



Note!

SIMV is available as VC-SIMV or PC-SIMV, similar to A/C.

Unlike A/C, SIMV allows spontaneous breaths between synchronized mandatory breaths, providing partial ventilatory support instead of full support.

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Pressure Support Ventilation (PSV)

Overview

- PSV is a patient-triggered assisted mode that delivers a preset inspiratory pressure to support each spontaneous breath. It reduces the work of breathing while requiring an intact spontaneous respiratory drive.

Breath Mechanism

Trigger
- Flow
- Pressure

Control
- Pressure

Cycle
- Flow

Mechanism

- Pressure support is applied to overcome ETT resistance.
- Patient initiates every breath.
- Flow-cycled; patient determines RR, flow, and Ti.
- VT varies with patient effort and lung mechanics.

Management

- Ventilation (↑ $PaCO_2$ / ↓ VT): ↑ Pressure Support.
- Oxygenation (↓ PaO_2): ↑ FiO_2 or / and ↑ PEEP.

Indications

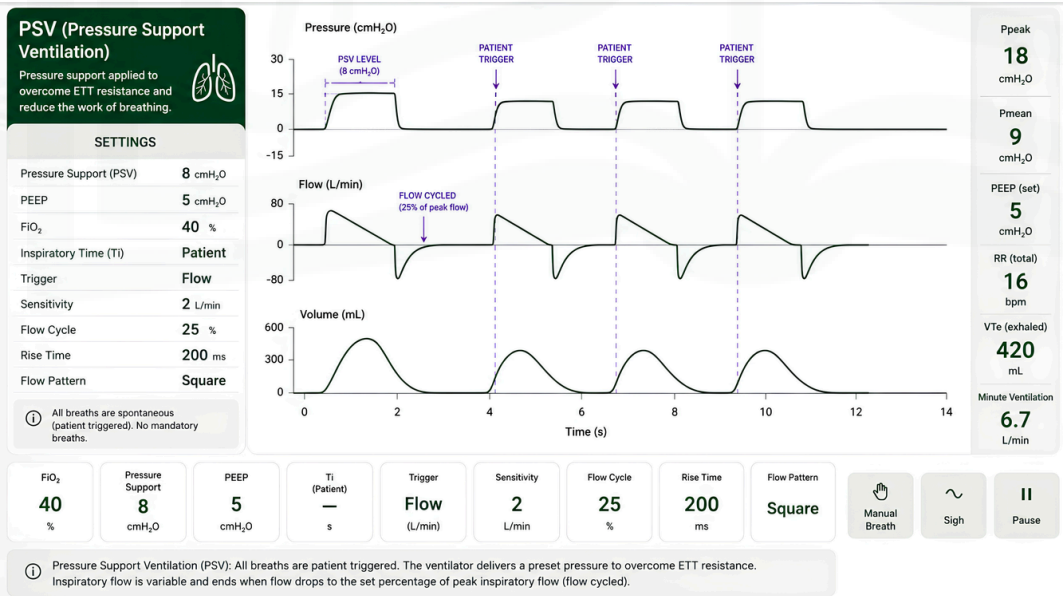
- Spontaneously breathing patients.
- Weaning from mechanical ventilation.
- To reduce work of breathing (WOB).

Advantages

- ↓ Work of breathing.
- Better patient comfort and synchrony.
- Variable inspiratory flow matches patient demand.
- No mandatory breaths.

Disadvantages

- Requires reliable spontaneous respiratory effort.
- VT is not guaranteed.
- VT decreases if compliance worsens or resistance increases.
- Excessive leaks may affect cycling.



Note!

If the patient becomes apneic (no spontaneous breaths) for a preset apnea interval (e.g., 20–40 seconds, depending on ventilator settings), the ventilator automatically switches to a predefined backup controlled mode (VC or PC) using preset backup settings to ensure continuous ventilation.

RESPIRATORY REFERENCE

PRESSURE-REGULATED VOLUME- CONTROL (PRVC)

Overview

- PRVC is a dual-control ventilation mode that automatically adjusts inspiratory pressure to achieve the preset tidal volume using the lowest effective airway pressure.

Breath Mechanism

Trigger
- Flow
- Pressure
- Time

Control
- Pressure

Cycle
- Time

Note!

If the required pressure approaches the preset high-pressure limit, PRVC prioritizes pressure safety, and the delivered VT may become lower than the target.

Mechanism

PRVC
Adjust pressure breath to breath

1st Breath = Volume control with inspiratory pause

2nd Breath = Pressure Control at Plateu

- Delivered Volume > Desired Volume => Dec Pressure by -3 cmH2O/Breath
- Delivered Volume < Desired Volume => inc Pressure by +3 cmH2O/Breath
- Delivered Volume = Desired Volume => Keep Same Pressure

Indications

- Patients requiring a guaranteed tidal volume with lower airway pressure.
- ARDS or patients at risk of barotrauma.

