ResMed

Therapy Handbook

Understanding therapy modes to support patient outcomes

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AASM Guidelines for effective titration and therapy

The following guidelines for effective titration apply to all forms of therapy discussed in this handbook:

- Positive airway pressure (PAP) titration recommendations are restricted to adult (≥12 years) and pediatric (<12 years) patients with obstructive sleep apnea.[1]
- All patients being considered for PAP titration should receive education on PAP, hands-on demonstration, careful mask fitting and acclimation prior to titration.[1]

The optimal setting for the titration of CPAP or BPAP is in an AASM-accredited sleep center or laboratory, with the titration protocol implemented by registered polysomnographic technologists and review of the titration study (including pressure selection) by a board certified sleep specialist. Additionally, the definitions, protocols, procedures, and indications for the diagnosis and management of OSA as specified in the AASM practice parameters for polysomnography and PAP, and the AASM Manual for the Scoring of Sleep and Associated Events (i.e., respiratory rules) should be followed. It is understood that the recommendations for minimum and maximum PAP may be constrained by the specific PAP device used during the titration protocol. Lastly, the expectation of the Task Force is that these recommendations should not be followed in a "cookbook" manner; instead, sleep technologists and clinicians should combine their experience and judgment with the application of these recommendations to attain the best possible titration in any given patient.

Medicare Device Billing Codes:[24]

CPAP Qualifications for HCPC E0601 may include therapy modes CPAP (continuous positive airway pressure), APAP (automatic positive airway pressure) and AutoSet for Her.
Bilevel Qualifications for HCPC E0470 may include therapy modes S (spontaneous) and VAuto (Auto bilevel).
Respiratory Assist Device HCPC E0471 or Bilevel with Back-up rate may include these therapy modes:

- **ST:** Spontaneous Timed
- **T:** Timed
- **PAC:** Pressure Assist Control
- **ASV and ASVAuto:** Adaptive servo-ventilation
- **VAPS:** Volume assured pressure support

Therapy guidelines for obstructive sleep apnea (OSA)

CPAP/APAP

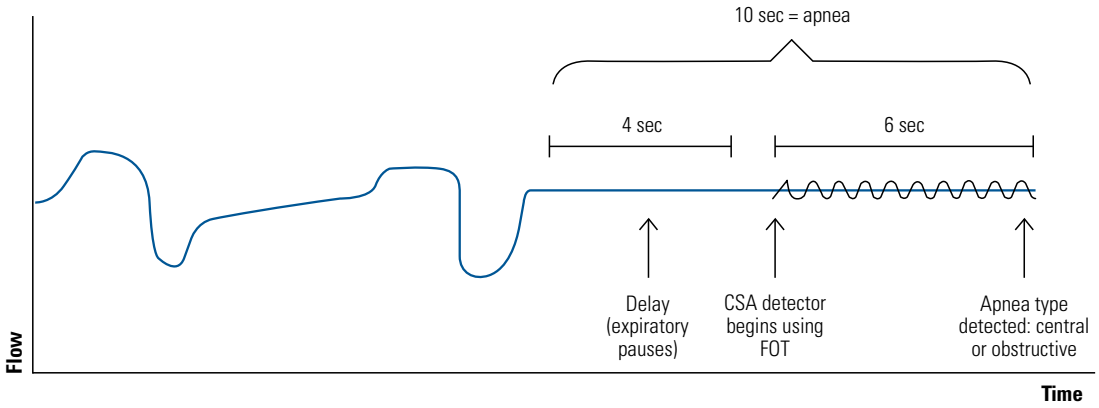
Therapy modes considered for the treatment of obstructive sleep apnea (OSA).

The technology

ResMed CPAP/APAP algorithms include forced oscillation technique (FOT) and the Easy-Breathe waveform. See the "comfort features" section of this handbook for details on the Easy-Breathe waveform.

Forced oscillation technique (FOT)[11]

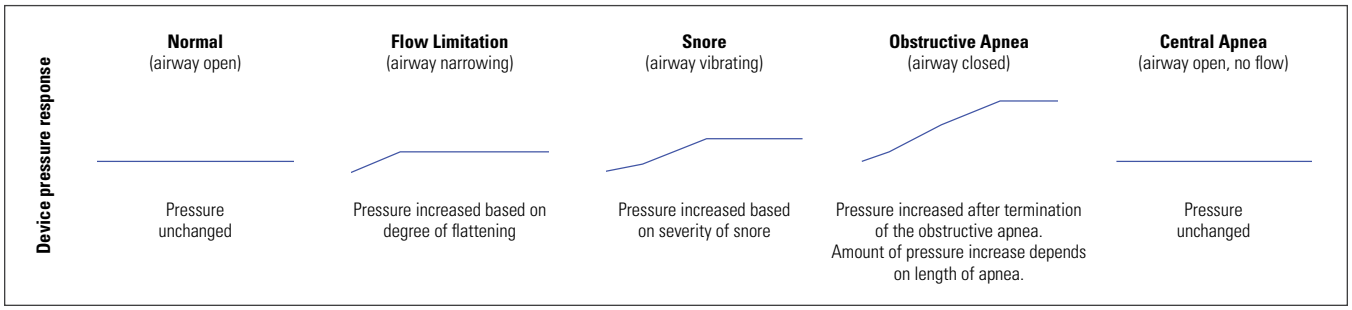
- Four seconds into an apnea, small oscillations in pressure are added to current device pressure.
- Central sleep apnea (CSA) detection algorithm uses the resulting flow and pressure (determined at the mask) to measure whether the airway is open or closed.
- If pressure oscillations are detected back at the device, the patient has a closed airway (obstructive apnea).
- If no pressure oscillations are detected, the airway is open (central apnea).



AutoSet Algorithm (APAP)[15]

How it works

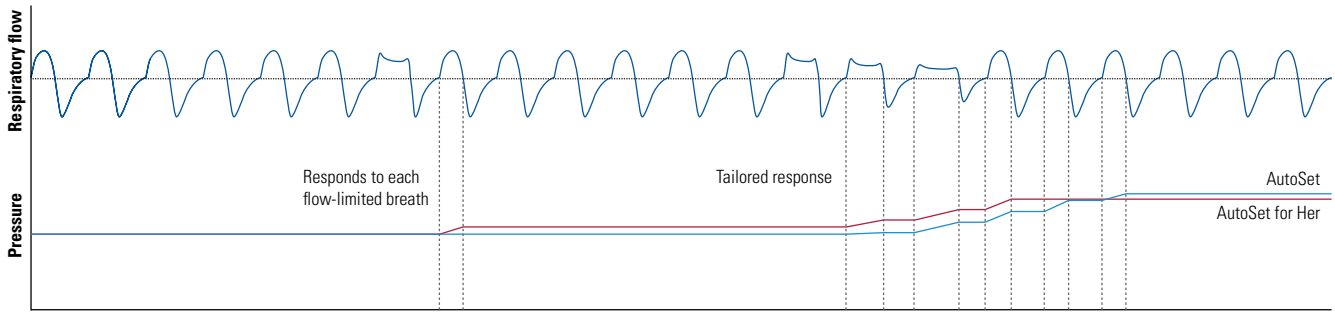
- Adjusts treatment pressure as a function of three parameters: flow limitation, snoring and obstructive apnea.
- Recognizes multiple shapes of flow limitation.



AutoSet for Her algorithm[2]

How it works

- Increased sensitivity to flow limitation and optimized response gain.
- Driven predominantly by flow limitation and snoring rather than apneas.
- Flow-limited breaths are managed using a single-breath index wherein expiratory positive airway pressure (EPAP) is increased in small increments.
- Response to snore and flow limitation is prioritized above 12 cm H_20.



