

BPAP introduction

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Outline

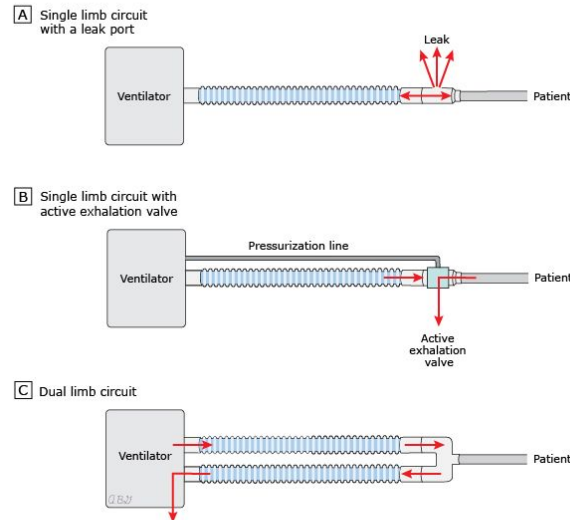
- BPAP mechanism
- Indications
- How to prescribe BPAP
- Follow-up
- Complications

BPAP mechanism

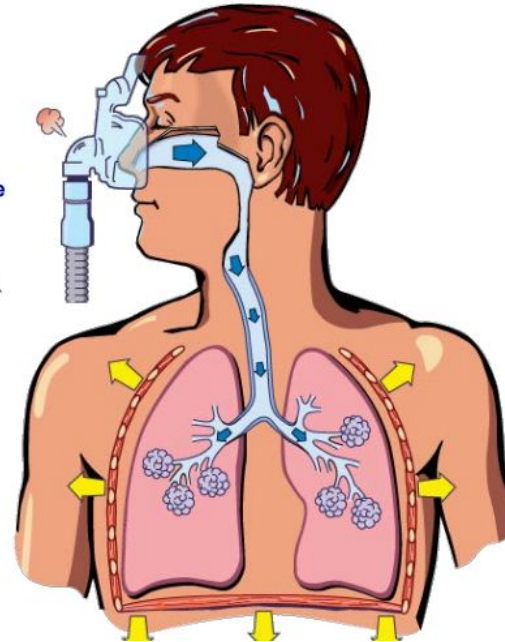
- “**B**ilevel **p**ositive **a**irway **p**ressure” mode
- NIV: non-invasive ventilator, via **mask and single limb circuit with a leak port**
- **Pressure-limited**, Volume-limited, Hybrid