Advantages

- Maintains target VT automatically.
- Uses the lowest pressure necessary.
- Better lung protection.
- Adapts to changes in lung compliance.

Disadvantages

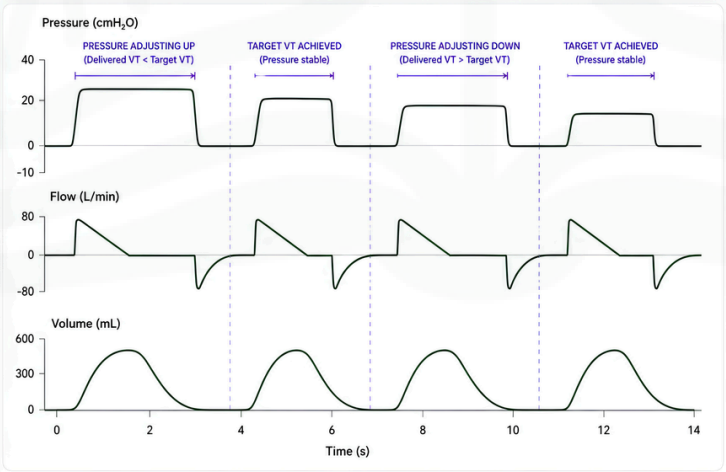
- Requires reliable spontaneous respiratory effort.
- VT is not guaranteed.
- VT decreases if compliance worsens or resistance increases.
- Excessive leaks may affect cycling.

PRVC (Pressure-Regulated Volume Control)

Dual-control mode that automatically adjusts inspiratory pressure to deliver the set tidal volume with the lowest possible airway pressure.

SETTINGS	
Target Tidal Volume (VT)	500 mL
Mandatory Rate (RR)	12 bpm
FiO_2	40 %
PEEP	5 cmH_2O
Inspiratory Time (Ti)	1.0 s
Trigger	Flow
Sensitivity	2 L/min
Pressure Limit (Pmax)	35 cmH_2O
Minimum Pressure (PEEP)	5 cmH_2O
Flow Pattern	Square

Ventilator automatically adjusts pressure to reach the target VT.



Ppeak	Pmean	RR (total)	VTe (exhaled)	Minute Ventilation
24 cmH_2O	10 cmH_2O	12 bpm	500 mL	6.0 L/min

FiO_2	Target VT	Mandatory RR	PEEP	Ti	Trigger	Sensitivity	Pressure Limit (Pmax)	Min Pressure (PEEP)	Flow Pattern	Manual Breath	Sigh	Pause
40 %	500 mL	12 bpm	5 cmH_2O	1.0 s	Flow (L/min)	2 L/min	35 cmH_2O	5 cmH_2O	Square			

PRVC automatically adjusts inspiratory pressure breath-by-breath to deliver the target tidal volume.
If delivered VT is low → pressure increases. If delivered VT is high → pressure decreases.
Pressure is limited by the set Pmax and will not fall below PEEP.

Management

- Ventilation (↑ $PaCO_2$ / ↓ VT): Increase target VT or RR; assess rising pressure needs.
- Oxygenation (↓ PaO_2): Increase FiO_2 and/or PEEP.
- High pressure alarm: Check compliance, airway resistance, secretions, bronchospasm, or ETT obstruction.

RESPIRATORY REFERENCE

Airway Pressure Release Ventilation (APRV)

Overview

A spontaneous mode of ventilation that promotes lung recruitment provides two levels of CPAP and allows spontaneous breathing at both levels both pressure levels are time triggered and time cycled.

Initial settings

- T High is set at 4-6 seconds
- T Low is set at 0.5-1 second (often 0.8)
- RR will be 8-12 b/m (no need to set it)
- P high (15-30) or Pplateu on conventional mode.
- P Low start from 0 cmH2O

You can add PS in APRV.

Indications

- Patients requiring a guaranteed tidal volume with lower airway pressure.
- ARDS or patients at risk of barotrauma.

TLow should not allow expiratory flow to return to zero, preserving intrinsic PEEP and maintaining an open lung strategy.

Weaning

“Drop & Stretch” strategy

Gradually ↓ PHigh and ↑ Thigh (Drop & Stretch) until CPAP level of 8, then assess for extubation.

Management

- Ventilation (↑ $PaCO_2$): Increase Release Frequency (↓ Thigh or ↑ RR) and/or increase ΔP (PHigh − PLow).
- Oxygenation (↓ PaO_2): Increase PHigh, Thigh, or FiO_2.