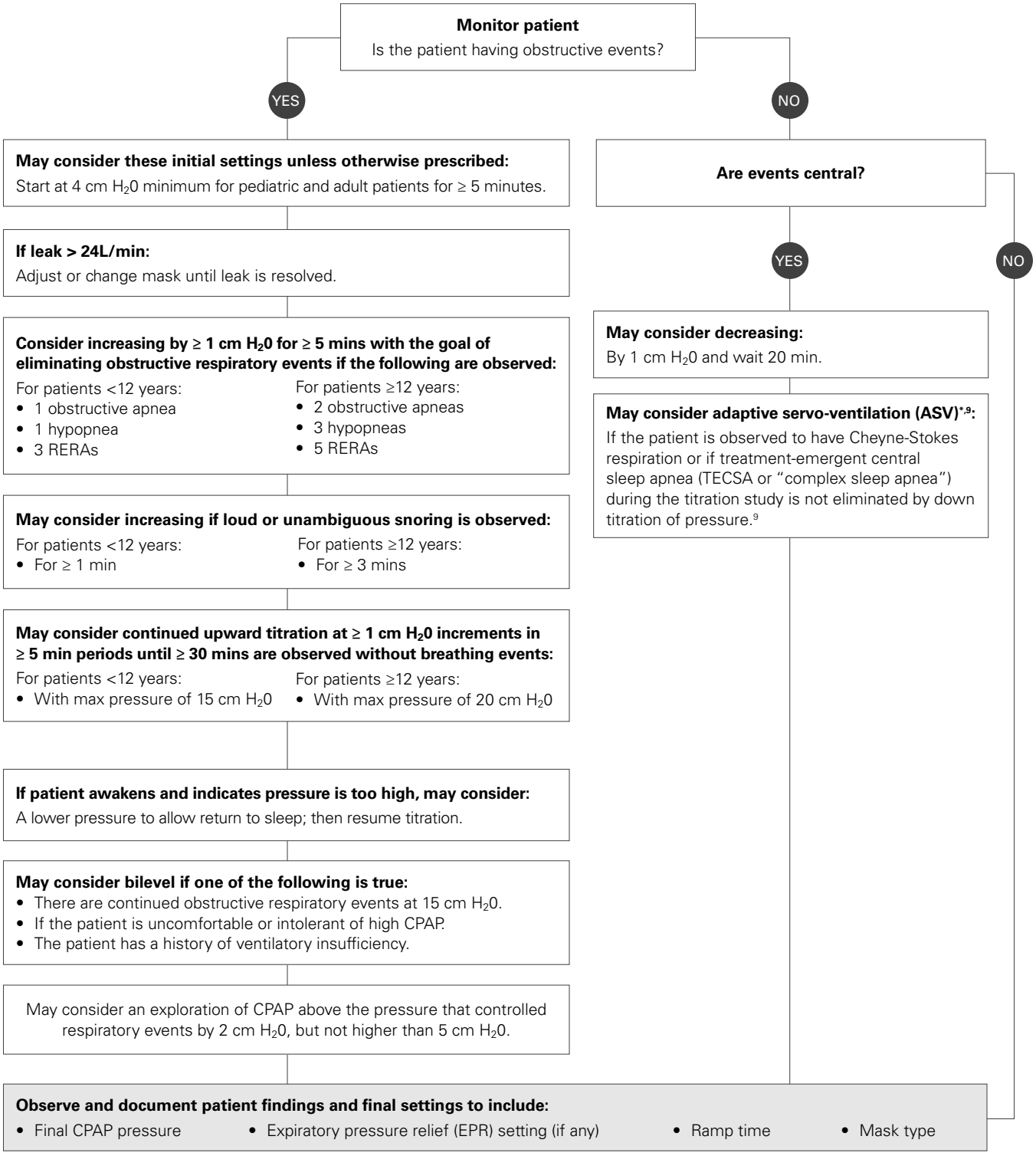
Expiratory pressure relief (EPR)[4]

How it works

- Maintains optimal treatment during inhalation and reduces delivered mask pressure during exhalation.
- If turned on:
  - Can be set to full time or ramp only.
  - Can set pressure relief to 1, 2 or 3 cm H_20 (will not drop below 4 cm H_20).

CPAP titration protocol[1]

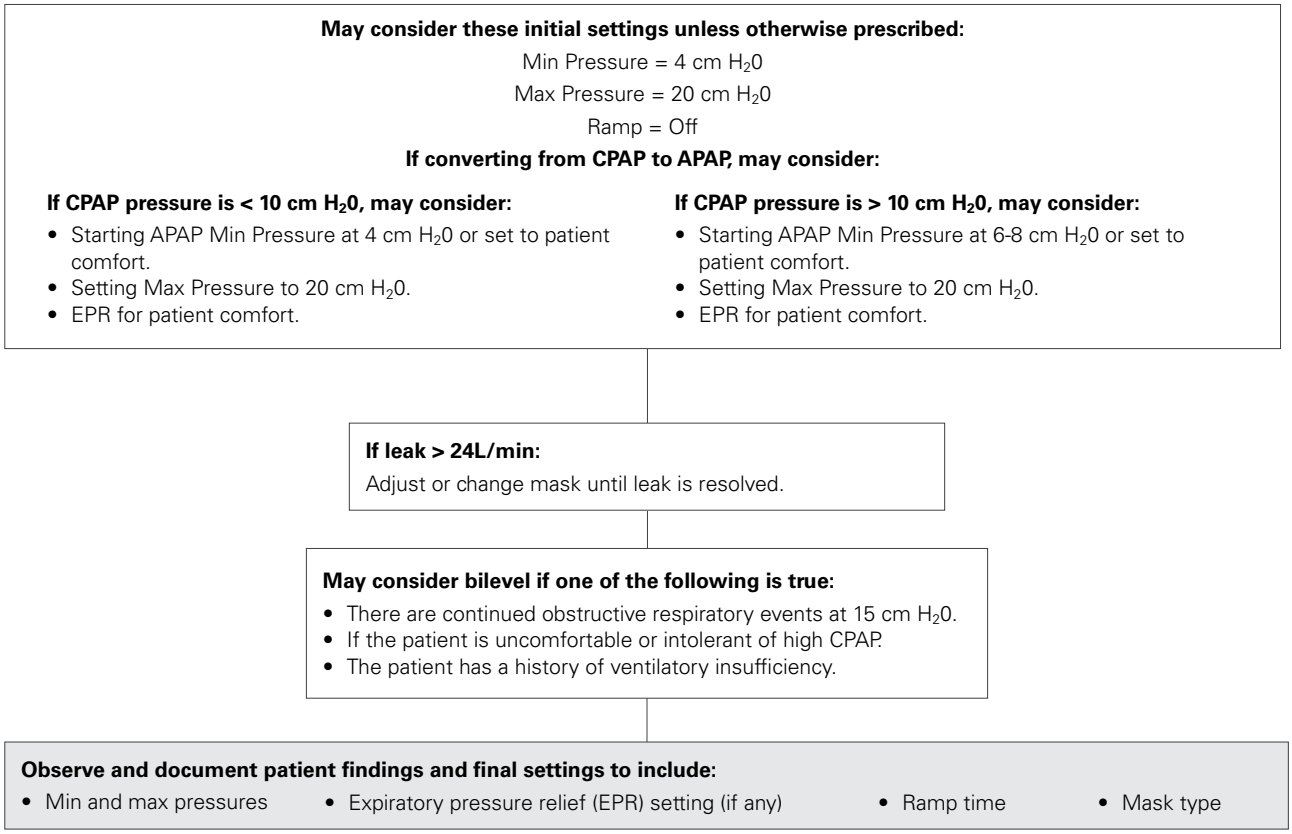
As adapted from AASM guidelines for adult and pediatric patients.



* ASV therapy is contraindicated in patients with chronic, symptomatic heart failure (NYHA 2-4) with reduced left ventricular ejection fraction (LVEF ≤ 45%) and moderate to severe predominant central sleep apnea.

APAP and APAP for Her titration protocol[1]

As adapted from the AASM guidelines.



Titration and therapy considerations

General

- For patients sensitive to pressure change, AutoSet Response can be set to **Soft** which will provide a gentler pressure.[3]
- If the patient complains of difficulty exhaling, may consider adding EPR.[4]
- If the patient has difficulty initiating sleep, may consider ramp to allow lower pressure to gradually increase to the minimum treatment pressure.
- Ensure the mask is fitted properly[1] and leak is minimized. With ResMed devices, unintentional leak should be <24L/min. Mask refit or adjustment should be performed whenever unintentional leak exceeds the threshold. Additionally, verify the mask setting is the mask type used (e.g., if using a full face mask, make sure to select **Full Face** mask setting).
- A higher starting CPAP may be considered for patients with an elevated BMI and/or re-titration studies.[1]
- In adult patients, may consider an increase of CPAP at larger increments, such as 2 or 2.5 cm H20, given the shorter CPAP titration duration in a split-night versus full-night study as dictated by patient's breathing patterns and clinical observations.[1]
- The optimal setting for the titration of CPAP or BPAP is in an AASM-accredited sleep center or laboratory, with the titration protocol implemented by registered polysomnographic technologists and review of the titration study (including pressure selection) by a board certified sleep specialist.
- These recommendations should combine their experience and judgment with the application of these recommendations to attain the best possible titration in any given patient.

Supplemental O_2[1]

- Supplemental O_2 may be considered during the PAP titration when, prior to the PAP titration, the patient's awake supine SpO_2 while breathing room air is ≤88%.
- Supplemental O_2 may be considered during the PAP titration when SpO_2 is ≤88% for ≥5 minutes in the absence of obstructive respiratory events.
- In both instances, supplemental O_2 may be introduced at 1 L/min ≥15 minutes and titrated upwards to achieve a target SpO_2 between 88% and 94%.

Indications of pressure intolerance[6]

Signs that a patient may be intolerant of high pressure settings include:

- Discomfort with properly fitted mask, often removing mask during sleep
- Arousals or microarousals
- Lack of progress to REM sleep cycle
- Bloated feeling or sensation of swallowing air
- History of failed CPAP
- Nasal congestion
- Difficulty exhaling despite EPR feature
- Complaints of smothering or chest wall discomfort

Therapy guidelines for OSA (noncompliant)

S/VAuto

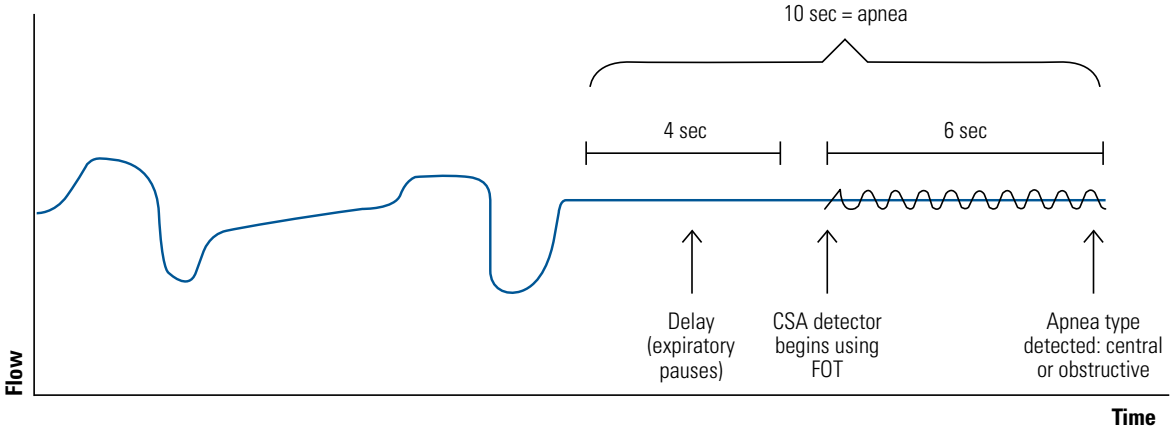
Therapy modes considered for the treatment of obstructive sleep apnea (OSA) and to help those struggling to adhere to PAP therapy (i.e., noncompliant patients).