- IPAP, EPAP

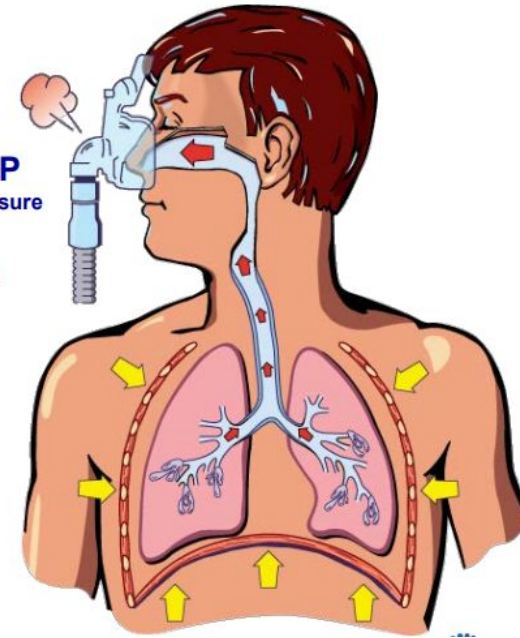
Ventilator circuits

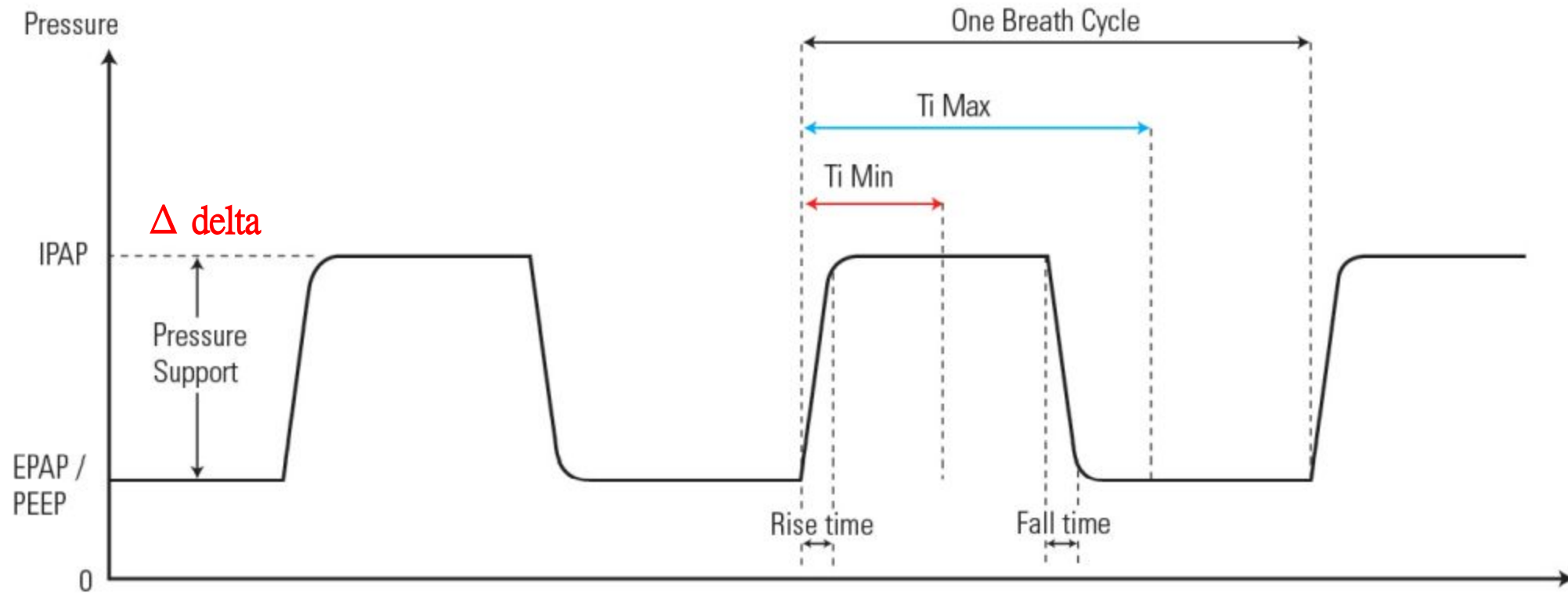


IPAP
high pressure



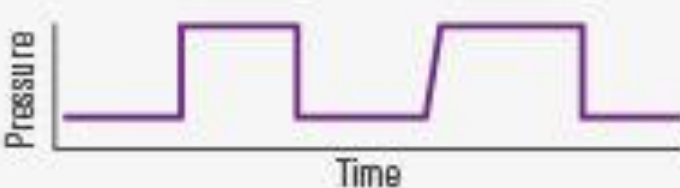



EPAP
low pressure

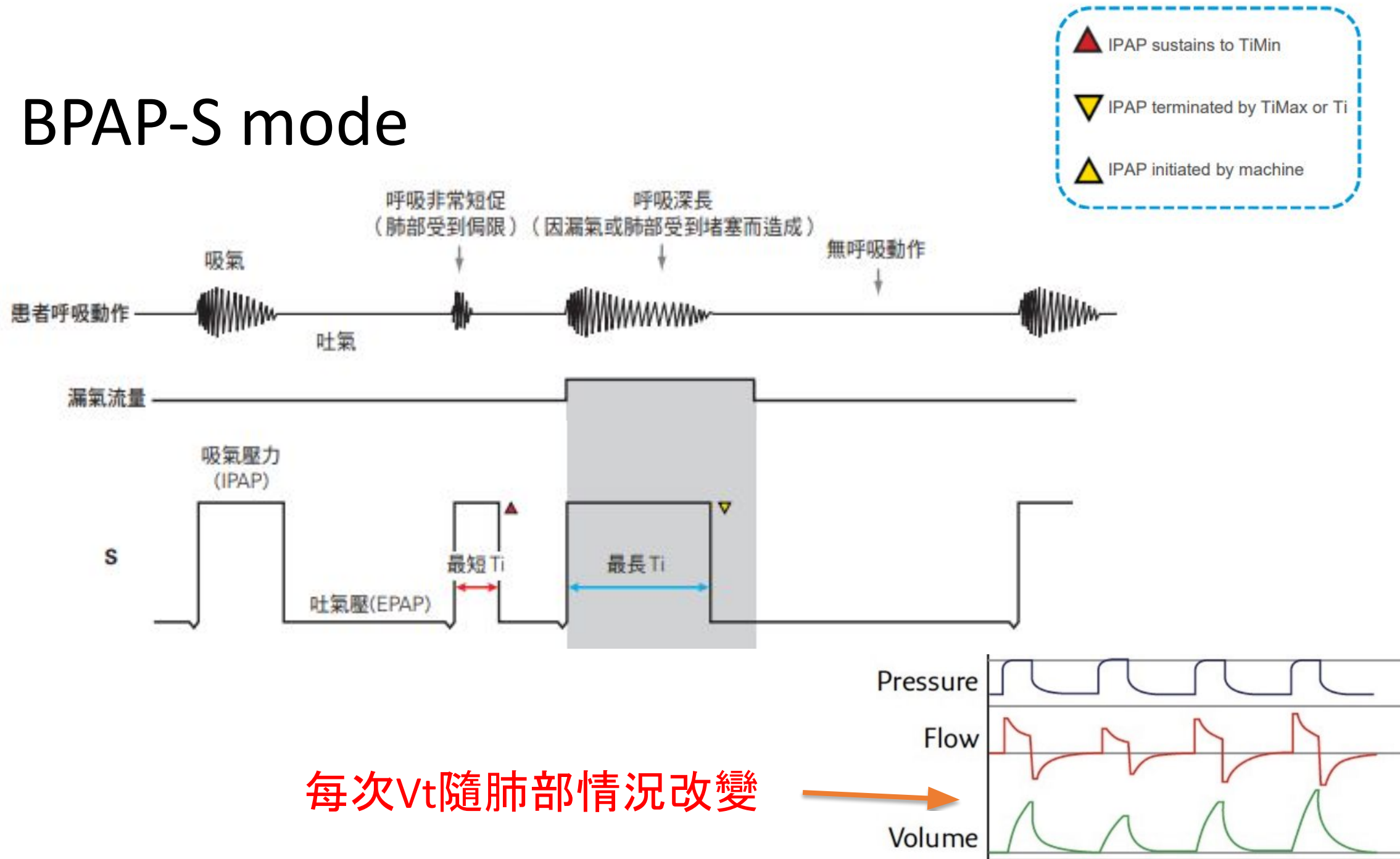




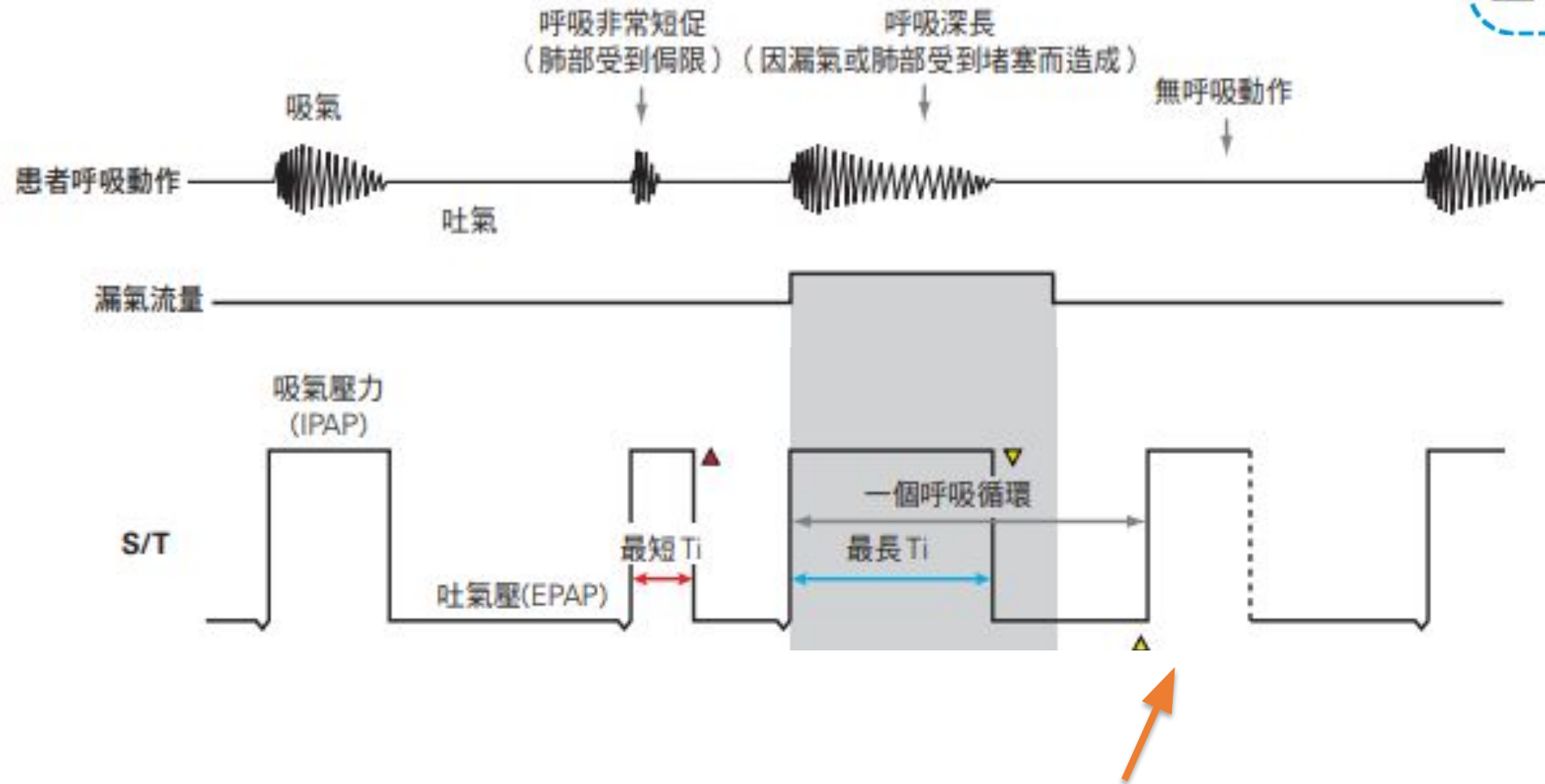
- **Pressure support (PS, Δ delta): augment ventilation**
 - via V_t (tidal volume) increases then alveolar ventilation
- **EPAP: overcome upper airway occlusion**
- Additional setting to optimize pts comfort and machine interaction
 - Trigger sensitivity, T_i , cycle sensitivity, rising time or falling time

Therapy	Aim	Features	Pressure Profile
Continuous Positive Airway Pressure (CPAP)	Maintain open upper airways	Fixed pressure	 <p>The graph shows a constant horizontal line representing a fixed pressure level over time.</p>
Automatic Positive Airway Pressure (APAP)	Maintain open upper airways	Continually adjusting pressure to optimize pressure level to the patient's needs	 <p>The graph shows a line that fluctuates up and down, representing pressure being adjusted in real-time based on patient needs.</p>
Variable Positive Airway Pressure (VPAP)	Support breathing in lung disease-related respiratory insufficiency	Fixed expiratory pressure and pressure support at inspiration, usually with fixed back-up rate	 <p>The graph shows a square wave pattern where pressure is low during expiration and rises to a fixed level during inspiration, then returns to the baseline.</p>
Adaptive Servo-Ventilation (ASV)	Stabilise breathing and keep upper airway open	Continually adjusting inspiratory and expiratory pressure with variable, on-demand, back up rate	 <p>The graph shows a highly complex, high-frequency fluctuating line, indicating continuous and adaptive pressure adjustments throughout the breathing cycle.</p>

