



Therapy Handbook

Understanding therapy modes
to support patient outcomes



Table of Contents		Respiratory diseases	44
Guidelines for effective titration and therapy		1	
Therapy guidelines for obstructive sleep apnea (OSA)		2	
CPAP/APAP		4	
The technology: how it works		4	
Titration protocol		7	
Titration and therapy considerations		11	
Therapy guidelines for OSA (noncompliant)		12	
S/VAuto		14	
The technology: how it works		14	
Titration protocol		17	
Titration and therapy considerations		21	
Therapy guidelines for central sleep apnea (CSA)		22	
ASV/ASVAuto		24	
The technology: how it works		24	
Titration protocol		27	
Titration and therapy considerations		31	
Therapy guidelines for respiratory diseases		32	
Spontaneous/Timed (ST)		34	
The technology: how it works		34	
Titration protocol		35	
Titration and therapy considerations		37	
iVAPS		38	
The technology: how it works		38	
Titration protocol		41	
Titration and therapy considerations		43	
Obstructive lung disease		46	
Obesity hypoventilation syndrome		46	
Restrictive lung disease		47	
Normal lung		47	
Synchrony settings		48	
Trigger sensitivity		50	
Rise time		50	
TiControl		51	
Cycle sensitivity		51	
Comfort features		52	
Easy-Breathe waveform		54	
Ramp		54	
Vsync		54	

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

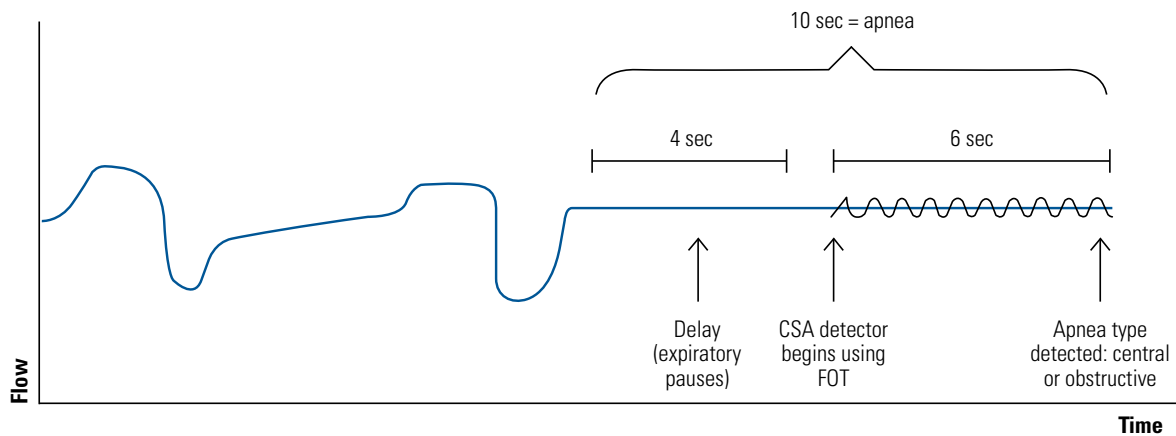
Therapy modes considered for the treatment of obstructive sleep apnea (OSA).

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

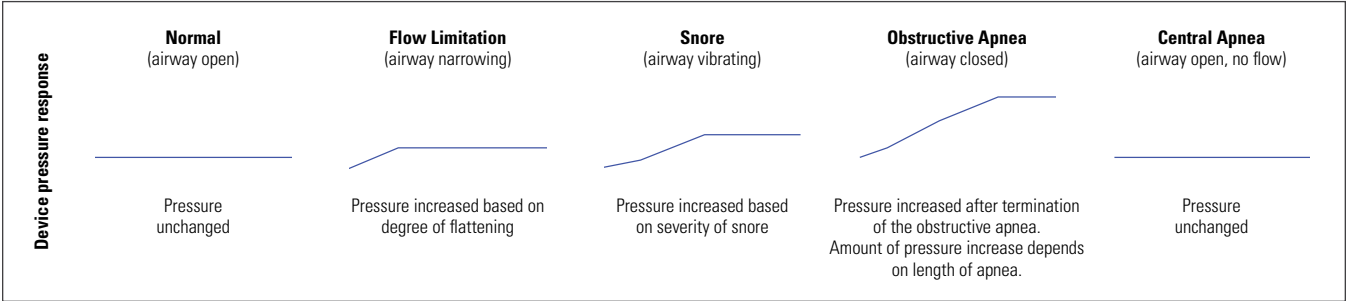
- Four seconds into an apnea, small oscillations in pressure are added to current device pressure.
- Central sleep apnea (CSA) detection algorithm uses the resulting flow and pressure (determined at the mask) to measure whether the airway is open or closed.
- If pressure oscillations are detected back 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

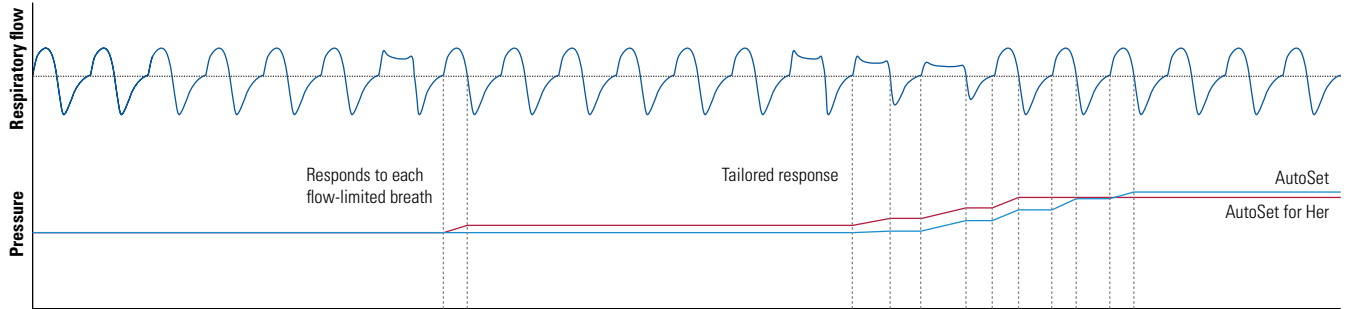
- Adjusts treatment pressure as a function of three parameters: flow limitation, snoring and obstructive apnea.
- Recognizes multiple shapes of flow limitation.



AutoSet for Her algorithm²

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 H₂O.