The technology

The S and VAuto algorithms include forced oscillation technique (FOT), trigger sensitivity, TiControl, cycle sensitivity and Vsync. The S algorithm also includes the Easy-Breathe waveform. See the "synchrony settings" and "comfort features" sections of this handbook for definitions and details on these technologies.

Forced oscillation technique (FOT)[11]

- Four seconds into an apnea, small oscillations in pressure are added to current device pressure.
- Central sleep apnea (CSA) detection algorithm uses the resulting flow and pressure (determined at the mask) to measure whether the airway is open or closed.
- If there is little or no flow at the mask, then the airway is closed (i.e., OSA).
- If the flow at the mask is large, then the airway is open (i.e., CSA).



S algorithm

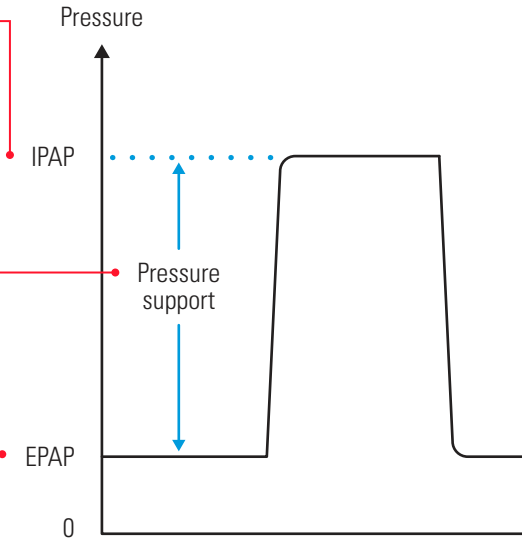
How it works

- Allows setting of two treatment pressures—inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP). This is often referred to as bilevel positive airway pressure (BPAP).
- Pressure support (PS) is the difference between IPAP and EPAP levels and may aid in achieving adequate tidal volume.
- The IPAP and EPAP settings remain constant through the night unless adjustments are made during the titration process.

IPAP
IPAP = EPAP + PS
May aid in:
- Achieving adequate tidal volume
- Achieving a respiratory rate (RR) <25 bpm[5]
- Decreasing work of breathing
- Reducing $PaCO_2$

Pressure support (PS)
PS = IPAP - EPAP
May aid in:
- Ventilatory support increases as PS increases
- Care must be taken not to overventilate

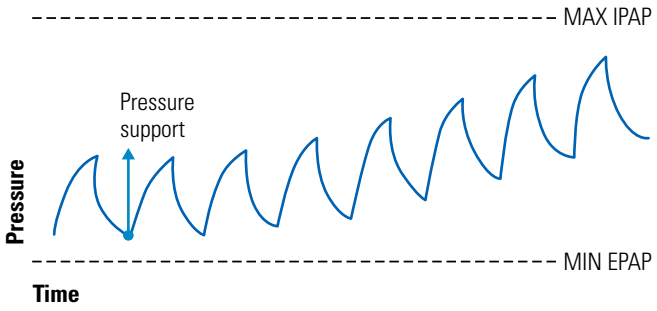
EPAP
EPAP = IPAP - PS
- Overcomes obstructive apneas and hypopneas
- May aid in improvement of oxygenation



VAuto algorithm

How it works

- Adjusts treatment pressure as a function of three parameters: inspiratory flow limitation, snore and obstructive apnea.
- PS remains fixed throughout the night.
- Min EPAP and Max IPAP settings allow delivered pressure ranges to be restricted.



S titration protocol

As adapted from AASM guidelines, Berry & Epstein for adult and pediatric patients.

Has patient been on CPAP therapy?

YES

May consider these initial settings unless otherwise prescribed:

- Minimum starting EPAP at 4 cm H_20 or the CPAP level at which obstructive apneas were eliminated.[1]
- IPAP-EPAP differential recommended range of 4-10 cm H_20.[1]
- Maintain starting pressures ≥ 5 min.[1]

NO

May consider these initial settings unless otherwise prescribed:

- Recommended minimum IPAP is 8 cm H_20.
- Recommended minimum EPAP is 4 cm H_20.
- IPAP-EPAP differential recommended range of 4-10 cm H_20.[1]
- Maintain starting pressures ≥ 5 min.[1]

If leak > 24L/min:

Adjust or change mask until leak is resolved.

For obstructive apneas, may consider increasing IPAP and EPAP by ≥ 1 cm H_20 every ≥ 5 min:[1]

For patients <12 years:

- If ≥ 1 obstructive event
- Recommended max IPAP 20 cm H_20

For patients ≥12 years:

- If ≥ 2 obstructive events

For hypopneas, RERAs or snoring, may consider increasing IPAP:

- Every 5 min if tidal volume is low (< 6-8 mL/kg).[7]
- If SpO_2 remains < 90% for ≥ 5 min and tidal volume is low (< 6-8 mL/kg).[7]
- If respiratory muscle rest has not been achieved by noninvasive positive pressure ventilation (NPPV) treatment at the current settings for ≥ 10 min.[7]

For patients <12 years, may consider:[1]

- ≥ 1 hypopnea
- ≥ 3 RERAs
- ≥ 1 min loud or ambiguous snoring

For patients ≥12 years, may consider:[1]

- ≥ 3 hypopneas
- ≥ 5 RERAs
- ≥ 3 min loud or ambiguous snoring

If patient awakens and indicates pressure is too high, may consider:

- A lower pressure to allow return to sleep; then resume titration.[1]

May consider an exploration of IPAP above the pressure that controlled respiratory events but should not exceed 5 cm H_20 or recommended max IPAP per age group.[1]

Are events central?

YES

For central events, may consider:[1]

- Decreasing to previous settings for 20 min.
- Adaptive servo-ventilation (ASV)* if the patient is observed to have Cheyne-Stokes respiration or if treatment-emergent central sleep apnea (TECSA or "complex sleep apnea") during titration is not eliminated by down titration of pressure.

If central events persist, may consider:

- ST, ASV* or iVAPs based on patient's underlying diseases.[7]
- Switching to iVAPS if the patient presents with nocturnal hypoventilation and central sleep apnea.[5]

NO

For SpO_2 <90% with all respiratory events eliminated, may consider:

- Increasing IPAP by ≥ 1 cm H_20 every ≥ 15 min until ≥ 90% SpO_2 is reached.[7]
- Adding O_2 if adequate tidal volume and respiratory rate have been optimized but SpO_2 remains <90% for ≥ 5 min.[7]
- Follow sleep lab protocols for adding O_2.
- Minimum starting O_2 rate 1 L/min in adult and pediatric patients.[7]
- O_2 rate may be increased in increments of 1 L/min every 5 min until SpO_2 >90%.[7]

Observe and document patient findings and final settings to include:

- IPAP and EPAP pressures
- Tidal volume and respiratory rate
- Synchrony settings
- Mask type

* ASV therapy is contraindicated in patients with chronic, symptomatic heart failure (NYHA 2-4) with reduced left ventricular ejection fraction (LVEF ≤ 45%) and moderate to severe predominant central sleep apnea.

VAuto titration protocol[1]

As adapted from AASM guidelines.

May consider these initial settings unless otherwise prescribed:

Min EPAP = 4 cm H_20

Pressure support = 4 cm H_20

Max IPAP = 20 cm H_20

Ramp = Off

If converting from bilevel S titration to VAuto, may consider:

If CPAP pressure is < 10 cm H_20, may consider:

- Starting Min EPAP at 4 cm H_20 or set to patient comfort.
- Setting Max IPAP to 25 cm H_20.
- Starting PS at 4 cm H_20.

If CPAP pressure is > 10 cm H_20, may consider:

- Starting Min EPAP at 6-8 cm H_20 or set to patient comfort.
- Setting Max IPAP to 25 cm H_20.
- Starting PS at 4-6 cm H_20.

If leak > 24L/min:

Adjust or change mask until leak is resolved.