BPAP-S mode

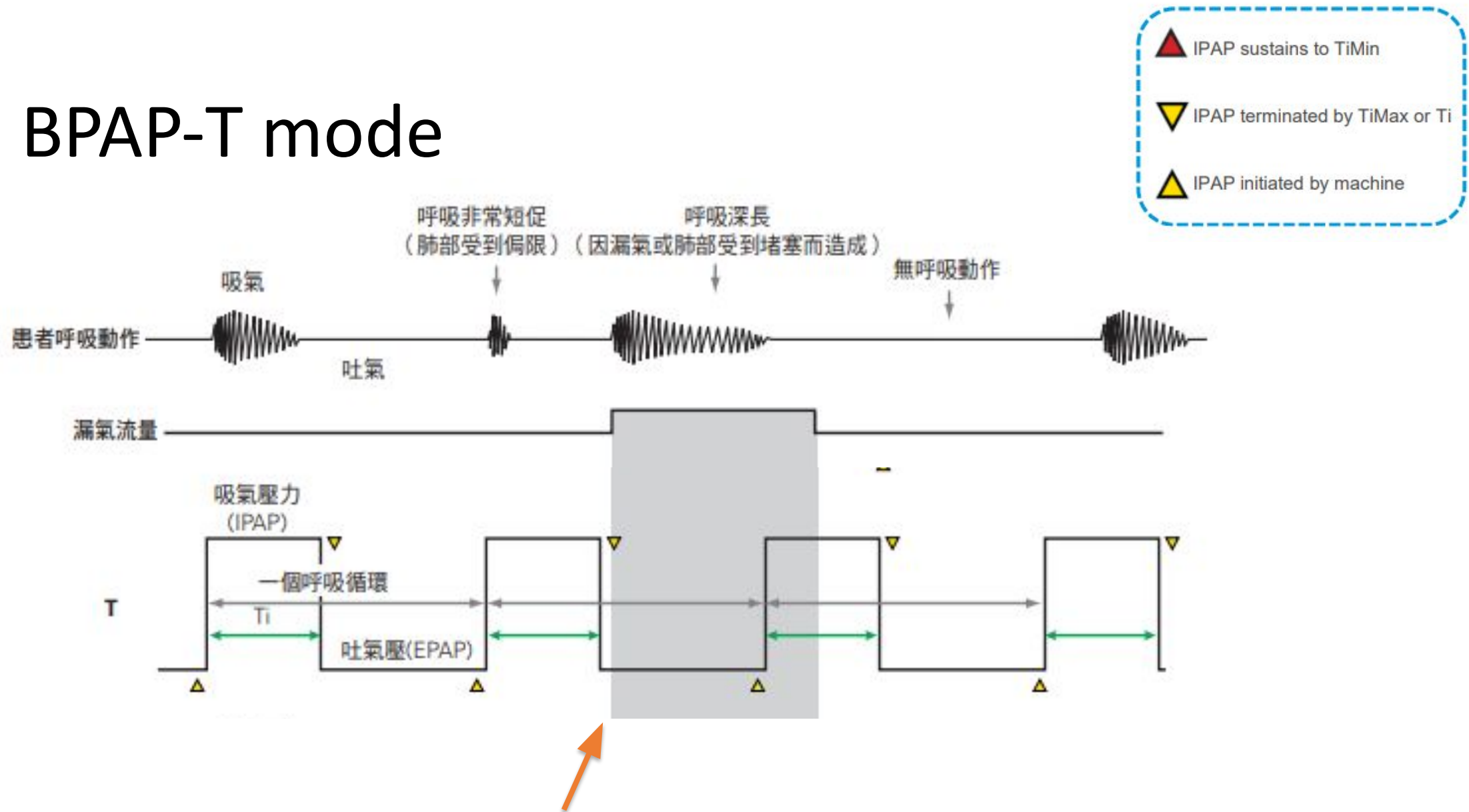


BPAP-S/T mode



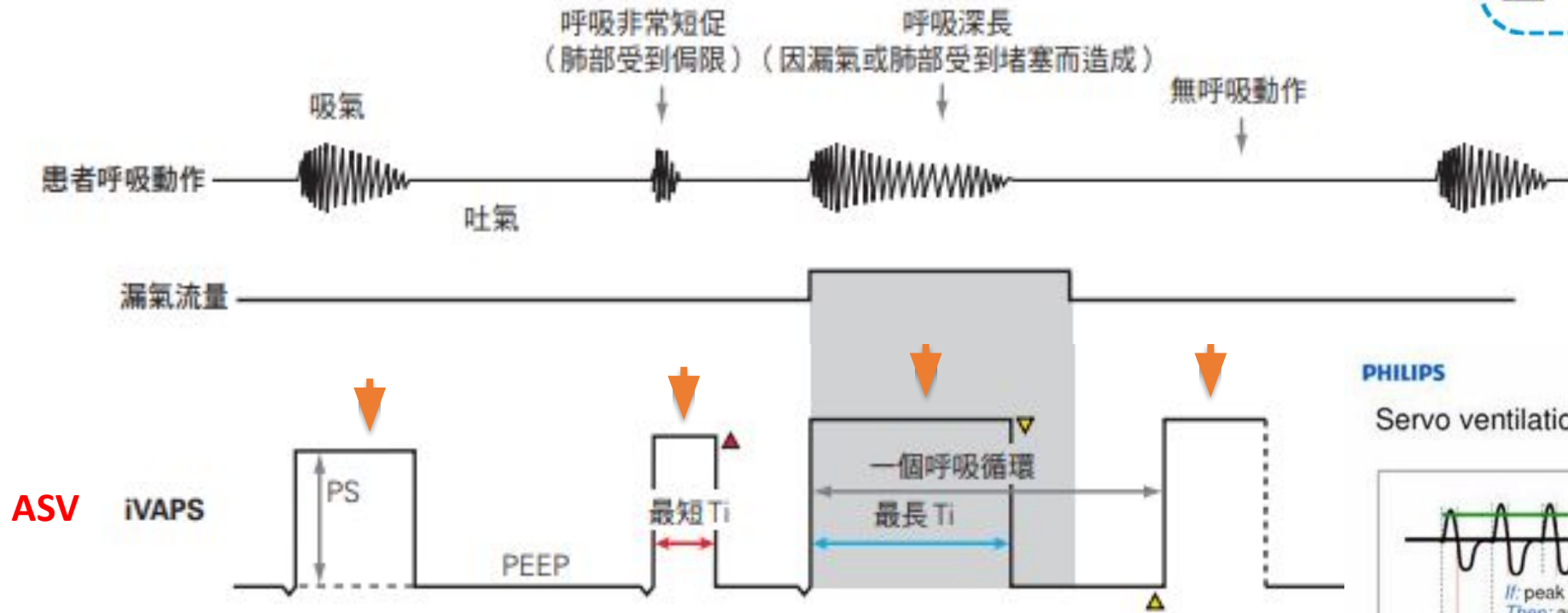
Back-up rate: for central apnea

BPAP-T mode



Asynchrony to pt's breathing effort

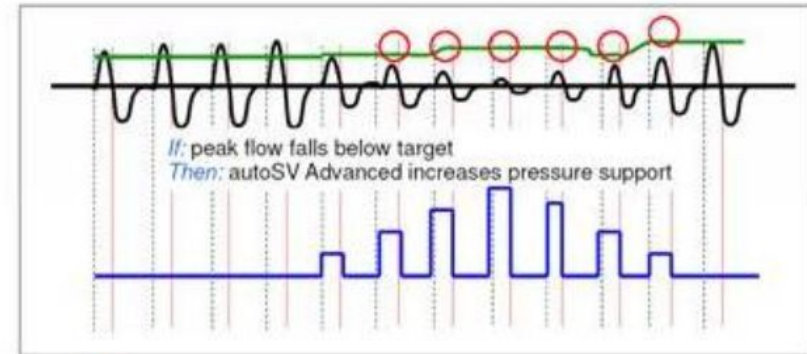
iVAS or ASV mode



- ▲ IPAP sustains to TiMin