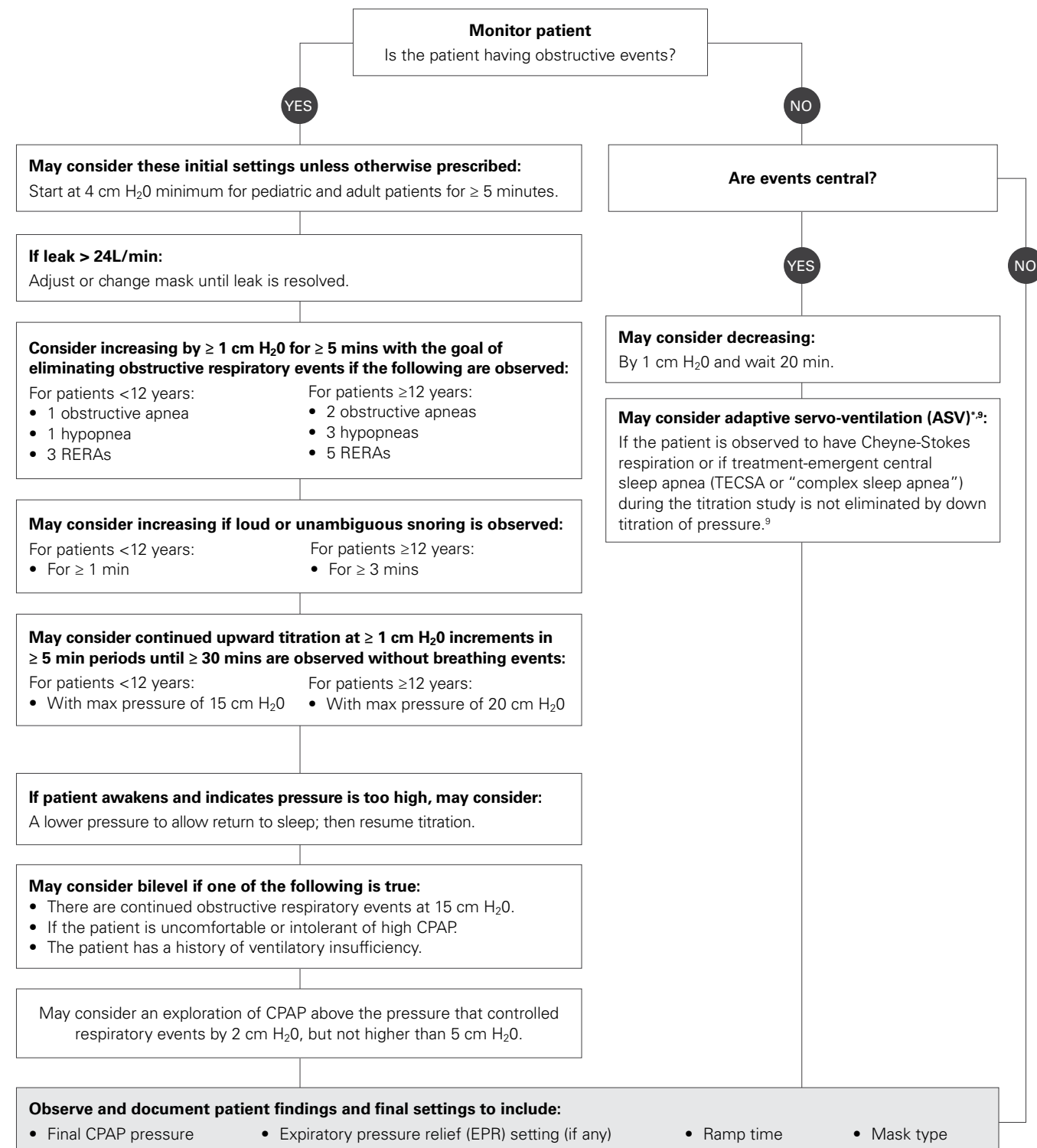
Expiratory pressure relief (EPR)⁴

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 H₂O (will not drop below 4 cm H₂O).

CPAP titration protocol¹

As adapted from AASM guidelines for adult and pediatric patients.



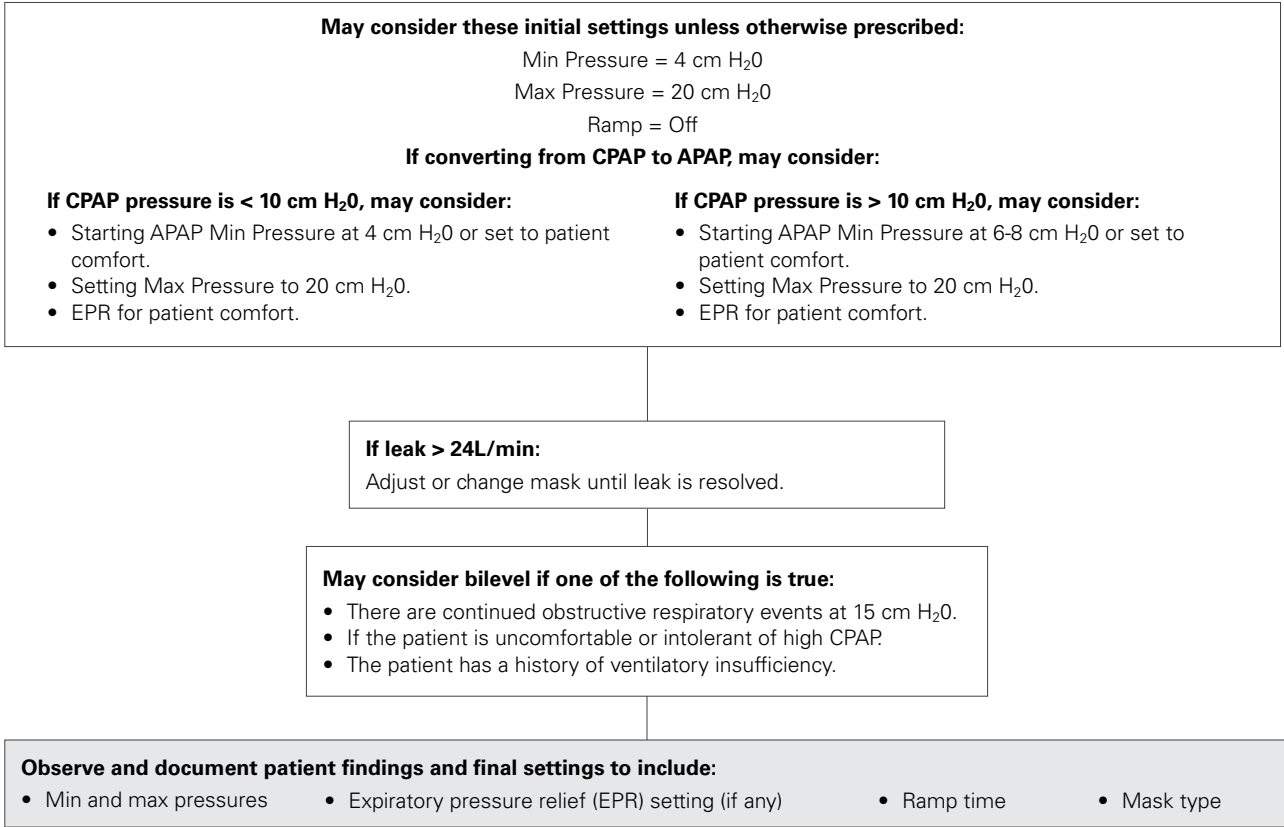
Notes

[illegible]

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

APAP and APAP for Her titration protocol¹

As adapted from the AASM guidelines.



Notes

[illegible]

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 properly¹ 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 H₂O, 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 O₂¹

- Supplemental O₂ may be considered during the PAP titration when, prior to the PAP titration, the patient's awake supine SpO₂ while breathing room air is ≤88%.
- Supplemental O₂ may be considered during the PAP titration when SpO₂ is ≤88% for ≥5 minutes in the absence of obstructive respiratory events.
- In both instances, supplemental O₂ may be introduced at 1 L/min ≥15 minutes and titrated upwards to achieve a target SpO₂ between 88% and 94%.