Observe and document patient findings and final settings to include:

- IPAP and EPAP pressures
- Tidal volume and respiratory rate
- Synchrony settings
- Mask type

Titration and therapy considerations

General

- Ensure the mask is fitted properly[1] and leak is minimized. With ResMed devices, unintentional leak should be <24L/min. Mask refit or adjustment should be performed whenever unintentional leak exceeds the threshold. Additionally, verify the mask setting is the mask type used (e.g., if using a full face mask, make sure to select **Full Face** mask setting).
- If the patient has difficulty initiating sleep, may consider ramp to allow lower pressure to gradually increase to the minimum treatment pressure.
- A higher starting IPAP and EPAP may be selected for patients with an elevated BMI and/or for re-titration studies.[1]
- If you are transitioning from PAP to S mode and using EPR, may consider starting EPAP at the lower EPAP setting (i.e., if set at PAP 10 cm H_20 with EPR of 3, start EPAP at 7 cm H_20).

Synchrony settings and comfort features

May consider an adjustment if:

- Patient complains of pressure discomfort.
- Chest wall movement is not in sync with mask pressure tracing.
- Inspiratory efforts do not trigger the device.

If rise time needs to be adjusted, turn off Easy-Breathe waveform. See the "synchrony settings" section of this handbook for more information.

Therapy guidelines for central sleep apnea (CSA)

ASV*/ASVAuto

Therapy modes considered for patients presenting with obstructive sleep apnea (OSA), central sleep apnea (CSA), treatment-emergent central sleep apnea (TECSA or "complex sleep apnea"), mixed apneas and periodic breathing weighing more than 66 lb (30 kg); targeted to normalize the apnea-hypopnea index (AHI).
It may be used for the treatment of CSA related to congestive heart failure (CHF) in adults with an ejection fraction >45% or mild CHF-related CSA.[8]

American Academy of Sleep Medicine (AASM) recommendation is that ASV contraindication is a Class Effect[8]	
Any **adaptive servo-ventilation (ASV) targeted to normalize the apnea-hypopnea index (AHI)** should not be used for the treatment of central sleep apnea (CSA) related to congestive heart failure (CHF) in adults with an ejection fraction ≤45% **AND** moderate or severe CSA-predominant, sleep-disordered breathing (SDB).	This **contraindication should not be generalized** to patients with other types of heart failure (HF) such as: • HF patients with preserved ejection fraction (EF >45%) • HF patients with mild sleep-disordered breathing (AHI <15) • HF patients with obstructive sleep apnea (OSA)-predominant SDB

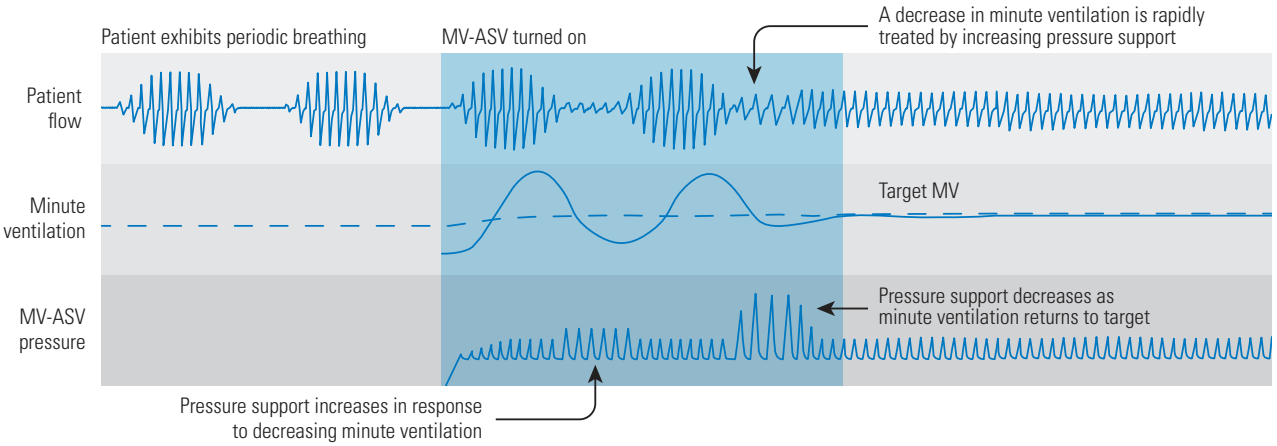
The technology

ResMed's ASV and ASVAuto algorithms include Vsync and the Easy-Breathe waveform. See the "synchrony settings" and "comfort features" sections of this handbook for definitions and details on these technologies.

ASV algorithm

How it works

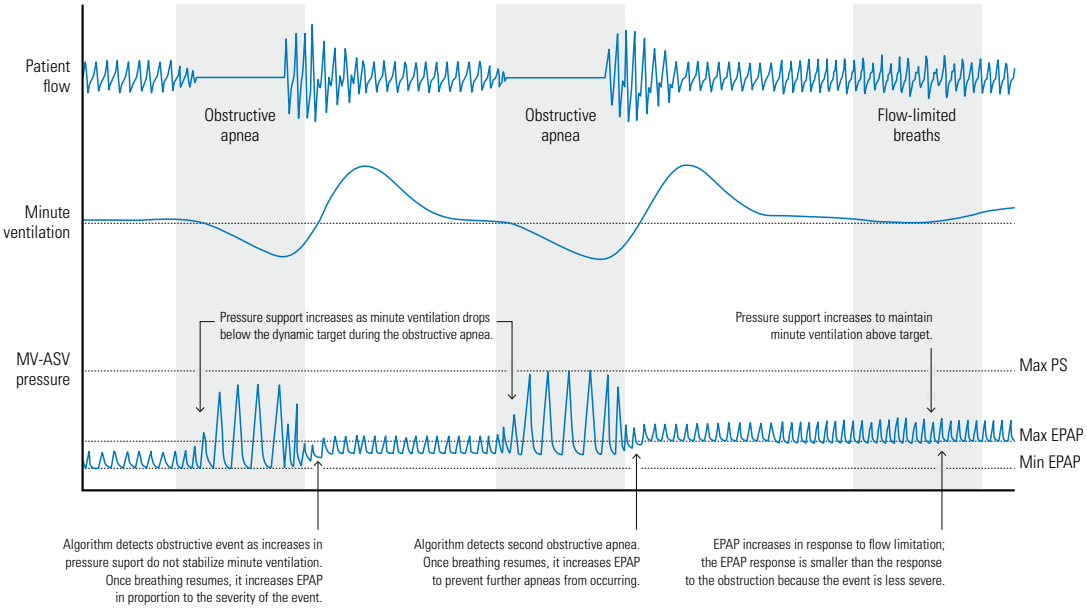
- Constantly monitors the patient's breathing pattern, minute ventilation (MV) and automatically adjusts pressure support (PS) in a defined range (Min PS and Max PS) to maintain target MV.
- Expiratory positive airway pressure (EPAP) is fixed and can be manually adjusted to eliminate obstructive events.



ASVAuto algorithm

How it works

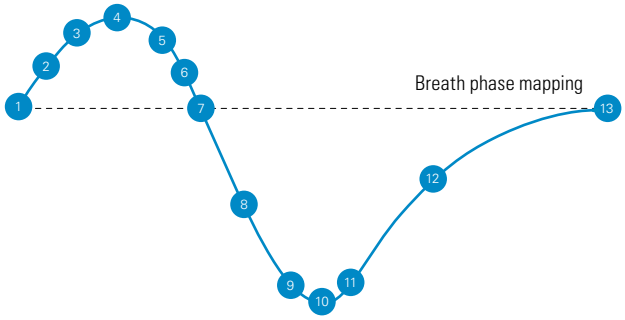
- In addition to ASV mode, ASVAuto automatically adjusts EPAP to provide only the amount of pressure required to maintain upper airway patency, stabilizing the upper airway to treat and help prevent obstructive apneas.
- Analyzes the state of the patient's upper airway on a breath-by-breath basis.
- EPAP is automatically adjusted based on three parameters: inspiratory flow limitation, snore and obstructive apnea.



Auto backup rate

How it works

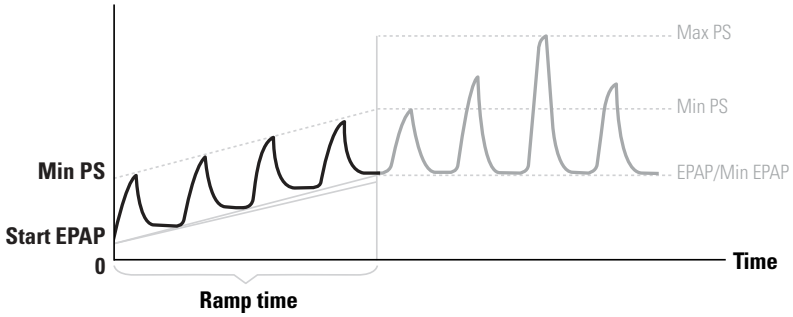
- Uses breath phase mapping to provide a timed backup rate synchronized with the patient's own breathing to maintain the target MV in the case of apneas.
- ASVAuto algorithm tracks 13 points on every breath cycle 50 times per second, designed to use each patient's unique MV target and respiratory rate to deliver therapy that stabilizes ventilation.