- ▼ IPAP terminated by TiMax or Ti
- ▲ IPAP initiated by machine

PHILIPS

Servo ventilation algorithm: Decreased peak flow



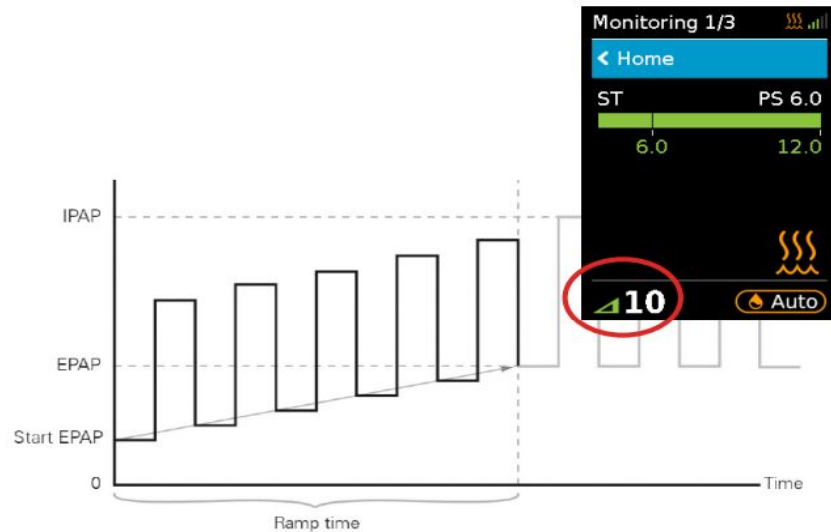
○ = Missed peak flow target (sdb)
Dynamic pressure support inversely proportionate to peak flow value