Indications of pressure intolerance⁶

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

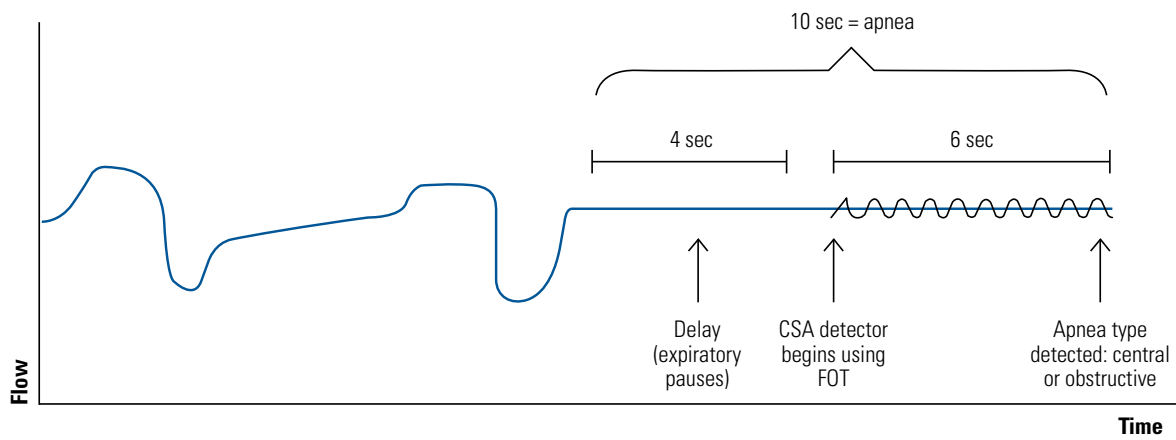
Therapy modes considered for the treatment of obstructive sleep apnea (OSA) and to help those struggling to adhere to PAP therapy (i.e., noncompliant patients).

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

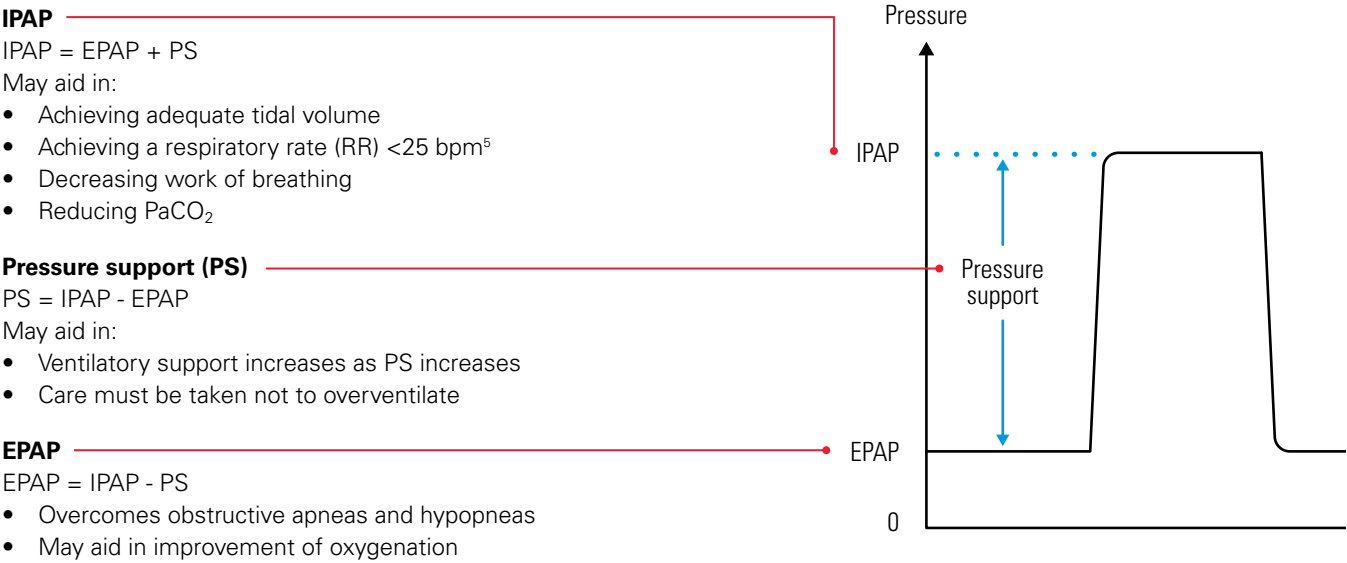
- Four seconds into an apnea, small oscillations in pressure are added to current device pressure.
- Central sleep apnea (CSA) detection algorithm uses the resulting flow and pressure (determined at the mask) to measure whether the airway is open or closed.
- If there is little or no flow at the mask,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

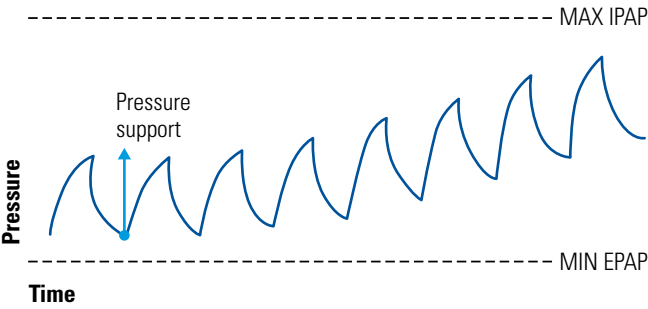
- Allows setting of two treatment pressures—inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP). This is often referred to as bilevel positive airway pressure (BPAP).
- Pressure support (PS) is the difference between IPAP and EPAP levels and may aid in achieving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