Ramp

How it works

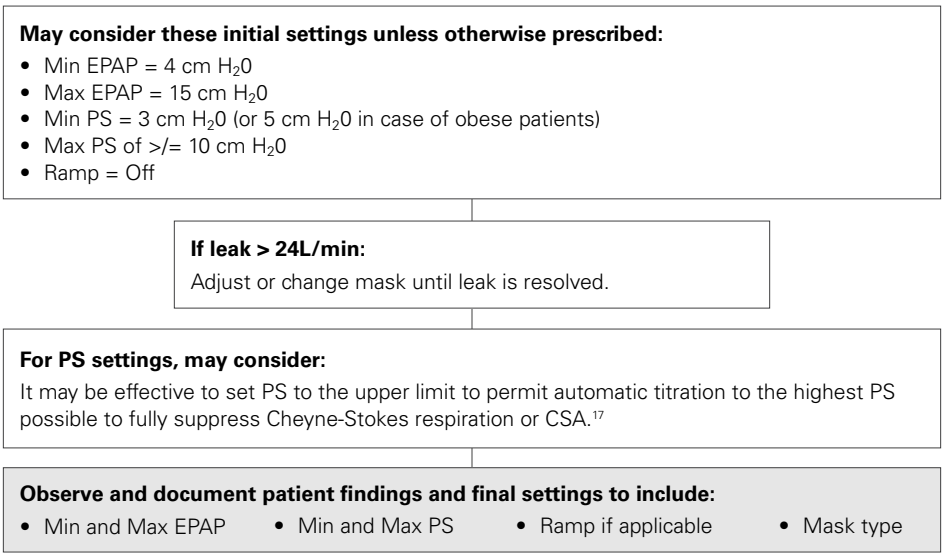
- Ramp time is the period during which EPAP increases linearly from a lower, more comfortable start pressure (Start EPAP) to the minimum treatment pressure (EPAP for ASV and Min EPAP for ASVAuto) before the auto-adjusting algorithm commences.
- During ramp, pressure remains at Min PS.
- After ramp, PS modulates within Min PS and Max PS; in ASVAuto, EPAP also modulates within Min EPAP and Max EPAP.



ASVAuto* titration protocol[9]

As adapted from AASM guidelines & Selim.

For patients weighing more than 66 lb (30 kg)



* ASV therapy is contraindicated in patients with chronic, symptomatic heart failure (NYHA 2-4) with reduced left ventricular ejection fraction (LVEF ≤ 45%) and moderate to severe predominant central sleep apnea.

ASV* titration protocol[9]

As adapted from AASM guidelines & Selim.

For patients weighing more than 66 lb (30 kg)

May consider these initial settings unless otherwise prescribed:

- EPAP= 4 cm H_20 or EPAP derived from PSG to eliminate events
- Min PS = 3 cm H_20 (or 5 cm H_20 in case of obese patients)
- Max PS of >/= 10 cm H_20
- Ramp = Off

If leak > 24L/min:

Adjust or change mask until leak is resolved.

If obstructive events (apneas, hypopneas, snoring or RERAs) are observed may consider:

EPAP may be increased 1 cm H_20 every 20 mins until obstructive events are eliminated.[1]

For PS settings, may consider:

- It may be effective to set PS to the upper limit to permit automatic titration to the highest PS possible to fully suppress Cheyne-Stokes respiration or CSA[17]

Observe and document patient findings and final settings to include:

- EPAP
- Min and Max PS
- Ramp if applicable
- Mask type

* ASV therapy is contraindicated in patients with chronic, symptomatic heart failure (NYHA 2-4) with reduced left ventricular ejection fraction (LVEF ≤ 45%) and moderate to severe predominant central sleep apnea.

Titration and therapy considerations

General

- Ensure the mask is fitted properly[1] and leak is minimized. With ResMed devices, unintentional leak should be <24L/min. Mask refit or adjustment should be performed whenever unintentional leak exceeds the threshold. Additionally, verify the mask setting is the mask type used (e.g., if using a full face mask, make sure to select **Full Face** mask setting).

ASV* applicability

ASV* may not be appropriate for patients with:[9]

- Chronic and profound hypoventilation
- Moderate to severe chronic obstructive pulmonary disorder (COPD)
- Restrictive thoracic or neuromuscular disease

ASV* will likely undertreat these patients; may consider moving them to iVAPS.[9]

* ASV therapy is contraindicated in patients with chronic, symptomatic heart failure (NYHA 2-4) with reduced left ventricular ejection fraction (LVEF ≤ 45%) and moderate to severe predominant central sleep apnea.

Therapy guidelines for respiratory diseases

Spontaneous/Timed (ST)*

Therapy modes may be considered for the treatment of

- Overlap syndrome and obstructive sleep apnea.
- Selected chronic alveolar hypoventilation syndromes in adults and children.[7]
- Chronic alveolar hypoventilation syndromes secondary to restrictive thoracic cage disorders (RTCD), neuromuscular diseases (NMD), and the obesity hypoventilation syndrome (OHS).[7]
- Patients with central hypoventilation, inappropriately low respiratory rate, or those who unreliably trigger to IPAP or cycle to EPAP due to muscle weakness[7]

The technology

ResMed's ST algorithm includes Vsync, rise time, trigger sensitivity, TiControl and cycle sensitivity. See the "synchrony settings" and "comfort features" sections of this handbook for definitions and details on these technologies.

ST mode

How it works

- Allows setting of two treatment pressures—inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP).
- Pressure support (PS) is the difference between IPAP and EPAP levels and may aid in achieving adequate tidal volume.
- Will supply additional breaths should the patient breath rate fall below the set backup rate.

* Please note that this therapy mode is available across a variety of devices that each have their own indications for use.

ST titration protocol

As adapted from AASM guidelines, Berry & Epstein for adult and pediatric patients.

Has patient been on CPAP therapy?

YES

May consider these initial settings unless otherwise prescribed:[7]

- Min EPAP at 4 cm H_20 or the CPAP level at which obstructive apneas were eliminated.
- IPAP = 4 cm H_20 above EPAP.
- Initial rate 1 to 2 bpm < spontaneous respiratory rate > 10 bpm.[7]
- IPAP-EPAP differential recommended range is 4-10 cm H_20.[1]
- Maintain starting pressures ≥ 5 min.

NO

May consider these initial settings unless otherwise prescribed:[7]

- Recommended minimum IPAP is 8 cm H_20.
- Recommended minimum EPAP is 4 cm H_20.
- Initial rate 1 to 2 bpm < spontaneous respiratory rate > 10 bpm.[7]
- IPAP-EPAP differential recommended range is 4-10 cm H_20.[1]
- Maintain starting pressures ≥ 5 min.

If leak > 24L/min:

Adjust or change mask until leak is resolved.

For obstructive apneas, may consider increasing IPAP and EPAP by ≥ 1 cm H_20 every ≥ 5 min:[1]

For patients <12 years:

- If ≥ 1 obstructive event
- Recommended max IPAP 20 cm H_20

For patients ≥12 years:

- If ≥ 2 obstructive events
- Recommended max IPAP 30 cm H_20

For hypopneas, RERAs or snoring, may consider increasing IPAP:

- Every 5 min if tidal volume is low (< 6-8 mL/kg).[7]
- If SpO_2 remains < 90% for ≥ 5 min and tidal volume is low (< 6-8 mL/kg).[7]
- If respiratory muscle rest has not been achieved by noninvasive positive pressure ventilation (NPPV) treatment at the current settings for ≥ 10 min.[7]

For patients <12 years, may consider:[1]

- ≥ 1 hypopnea
- ≥ 3 RERAs
- ≥ 1 min loud or ambiguous snoring

For patients ≥12 years, may consider:[1]

- ≥ 3 hypopneas
- ≥ 5 RERAs
- ≥ 3 min loud or ambiguous snoring

If patient awakens and indicates pressure is too high, may consider:

- A lower pressure to allow return to sleep; then resume titration.[1]

May consider an exploration of IPAP above the pressure that controlled respiratory events but should not exceed 5 cm H_20 or recommended max IPAP per age group.[1]

For backup rate and respiratory rate, may consider:[7]

- Increasing backup rate in 1–2 bmp increments every 10 min if desired backup rate has not been attained.
- Decreasing backup rate if the patient reports discomfort thought to be related to a high respiratory rate or if NPPV device-triggered and patient-triggered breaths are frequently superimposed (stacking of breaths).

Are events central?

YES

For central events, may consider:[1]

- Decreasing to previous settings for 20 min.
- Adaptive servo-ventilation (ASV)* may be considered if the patient is observed to have Cheyne-Stokes respiration or if treatment-emergent central sleep apnea (TECSA or "complex sleep apnea") during titration is not eliminated by down titration of pressure.

If central events persist, may consider:

- ASV* or iVAPs based on patient's underlying diseases.[7]
- If the patient presents with nocturnal hypoventilation and central sleep apnea, consider switching to iVAPS.[5]

NO

For SpO_2 <90% with all respiratory events eliminated, may consider:

- Adding O_2 if adequate tidal volume and respiratory rate have been optimized but SpO_2 remains <90% for ≥ 5 min.[7]
- Follow sleep lab protocols for adding O_2.
- Minimum starting O_2 rate 1 L/min in adult and pediatric patients.[7]
- O_2 rate may be increased in increments of 1 L/min every 5 min until SpO_2 >90%.[7]

Observe and document patient findings and final settings to include:

- IPAP and EPAP pressures
- Tidal volume
- Backup rate
- Synchrony settings
- Mask type

* ASV therapy is contraindicated in patients with chronic, symptomatic heart failure (NYHA 2-4) with reduced left ventricular ejection fraction (LVEF ≤ 45%) and moderate to severe predominant central sleep apnea.