- $MV \text{ (minute ventilation)} = RR * V_t$

Variable pressure support with backup rate

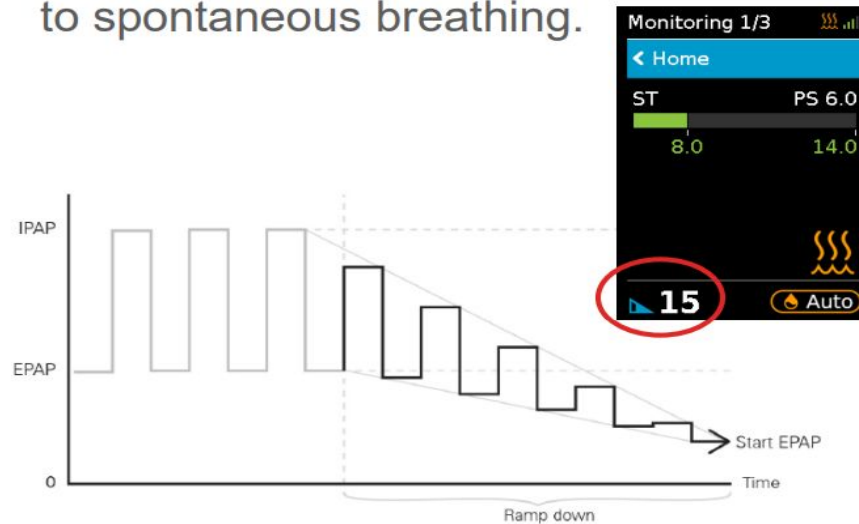
New technology of BPAP-Ramp

- **Ramp** makes the beginning of treatment more comfortable.