VAuto algorithm

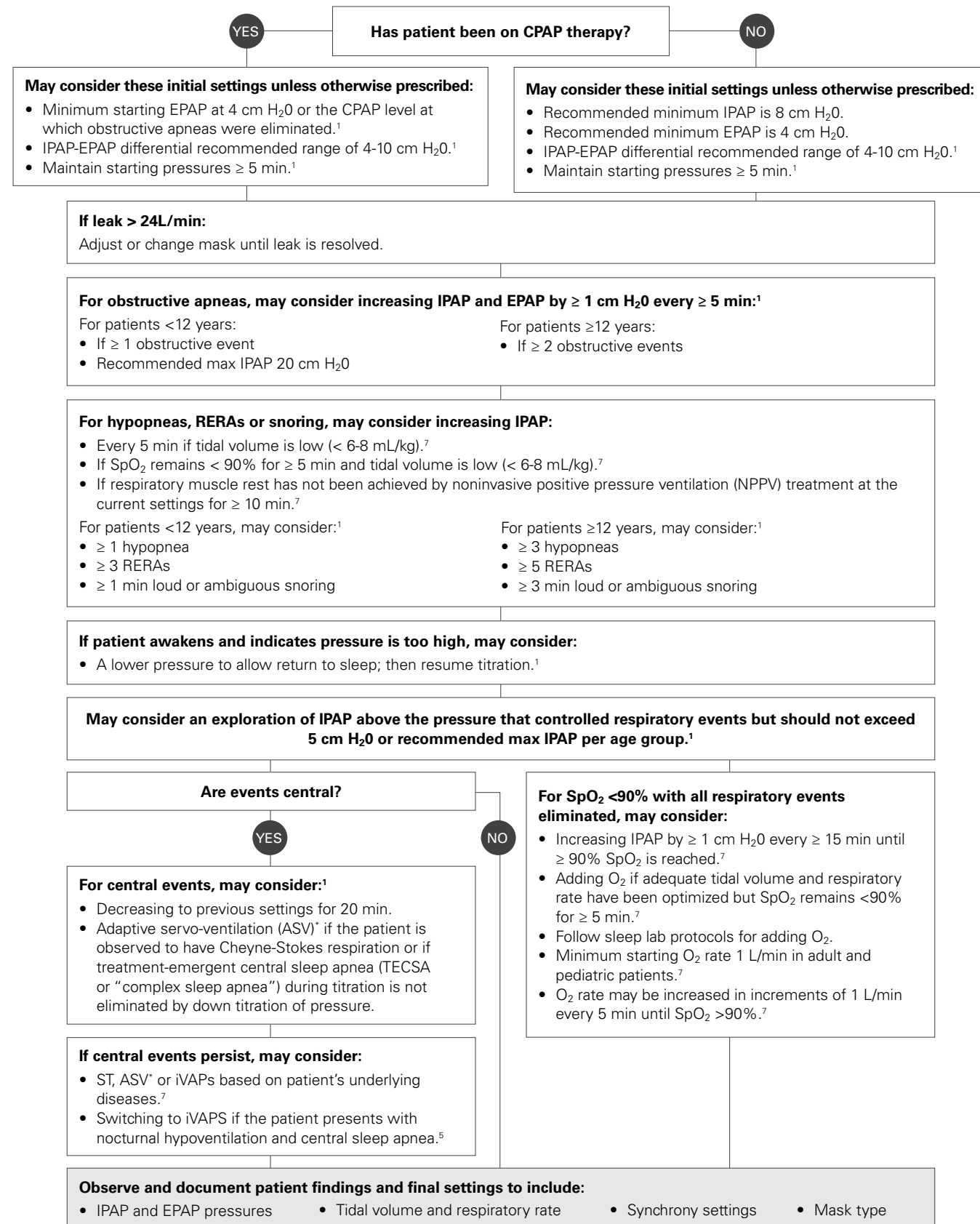
How it works

- 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.



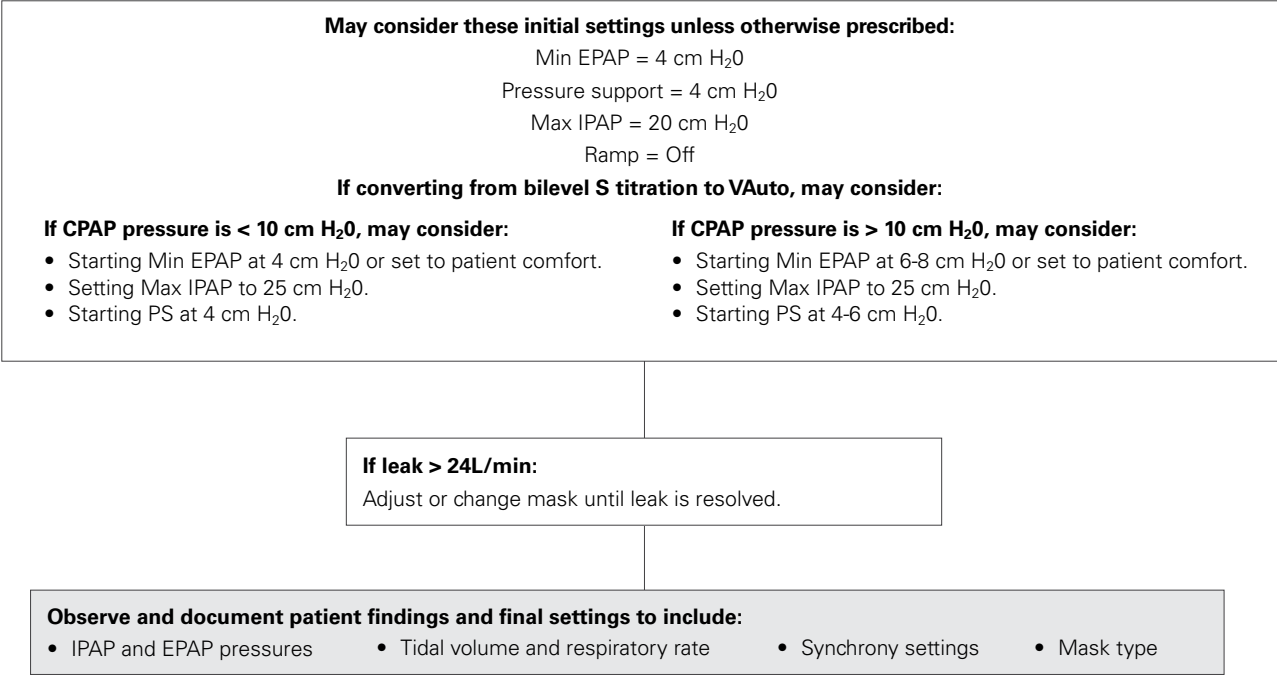
* ASV therapy is contraindicated in patients with chronic, symptomatic heart failure (NYHA 2-4) with reduced left ventricular ejection fraction (LVEF $\leq 45\%$) and moderate to severe predominant central sleep apnea.

Notes

[illegible]

VAuto titration protocol¹

As adapted from AASM guidelines.



Notes

[illegible]

Titration and therapy considerations

General

- Ensure the mask is fitted properly¹ 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 H₂O with EPR of 3, start EPAP at 7 cm H₂O).