Titration and therapy considerations

General

- Ensure the mask is fitted properly[1] and leak is minimized. With ResMed devices, unintentional leak should be <24L/min. Mask refit or adjustment should be performed whenever unintentional leak exceeds the threshold. Additionally, verify the mask setting is the mask type used (e.g., if using a full face mask, make sure to select **Full Face** mask setting).
- A higher starting IPAP and EPAP may be considered for patients with an elevated BMI and/or for re-titration studies.[1]

Synchrony settings and comfort features

May consider an adjustment if:

- Patient complains of pressure discomfort.
- Chest wall movement is not in sync with mask pressure tracing.
- Inspiratory efforts do not trigger the device.

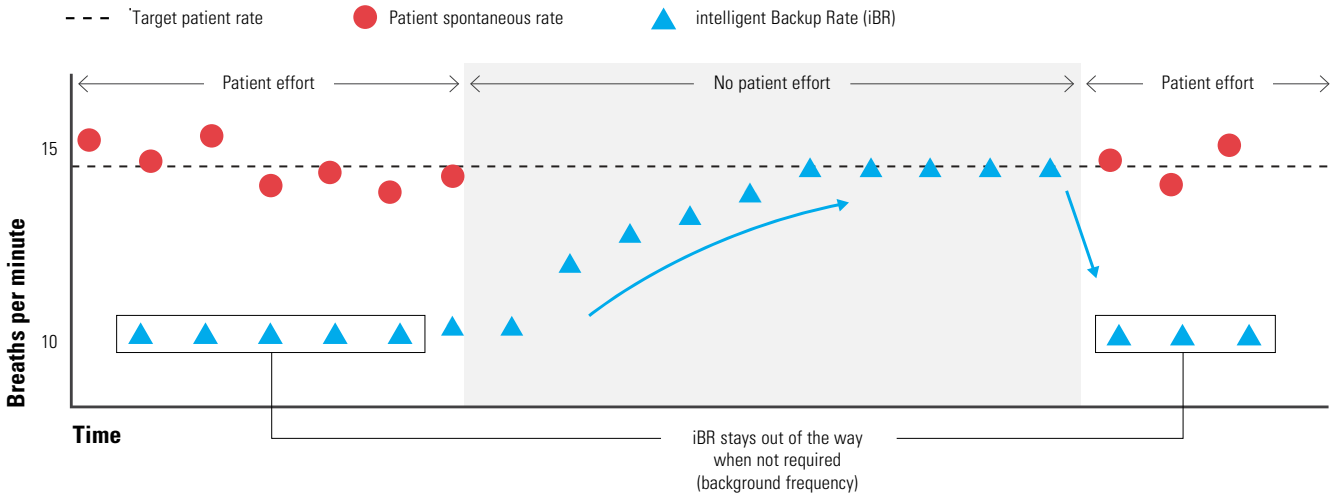
See the "synchrony settings" and "comfort features" sections of this handbook for more information.

Backup rate (BR)

- BR is the set minimal breaths (timed rate) per minute.[7]
- If ideal BR cannot be determined, may consider switching to iBR (Only available in certain devices).

intelligent Backup Rate (iBR)

- iBR maximizes the patient's opportunity to spontaneously breathe before bringing the patient back to target if backup breaths are required.
- iBR is set by entering the patient's stable resting respiratory rate; if patient spontaneous rate drops to 2/3 of the set target respiratory rate, iBR will return patient to the target rate.
- A single spontaneous triggered breath resets the iBR to its background rate.



iVAPS

For ventilatory insufficiency or obstructive sleep apnea for patients weighing more than 66 lb (30 kg).

Ventilatory insufficiency may include the following chronic hypoventilation syndromes:

- Obesity hypoventilation syndrome (OHS) is defined as a combination of obesity (body mass index ≥30 kg·m−2), daytime hypercapnia (arterial carbon dioxide tension ≥45 mmHg) and sleep disordered breathing.[21]
- Chronic obstructive pulmonary disease (COPD): Two main COPD conditions are chronic bronchitis and emphysema.[17]
- Restrictive thoracic or neuromuscular disease (NMD): Chronic progressive NMD and forced vital capacity (FVC) <50% of predicted or maximum inspiratory pressure (MIP) less than 60 cm H_20.[7]

Restrictive thoracic may include the following:

- Kyphosis[22]
- Scoliosis[22]
- Diaphragmatic paralysis[23]
- Sclerosis[22]
- Pulmonary fibrosis/interstitial lung disease[22]

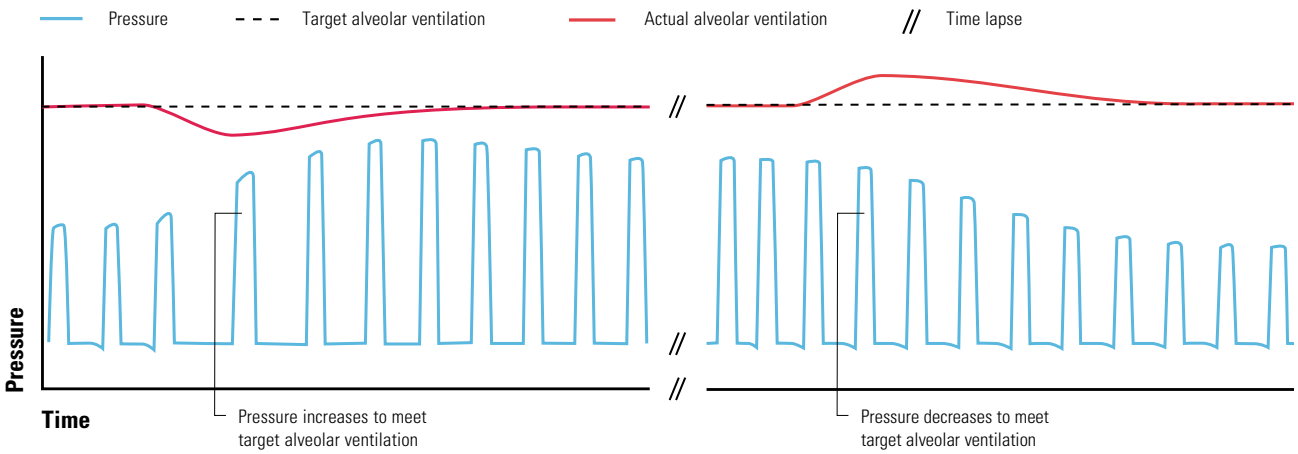
The technology

ResMed's iVAPS algorithm includes Vsync, rise time, trigger sensitivity, TiControl and cycle sensitivity. See the "synchrony settings" and "comfort features" sections of this handbook for definitions and details on these technologies.

iVAPS

How it works

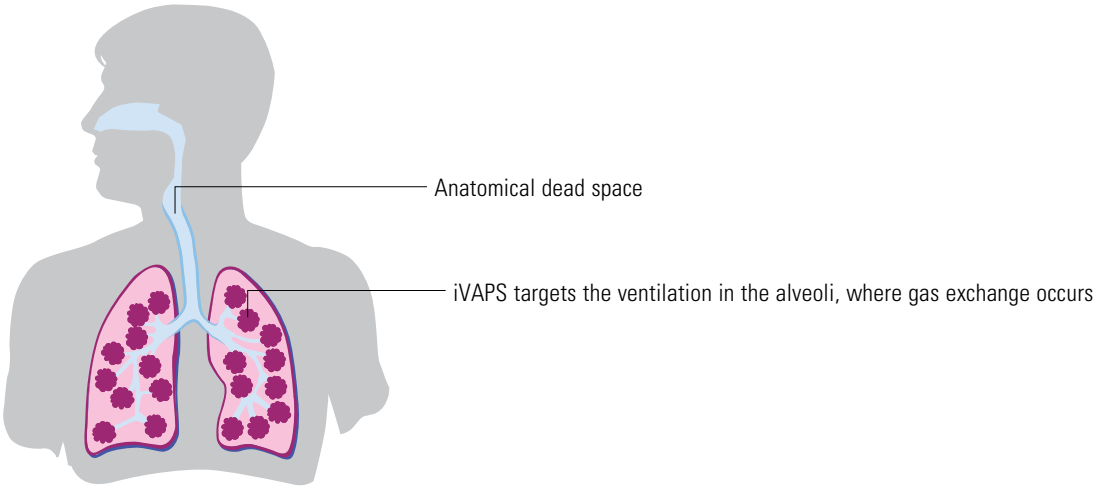
- Maintains a preset target alveolar minute ventilation by monitoring delivered ventilation, adjusting pressure support (PS) and automatically providing intelligent backup breath.