Advantages

- Improves oxygenation and alveolar recruitment.
- Allows spontaneous breathing.
- Reduces peak airway pressure.
- May improve hemodynamics and reduce sedation requirements.

Disadvantages

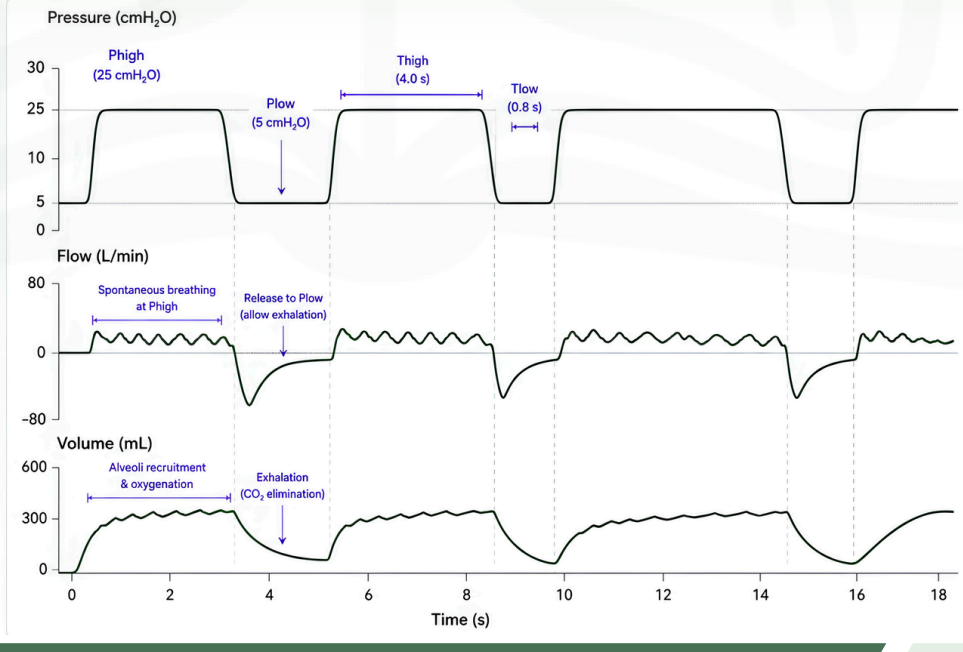
- Requires close monitoring and clinician experience.
- Auto-PEEP may occur.
- Inappropriate settings can cause hyperinflation or CO_2 retention.

APRV
(Airway Pressure Release Ventilation)

Mode that maintains a prolonged high airway pressure with brief releases to a low pressure, allowing spontaneous breathing throughout the cycle.

SETTINGS	
PHigh	25 cmH_2O
PLow	5 cmH_2O
Thigh	4.0 s
Tlow	0.8 s
FiO_2	40 %
Trigger	Spontaneous
Cycle	Time
Rise Time	0.2 s
Flow Pattern	Square

Spontaneous breathing is allowed at both PHigh and PLow.



PHigh 25 cmH_2O

PLow 5 cmH_2O

Thigh 4.0 s

Tlow 0.8 s

FiO_2 40 %

Minute Ventilation 6.5 L/min

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Additional Modes

Adaptive Support Ventilation (ASV)

ASV is a closed-loop ventilation mode that automatically adjusts pressure, tidal volume (VT), and respiratory rate (RR) to achieve a preset target minute ventilation (MV). The clinician sets the desired %MV based on the patient's ideal body weight, while the ventilator delivers a test breath to assess lung mechanics and continuously selects the optimal VT and RR. As the patient's compliance, resistance, or respiratory effort changes, the ventilator automatically modifies the inspiratory pressure to maintain the target ventilation. ASV is particularly useful for patients with changing lung mechanics and during weaning, as it improves patient–ventilator synchrony and reduces the need for frequent manual ventilator adjustments.

Volume Support Ventilation (VSV)

mode delivers a breath exactly like conventional PSV, but the machine can guarantee minute ventilation

The pressure support is automatically adjusted up or down according to the patient's lung compliance and/or resistance to deliver a preset tidal volume

Proportional Assist Ventilation (PAV)

PAV is an assisted mode of mechanical ventilation in which inspiratory pressure and flow are delivered in direct proportion to the patient's inspiratory effort. Ventilatory assistance is determined by the selected gain, which compensates for airway resistance (Raw) and lung elastance, allowing continuous adjustment of pressure and flow according to the patient's ventilatory demand. Unlike conventional ventilation modes, no fixed inspiratory pressure, tidal volume, inspiratory time, or inspiratory flow is preset, resulting in ventilatory support that varies breath-by-breath with the patient's spontaneous effort.