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

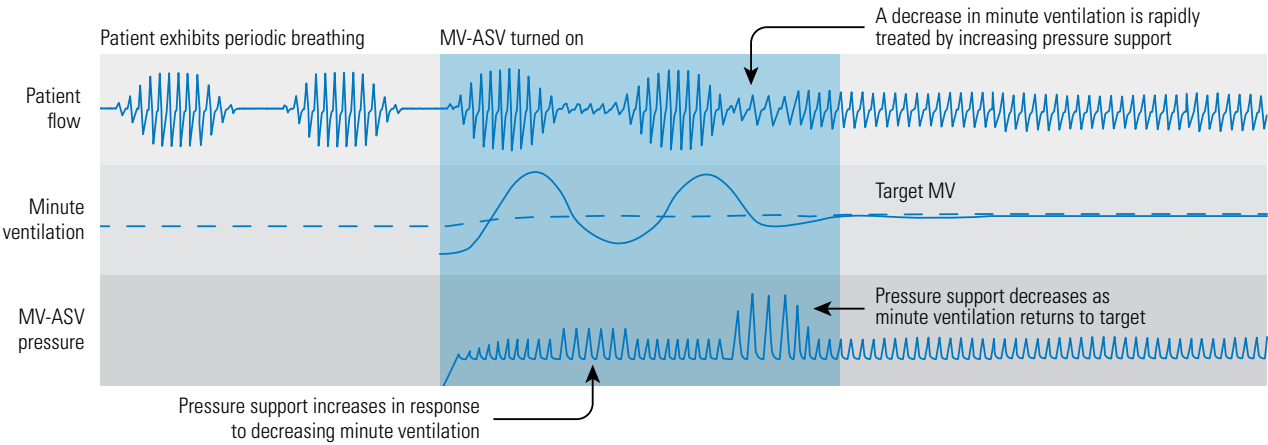
The technology

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

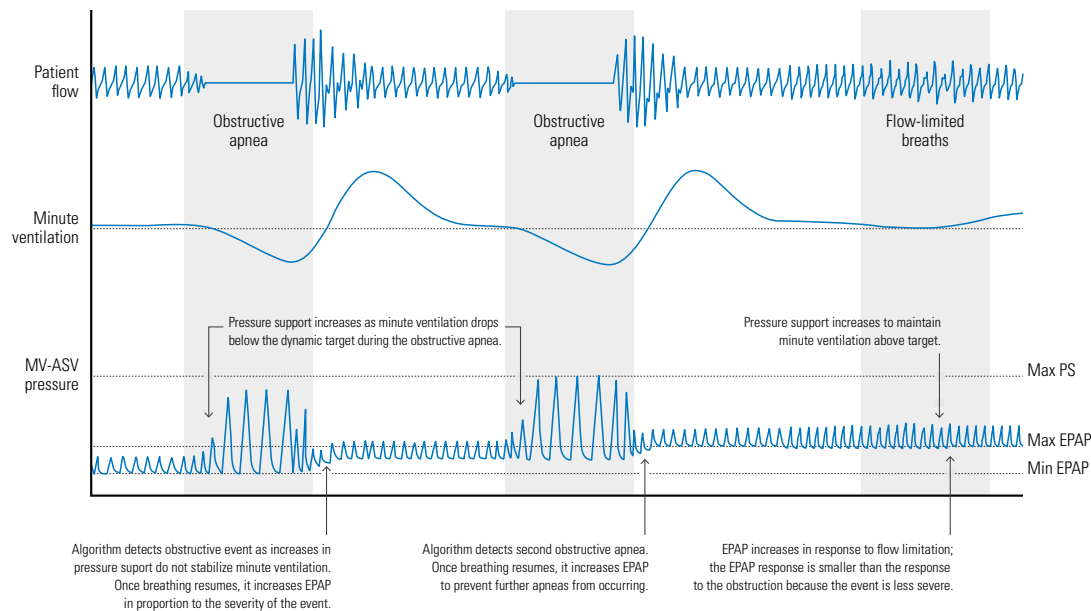
- Constantly monitors the patient’s breathing pattern, minute ventilation (MV) and automatically adjusts pressure support (PS) in a defined range (Min PS and Max PS) to maintain target MV.
- Expiratory positive airway pressure (EPAP) is fixed and can be manually adjusted to eliminate obstructive events.



ASVAuto algorithm

How it works

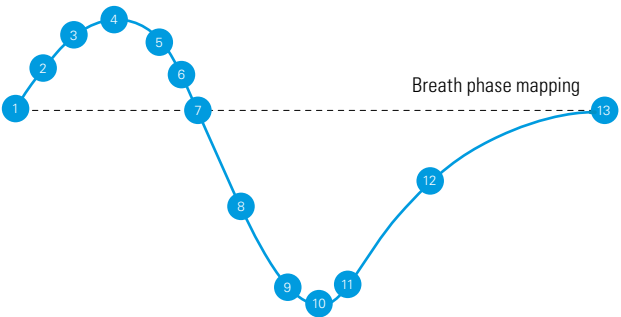
- In addition to ASV mode, ASVAuto automatically adjusts EPAP to provide only the amount of pressure required to maintain upper airway patency, stabilizing the upper airway to treat and help prevent obstructive apneas.
- Analyzes the state of the patient’s upper airway on a breath-by-breath basis.
-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



Auto backup rate

How it works

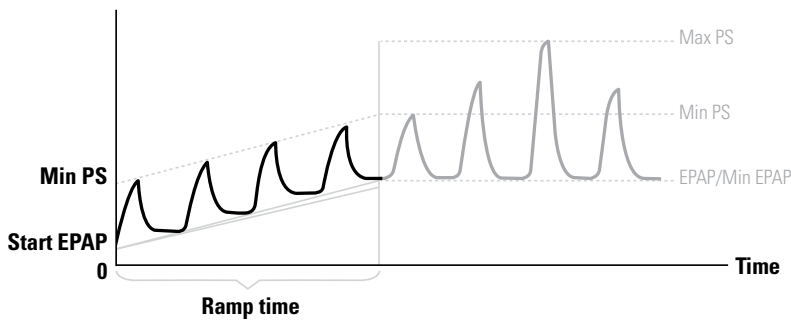
- Uses breath phase mapping to provide a timed backup rate synchronized with the patient’s own breathing to maintain the target MV in the case of apneas.
- ASVAuto algorithm tracks 13 points on every breath cycle 50 times per second, designed to use each patient’s unique MV target and respiratory rate 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 protocol⁹

As adapted from AASM guidelines & Selim

For patients weighing more than 66 lb (30 kg)

May consider these initial settings unless otherwise prescribed:

- Min EPAP = 4 cm H₂O
- Max EPAP = 15 cm H₂O
- Min PS = 3 cm H₂O (or 5 cm H₂O in case of obese patients)
- Max PS of $\geq$ 10 cm H₂O
- Ramp = Off

If leak > 24L/min:

Adjust or change mask until leak is resolved.

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:

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

Notes

[illegible]

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

ASV* titration protocol⁹

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 H₂O or EPAP derived from PSG to eliminate events
- Min PS = 3 cm H₂O (or 5 cm H₂O in case of obese patients)
- Max PS of ≥ 10 cm H₂O
- 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 H₂O 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 CSA¹⁷

Observe and document patient findings and final settings to include:

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

Notes

This image shows a full page of blank, lined paper. It features approximately 20 evenly spaced horizontal grey lines across its entire width, providing a guide for handwriting or typing. The background is a clean, solid white color.

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

Titration and therapy considerations

General

- Ensure the mask is fitted properly¹ 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 weakness⁷