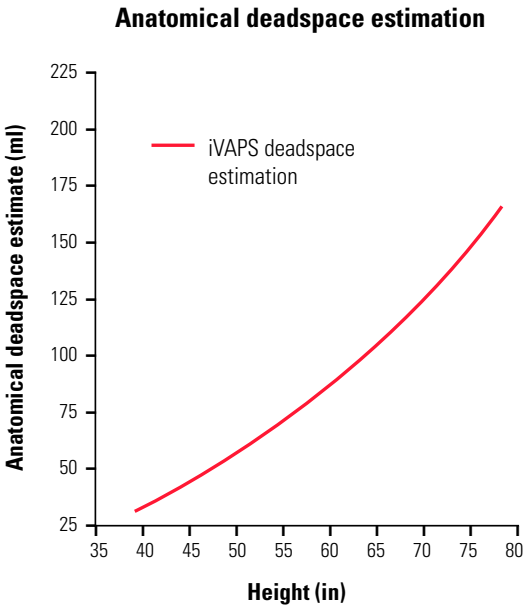


Target alveolar ventilation

How it works

- iVAPS targets alveolar ventilation where gas exchange occurs.
- Alveolar ventilation cannot be measured directly, so iVAPS estimates it using a height-approximated value of anatomical deadspace (Va=(Vt-Vd) x RR). Default Va = 5.2 L/min.[9]

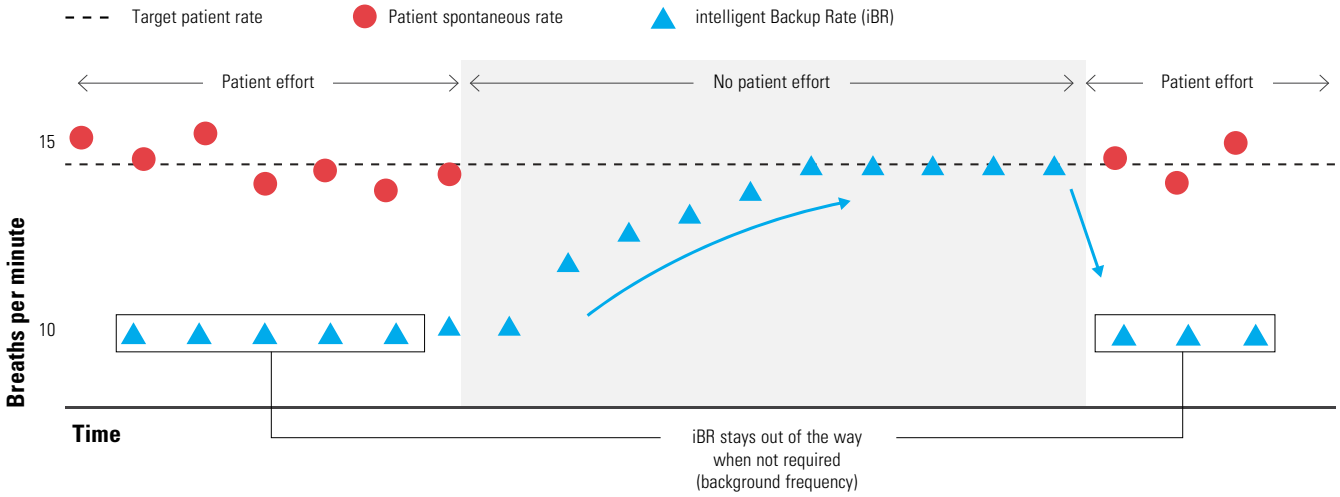




intelligent Backup Rate (iBR)

How it works

- iBR maximizes the patient's opportunity to spontaneously breathe before bringing the patient back to target if backup breaths are required.
- iBR is set by entering the patient's stable resting respiratory rate; if patient spontaneous rate drops to 2/3 of the set target respiratory rate, iBR will return patient to the target rate.
- A single spontaneous triggered breath resets the iBR to its background rate.



Auto EPAP

How it works

- Automatically adjusts EPAP to provide only the amount of pressure required to maintain upper airway patency, stabilizing the upper airway to treat and help prevent obstructive apneas.
- Analyzes the state of the patient's upper airway on a breath-by-breath basis.
- Automatically adjusts EPAP based on three parameters: inspiratory flow limitation, snore and obstructive apnea.

iVAPS titration protocol

As adapted from AASM guidelines & Berry for adult and pediatric patients.

May consider these initial settings unless otherwise prescribed:[7]

- Patient height in inches
- Target patient rate = patient's spontaneous resting respiratory rate (ideally ≥ 15 bpm); iBR activates at 2/3 of the set target respiratory rate
- Set target Va = 6-8 mL/kg IBW
- EPAP = 4 cm H_20
- Min PS = 4 cm H_20
- Max PS = 20 cm H_20

Evaluate and titrate:

- Compare target patient rate, target Va, Vt, SpO_2 and CO_2 to baseline.
- Record airflow, tidal volume, leak and delivered pressure signals.

If leak > 24L/min:

Adjust or change mask until leak is resolved.

For obstructive apneas, may consider increasing IPAP and EPAP by ≥ 1 cm H_20 every ≥ 5 min:[1]

For patients <12 years:

- ≥ 1 obstructive event

For patients ≥12 years:

- ≥ 2 obstructive events

For hypopneas, RERAs or snoring, may consider:

- Increasing Min PS:[7]

For patients <12 years:[1]

- ≥ 1 hypopnea
- ≥ 3 RERAs
- ≥ 1 min loud or ambiguous snoring

For patients ≥12 years:[1]

- ≥ 3 hypopneas
- ≥ 5 RERAs
- ≥ 3 min loud or ambiguous snoring

If SpO_2 < 90% and tidal volume is low (<6ml/kg) with all respiratory events eliminated, may consider:[7]
Is the patient achieving target Va?

YES

- May consider increase target Va by 0.3 ≥ 5 min until desaturations are resolved.

NO

- Ensure Max PS is not restricting tidal volume.
- If EPAP + Max PS is < 30 cm H_20, may consider increasing Max PS to achieve total pressure of 30 cm H_20.

- If respiratory muscle rest/respiratory rate (<25 bpm) has not been achieved at the current settings for ≥ 10 min, may increase min PS 1-2 cm H_20 ≥ 5 min.

If events persist, may consider referencing synchrony settings and titration considerations.

For SpO_2 <90% with all respiratory events eliminated, may consider:[7]

- Adding O_2 if adequate tidal volume and respiratory rate have been optimized but SpO_2 remains <90% for ≥ 5 min.
- Follow sleep lab protocols for adding O_2.
- Minimum starting O_2 rate 1 L/min in adult and pediatric patients.
- Increasing O_2 in increments of 1 L/min every 5 min until SpO_2 >90%.

For target patient rate, may consider:[7]

- Increasing by 1-2 bmp increments every 10 min if desired goal of backup rate has not been attained.

Observe and document patient findings and final settings to include:

- EPAP, Min and Max pressures
- Target patient rate and target Va
- Patient tidal volume, Va, and respiratory rate
- Synchrony settings
- Mask type

Titration and therapy considerations

General

- Ensure the mask is fitted properly[1] and leak is minimized. With ResMed devices, unintentional leak should be <24L/min. Mask refit or adjustment should be performed whenever unintentional leak exceeds the threshold. Additionally, verify the mask setting is the mask type used (e.g., if using a full face mask, make sure to select **Full Face** mask setting).
- A higher starting IPAP and EPAP may be considered for patients with an elevated BMI and/or for re-titration studies.[1]

Synchrony settings and comfort features

- May consider an adjustment if:
  - Patient complains of pressure discomfort.
  - Chest wall movement is not in sync with mask pressure tracing.
  - Inspiratory efforts do not trigger the device.
- If PS is maxed and tidal volume is low, consider increasing Ti Min.

See the "synchrony settings" and "comfort features" sections of this handbook for more information.

Carbon dioxide monitoring[7]

- In studies with monitored transcutaneous carbon dioxide ($tcPCO_2$) with diaphragm and sternocleidomastoid electromyograms using surface electrodes, adequate ventilatory support during sleep is defined as a 50% reduction in electromyogram activity with an accompanying increase in oxyhemoglobin saturation and decrease in $tcPCO_2$.
- $tcPCO_2$ can be monitored for noninvasive positive pressure ventilation (NPPV) titration.
- End-tidal PCO_2 ($PetCO_2$) monitoring may be useful during NPPV titration.

Respiratory diseases

Respiratory diseases

Obstructive lung disease (COPD, chronic bronchitis and emphysema)[18]

- The two main COPD conditions are chronic bronchitis and emphysema. These diseases affect different parts of the lungs and can lead to difficulty breathing.
- Characterized by progressive airflow limitation that is not fully reversible, associated with an abnormal inflammatory response of the lungs to noxious particles or gases.
- Impact to ventilation:[10]
  - Patients may favor a longer expiration time or I:E ratio of 1:3, 1:4, 1:5 to optimize CO_2 exhalation
  - Increased work of breathing (WOB)
  - Increased auto-positive end-expiratory pressure (auto-PEEP)
- May consider these recommended synchrony settings:[7, 9,10]
  - Trigger sensitivity: Medium
  - Rise time (ms): 150
  - Ti Min (sec): 0.3
  - Ti Max (sec): 1.0
  - Cycle sensitivity: High

Obesity hypoventilation syndrome (OHS)[7,19]

- Obesity hypoventilation syndrome (OHS) is defined as a combination of obesity (body mass index ≥30 kg·m−2), daytime hypercapnia (arterial carbon dioxide tension ≥45 mmHg) and sleep disordered breathing.[21]
- Due to the restrictive disorder, hypoventilation is worse during rapid eye movement (REM) sleep compared to non-REM sleep.
- Impact to ventilation:[13]
  - Decreased capacity/weak respiratory muscles, decreased lung compliance, and abnormal respiratory mechanics
  - Increased WOB
  - Increased oxygen demand
  - Impaired central responses to hypercapnia and hypoxia
  - Upper airway obstruction
- May consider these recommended synchrony settings:[7, 9,10]
  - Trigger sensitivity: Medium
  - Rise time (ms): 300
  - Ti Min (sec): 0.8
  - Ti Max (sec): 1.5
  - Cycle sensitivity: Medium

Restrictive lung disease (neuromuscular, chest wall abnormality)[14]

- Neuromuscular disorders can produce significant respiratory complications including the following:
  - Respiratory and bulbar muscle weakness can produce ineffective cough.
  - Swallowing dysfunction can produce aspiration-related lung disease.
  - Abnormal muscle tone can produce chest wall deformities.