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

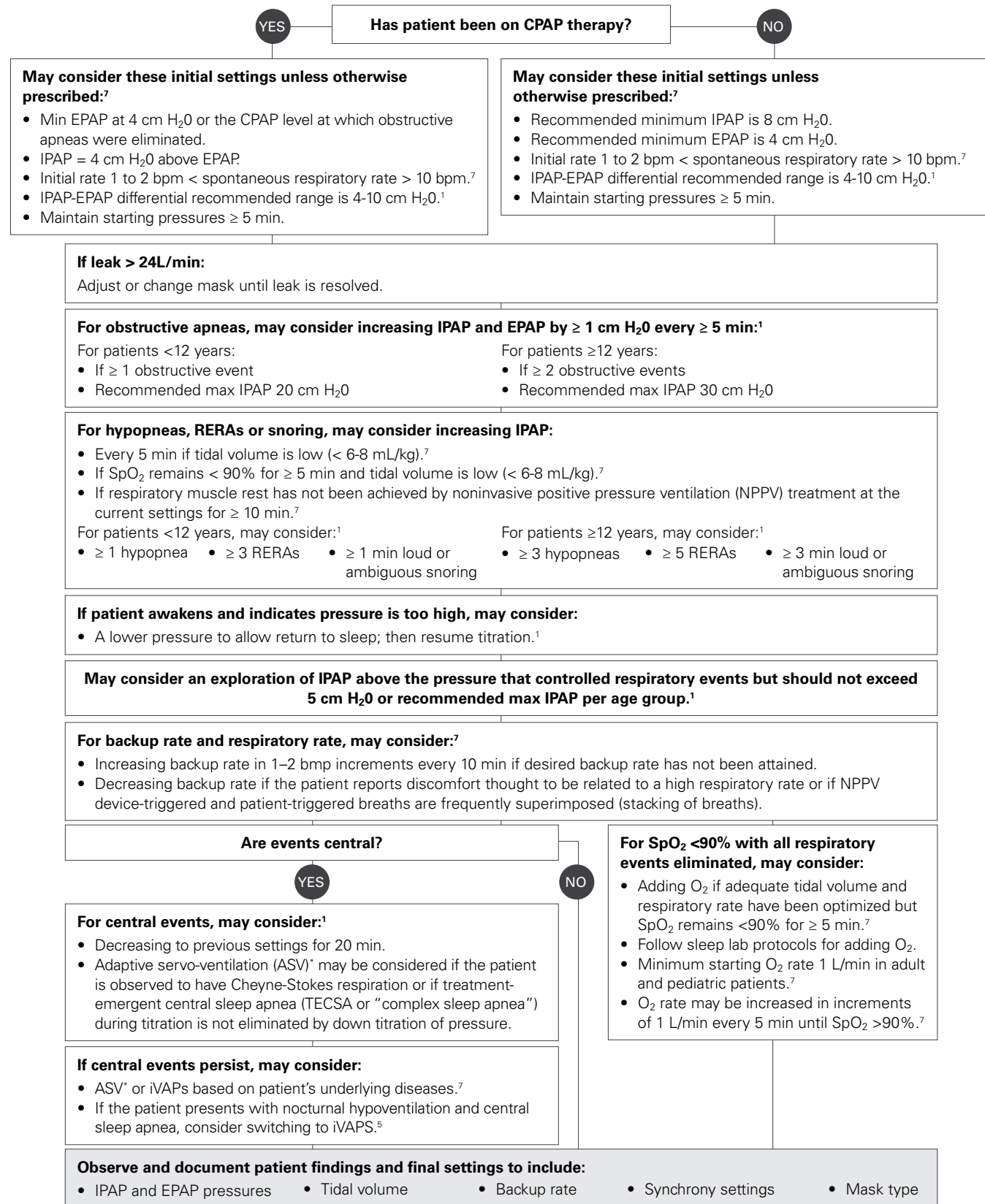
How it works

- 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.



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

Notes

[illegible]

Titration and therapy considerations

General

- Ensure the mask is fitted properly¹ 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.

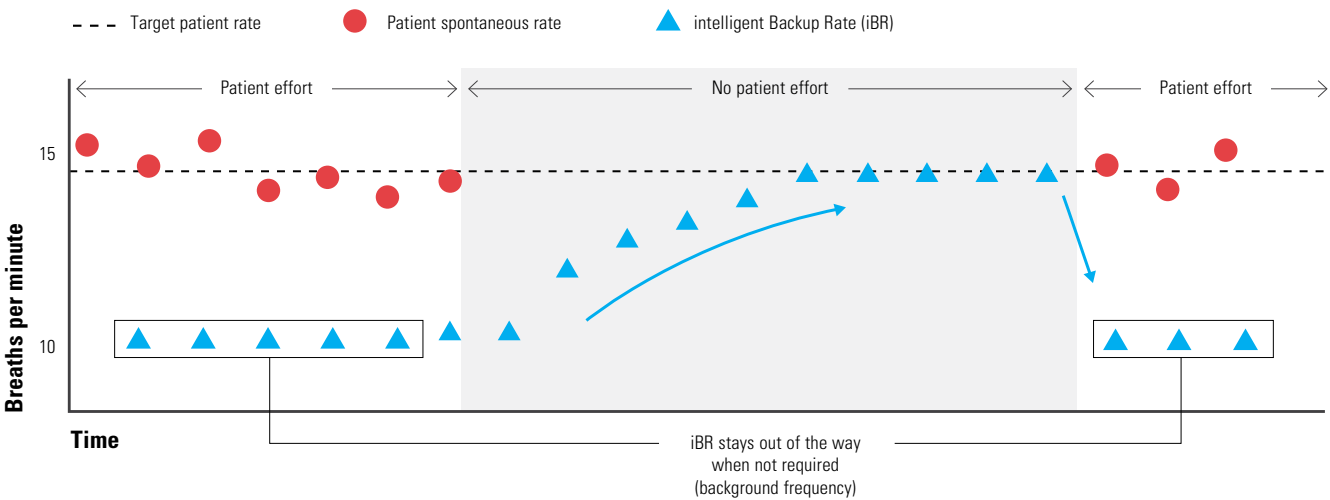
See the “synchrony settings” and “comfort features” sections of this handbook for more information.

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 H₂O.⁷

Restrictive thoracic may include the following:

- Kyphosis²²
- Scoliosis²²
- Diaphragmatic paralysis²³
- Sclerosis²²
- Pulmonary fibrosis/interstitial lung disease²²

The technology

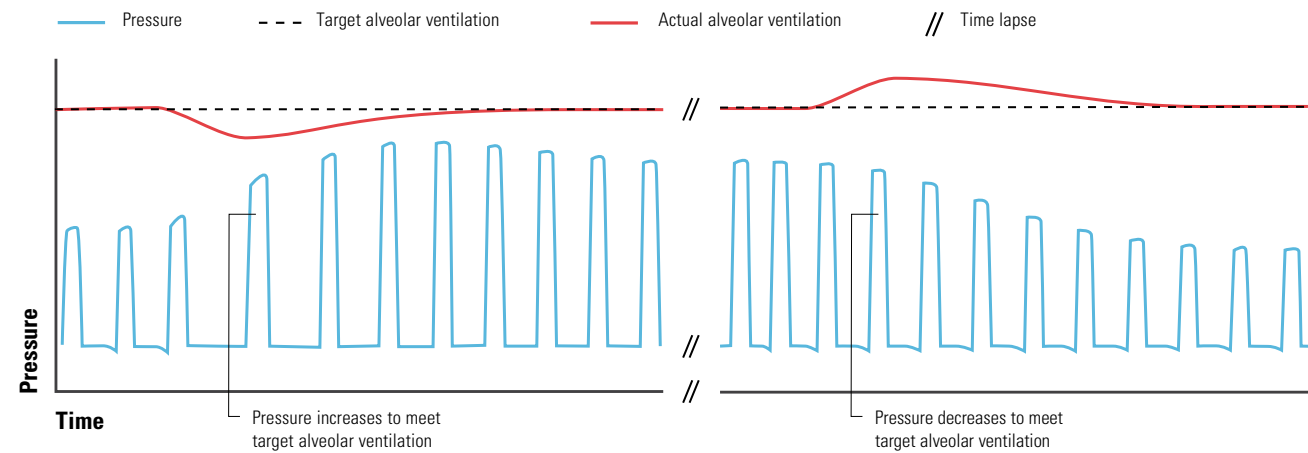
ResMed’s iVAPS algorithm includes Vsync, rise time, trigger sensitivity, TiControl and cycle sensitivity.

See the “synchrony settings” and “comfort features” sections of this handbook for definitions and details on these technologies.

iVAPS

How it works

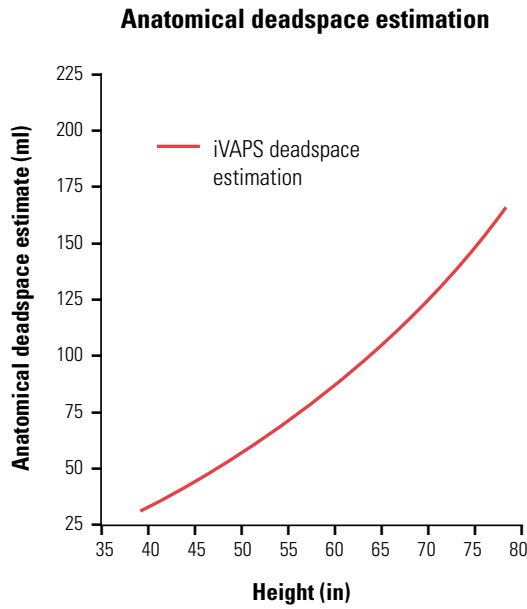
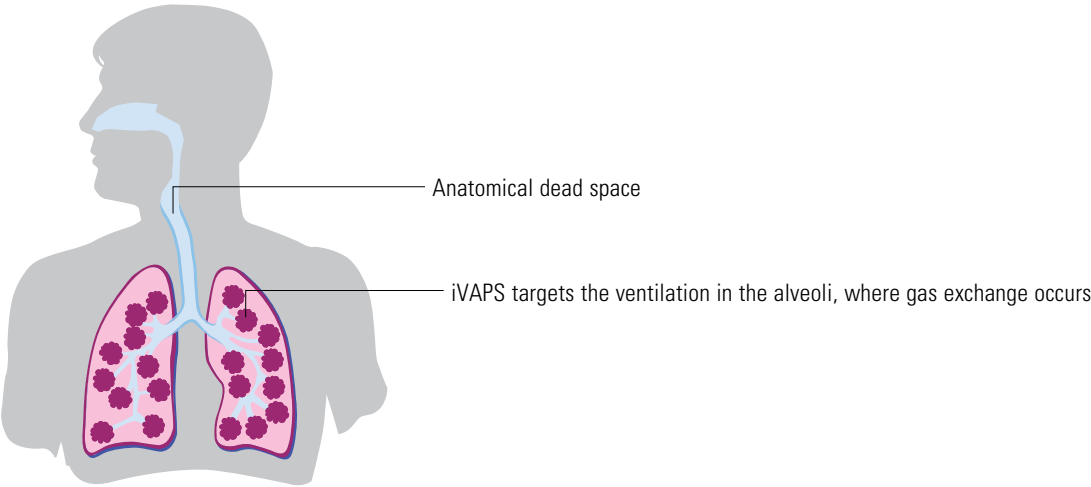
- Maintains a preset target alveolar minute ventilation by monitoring delivered ventilation, adjusting pressure support (PS) and automatically providing intelligent backup breath.



Target alveolar ventilation

How it works

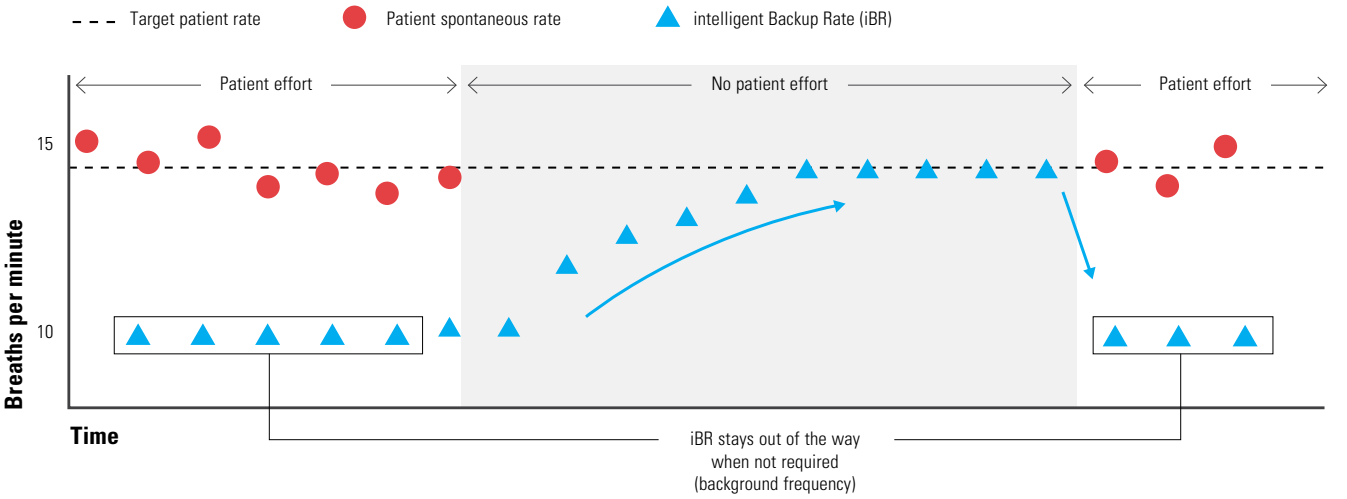
- iVAPS targets alveolar ventilation where gas exchange occurs.
- Alveolar ventilation cannot be measured directly, so iVAPS estimates it using a height-approximated value of anatomical deadspace ($V_a=(V_t-V_d) \times RR$). Default $V_a = 5.2 \text{ L/min.}^9$



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 V_a = 6-8 mL/kg IBW
- EPAP = 4 cm H₂O
- Min PS = 4 cm H₂O
- Max PS = 20 cm H₂O

Evaluate and titrate:

- Compare target patient rate, target V_a , V_t , 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 H₂O 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 $\text{SpO}_2 < 90\%$ and tidal volume is low ($<6\text{ml/kg}$) with all respiratory events eliminated, may consider:⁷
Is the patient achieving target V_a ?

YES

- May consider increase target V_a by $0.3 \geq 5$ min until desaturations are resolved.

NO

- Ensure Max PS is not restricting tidal volume.
- If EPAP + Max PS is $< 30 \text{ cm H}_2\text{O}$, may consider increasing Max PS to achieve total pressure of $30 \text{ cm H}_2\text{O}$.

- 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 $H_2O \geq 5$ min.

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

For SpO₂ <90% with all respiratory events eliminated, may consider:⁷

- Adding O₂ if adequate tidal volume and respiratory rate have been optimized but SpO₂ remains <90% for ≥ 5 min.
- Follow sleep lab protocols for adding O₂.
- Minimum starting O₂ rate 1 L/min in adult and pediatric patients.
- Increasing O₂ in increments of 1 L/min every 5 min until SpO₂ >90%.

For target patient rate, may consider:⁷

- Increasing by 1-2 bpm 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
- Patient tidal volume, V_a , and respiratory rate
- Mask type
- Target patient rate and target V_a
- Synchrony settings

Notes

[illegible]

Titration and therapy considerations

General

- Ensure the mask is fitted properly¹ 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 monitoring⁷

- In studies with monitored transcutaneous carbon dioxide (tcPCO₂) 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 tcPCO₂.
- tcPCO₂ can be monitored for noninvasive positive pressure ventilation (NPPV) titration.
- End-tidal PCO₂ (PetCO₂) 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 CO₂ 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 $\geq 30 \text{ kg}\cdot\text{m}^{-2}$), daytime hypercapnia (arterial carbon dioxide tension $\geq 45 \text{ mmHg}$) 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 SpO₂
- 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.

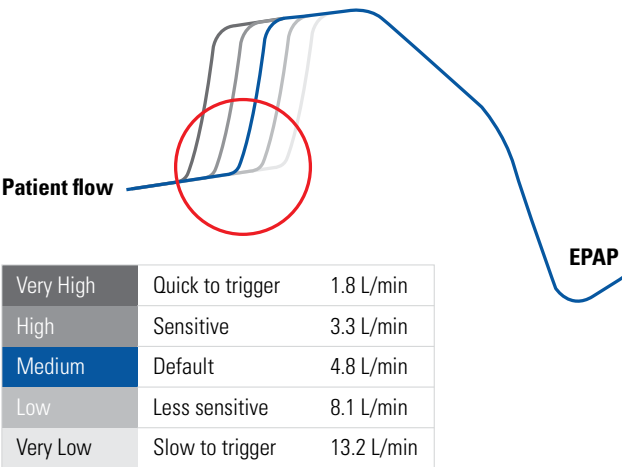
Default Synchrony Settings (Only available in certain devices):