  All of this can ultimately lead to repeated chest infections and chronic respiratory failure.
- Impact to ventilation:[14]
  - Patients may favor a shorter expiration time or I:E ratio of 1:1 or 1:2 to optimize alveolar recruitment and oxygenation
  - Increased chest wall stiffness
  - Global respiratory muscle weakness and decreased ventilation capacity leading to hypoventilation and central apnea
  - Increased WOB
  - Decreased SpO_2
- May consider these recommended synchrony settings:[7, 9,10]
  - Trigger sensitivity: High
  - Rise time (ms): 300
  - Ti Min (sec): 0.8
  - Ti Max (sec): 1.5
  - Cycle sensitivity: Low

Synchrony settings

Synchrony settings

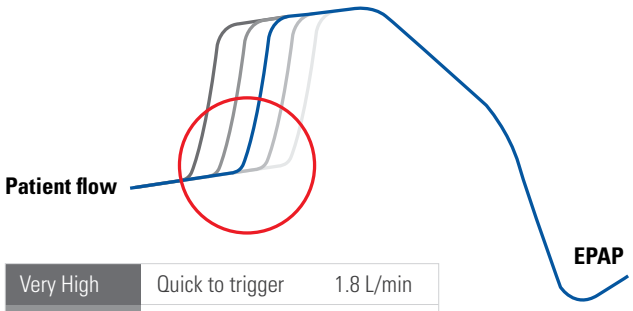
The settings listed below may be clinically adjusted to achieve patient comfort and assist with asynchrony issues.
Default Synchrony Settings (Only available in certain devices):

- Trigger sensitivity: Medium
- Rise time (ms): 300
- Ti Min (sec): 0.3
- Ti Max (sec): 2.0
- Cycle sensitivity: Medium

Trigger sensitivity[7]

- Trigger settings can be adjusted to help the device better recognize patients with decreased inspiratory efforts.
- The **Medium** setting is the default.
- The **Low** or **Very Low** (less sensitive) settings may be considered for:
  - Cardiogenic oscillations and subsequent auto-triggering.
  - Any time the patient reports that breaths are starting before inhaling; decreasing trigger sensitivity can assist the patient in transitioning from EPAP to IPAP.
- The **High** or **Very High** (more sensitive) settings may be considered:
  - For patients with very weak respiratory effort, such as those with neuromuscular diseases.
  - Any time the patient reports of not being able to initiate a breath; increasing trigger sensitivity can assist the patient in transitioning from EPAP to IPAP with greater ease.

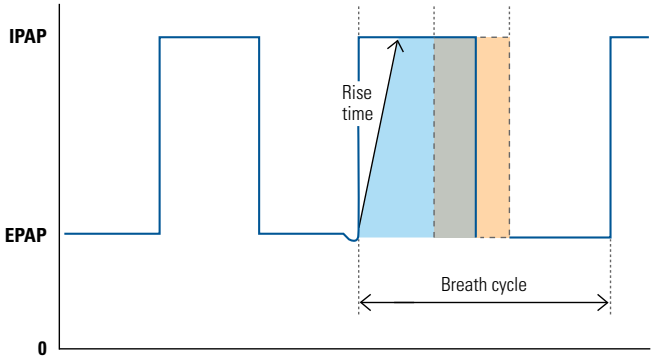
5 trigger sensitivity levels: minimum flow required to initiate IPAP (flow L/min)



Very High	Quick to trigger	1.8 L/min
High	Sensitive	3.3 L/min
Medium	Default	4.8 L/min
Low	Less sensitive	8.1 L/min
Very Low	Slow to trigger	13.2 L/min

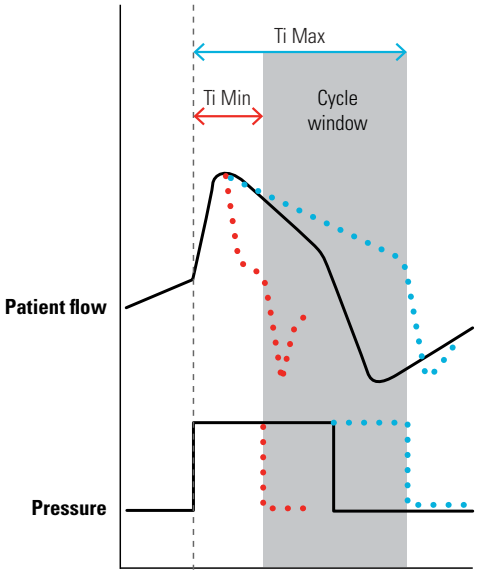
Rise time[7]

- Sets the time required to go from EPAP to IPAP (pressure support).
- The smaller the rise time value, the faster the IPAP (PS) delivery and the faster the flow.
- The greater the rise time value, the longer it takes for pressure to increase from EPAP to IPAP and the slower the flow.
- A slower rise time (flow) may assist with mask leak, gastric insufflation and feelings of pressure intolerance.



TiControl[7]

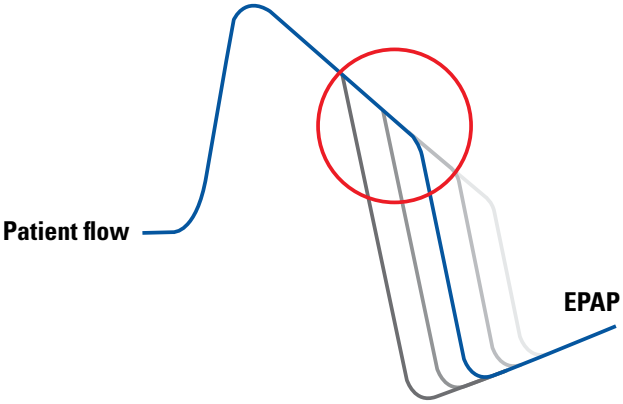
- Allows for management of the time a patient spends in the inspiratory phase of their breath cycle.
- Ti Min and Ti Max parameters limit or prolong inspiratory time, providing a "window of opportunity" to maximize synchronization.
- Adjusting Ti Min properly may aid in providing adequate time for gas exchange without having to increase the pressure setting.
- A shorter inspiratory time may be useful for patients with concurrent obstructive airway disease, especially at higher respiratory rates, to allow adequate time for exhalation.
- A longer inspiratory time may be useful for patients with restrictive disease such as decreased respiratory system compliance.



Cycle sensitivity[7]

- Cycle sensitivity settings determine transition to exhalation.
- The device must be able to identify a decrease in flow to know when to switch pressure from IPAP to EPAP as the patient attempts to exhale.
- The **Medium** setting is the default.
- The **Low** or **Very Low** (less sensitive) settings may be considered:
  - When a longer inspiratory time is desired, such as for patients with very weak respiratory effort
  - If a restrictive disorder patient complains of early cycling (cutting off breath) decreasing cycl sensitivity may help the patient transition from IPAP to EPAP.
- The **High** or **Very High** (more sensitive) settings ma be considered:
  - When a shorter inspiratory time is desired to allow for an adequate expiratory time; may be beneficial with COPD patients.
  - Any time the patient reports that breaths are too long, or they find it difficult to get the machine to cycle from IPAP to EPAP.

Adjustable cycle settings from 5% to 90% (% of peak inspiratory flow)



Very High	Quick to cycle	50% of peak flow
High	Sensitive	35%
Medium	Default	25%
Low	Less sensitive	15%
Very Low	Slow to cycle	8%

Comfort features

Comfort features

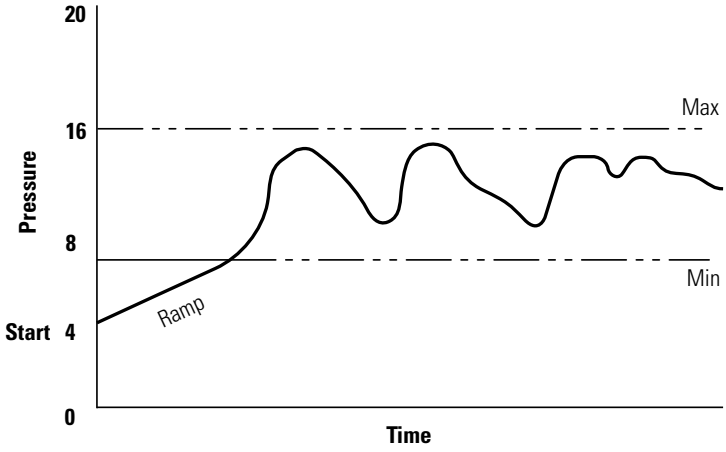
Easy-Breathe waveform[4]

- Delivers a smooth waveform that intelligently recreates a patient's individual breathing pattern, so breathing feels more natural and provides enhanced comfort with smoother, more natural pressure delivery.
- When Easy-Breathe waveform is activated, rise time cannot be adjusted.

Ramp

How it works

- Begins with lower pressure, gradually increasing to the minimum treatment pressure.



Vsync

- Allows the device to estimate the patient respiratory flow in the presence of unintentional leak.
- Using the respiratory flow signal, the device is able to trigger and cycle closely with the patient's effort.

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