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

Trigger sensitivity⁷

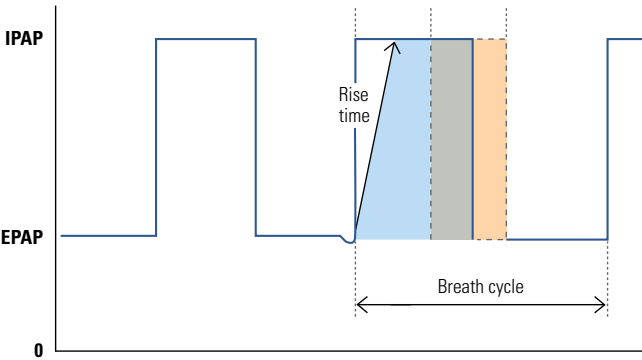
- Trigger settings can be adjusted to help the device better recognize patients with decreased inspiratory efforts.
- The **Medium** setting is the default.
- The **Low** or **Very Low** (less sensitive) settings may be considered for:
 - Cardiogenic oscillations and subsequent auto-triggering.
 - Any 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)



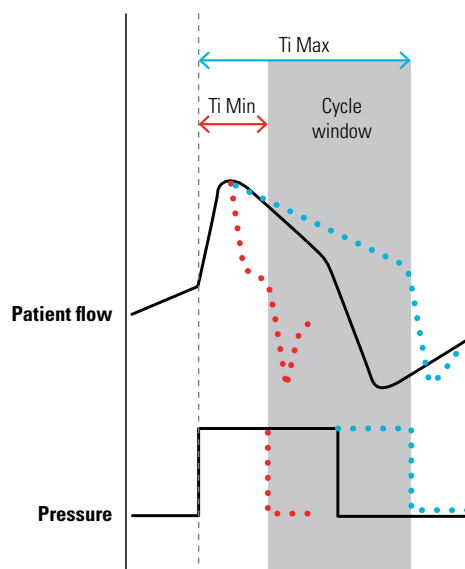
Rise time⁷

- 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.



TiControl⁷

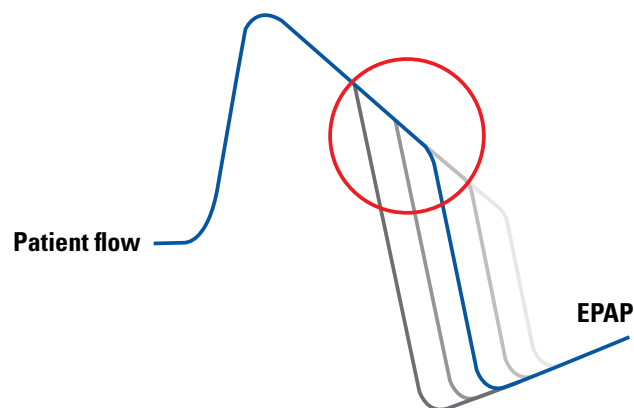
- Allows for management of the time a patient spends in the inspiratory phase of their breath cycle.
- Ti Min and Ti Max parameters limit or prolong inspiratory time, providing a “window of opportunity” to maximize synchronization.
- Adjusting Ti Min properly may aid in providing adequate time for gas 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 sensitivity⁷

- 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 cycle sensitivity may help the patient transition from IPAP to EPAP.
- The **High** or **Very High** (more sensitive) settings may 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

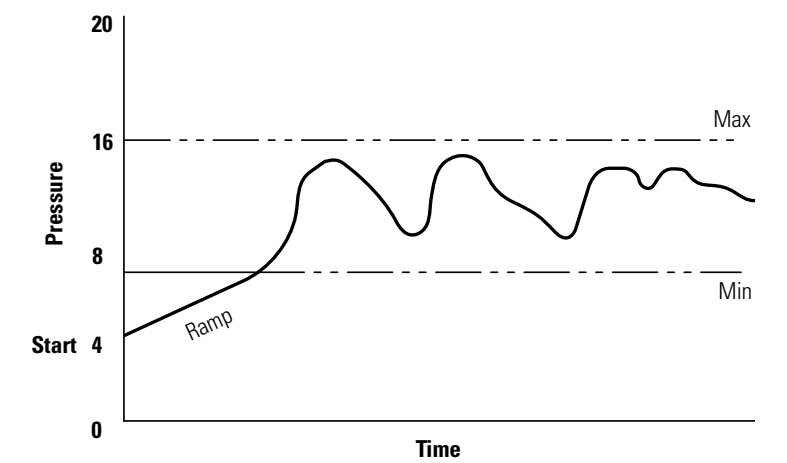
Easy-Breathe waveform⁴

- 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.

1. Kushida CA et al. *J Clin Sleep Med*. 2008. 4(2); 157-71.
2. McArdle N et al. *Sleep* 2015. 38(11);1775-1781
3. Jayaraman G. et al. *Sleep Breath* 2011.15(4);781-4.135(2). 337-43
4. <https://www.resmed.com/en-us/sleep-apnea/cpap-parts-support/sleep-apnea-full-products-list/cpap-machines/airsense-11/>
5. Epstein LJ et al. *J Clin Sleep Med* 2009. 5(3); 263-276
6. Palot A et al *J Thorac Dis* 2023. 15(2); 918-927
7. Berry R et al. *J Clin Sleep Med*. 2010. 6(5); 492-505
8. Aurora RN et al. *J Clin Sleep Med*. 2016.12(5);757–761
9. Selim, B., & Ramar, K. (2016). Advanced positive airway pressure modes: adaptive servo ventilation and volume assured pressure support. *Expert Review of Medical Devices*, 13(9), 839–851
10. Joliet P et al. *Crit Care* 2006.10(6); 236
11. Armistead J et. al. White paper - AirSense™10 Apnea Hypopnea Index (AHI) Scoring and Advanced Event Detection – 2014 11
12. Arnal M et al. *Chron Resp Disease*. 2019. 16; 1-14
13. Mokhlesi B et al. *Proc Am Thorac Soc*. 2008. 5; 218-225 DOI: 10.1513/pats.200708-122MG
14. Wenninger S et al. *Current Opinion Neur*. 2021. 34(5); 686-696
15. Armistead JP et al. Study of an auto-adjusting CPAP algorithm for the treatment of obstructive sleep apnoea. *Am J Respir Crit Care Med* 2009;179:A3570.
16. Wiggins A et al. Obstructive Sleep Apnea in Women: Specific Issues and Interventions. *Biomed Res Int*. 2016;2016:1764837. doi: 10.1155/2016/1764837. Epub 2016 Sep 6. PMID: 27699167; PMCID: PMC5028797
17. Lee K. Brown, MD. BS. Adaptive Servo-Ventilation for sleep apnea: technology, titration protocols and treatment efficacy. p424
18. Rodrigues S O et al. *Pharmaceuticals*. 2021; 14:979 DOI: 10.3390/ph14100979
19. Randerath W. J. et al.). *Pneumologie*. 2008 Jul;62(7);398-403.
20. Ye L, et al. *J Clin Sleep Med* 2009; 5(6) 512-518.
21. Masa J et al. *Eur Resp Review* 2019;28(151): 180097.
22. Martinez-Pitre PJ et al. Restrictive Lung Disease. [Updated 2023 Jul 25]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
23. Khan A et al. *J Clin Sleep Med* 2014;10(5):509-515.
24. U.S. Centers for Medicare & Medicaid Services. Local Coverage Determination (LCD): Respiratory Assist Devices (L33800), retrieved Aug 1, 2019 from <https://www.cms.gov/medicare-coverage-database/ResMed.com/Reimbursement>.

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