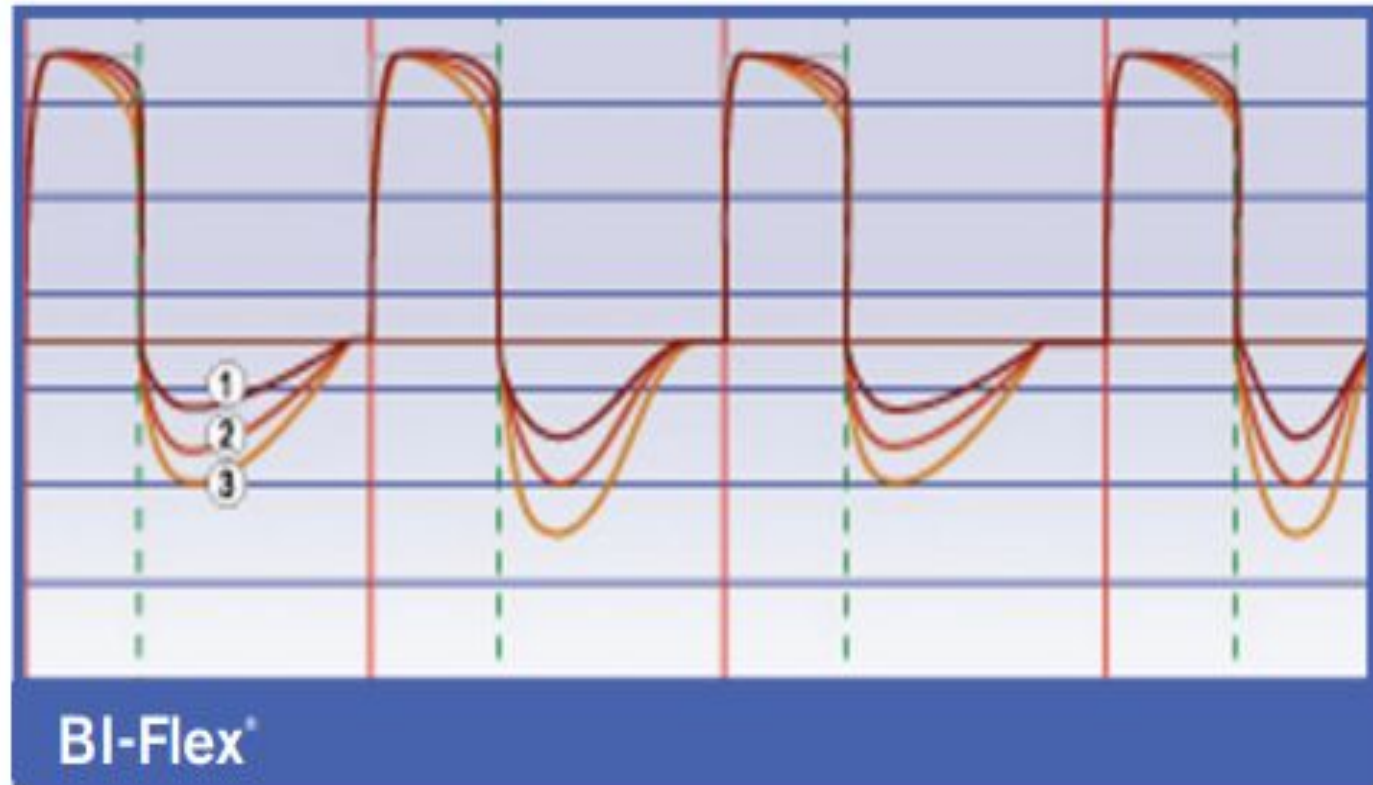
Off / 5 – 45 minutes

- When stopping therapy, **Ramp Down** gives patients the option to gradually reduce pressure support and EPAP, providing a more comfortable transition to spontaneous breathing.



15 minutes then CPAP

New technology of BPAP-Bi-Flex



Inhalation

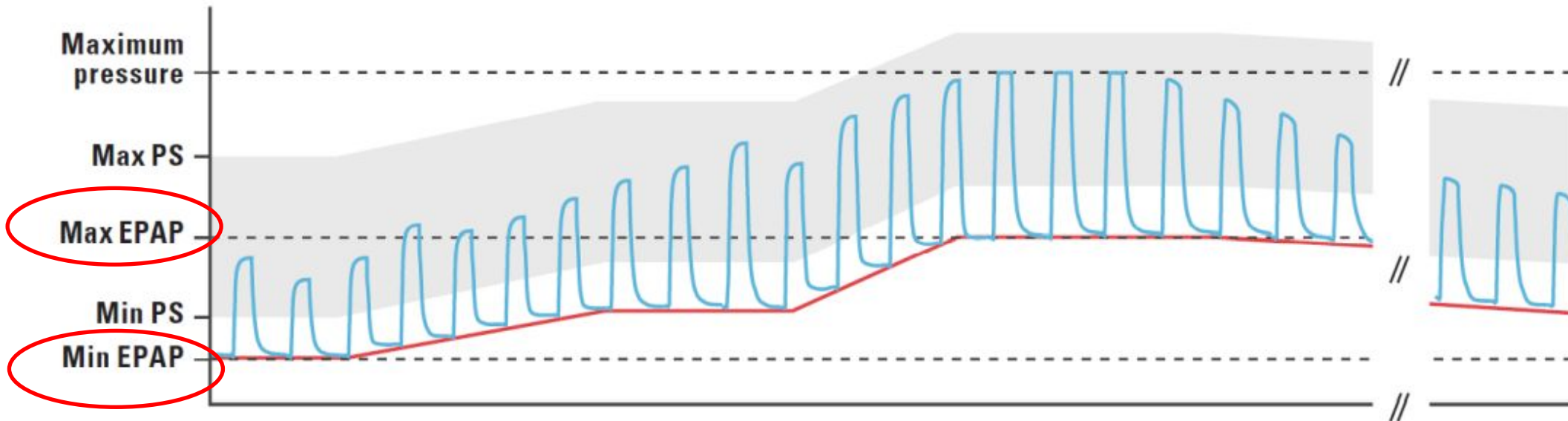
Exhalation

Pressure relief ☐ more natural
breathing

*Gay, P.C., et al., *Sleep*. Volume 28, Abstract Supplement 2005, #625, p. A210.

New technology of BPAP-Auto-EPAP

Auto-EPAP: **similar APAP algorithm** to overcome upper airway occlusion



Indication of BPAP

- Acute respiratory failure
 - Acute exacerbation of COPD, Acute cardiogenic pulmonary edema
 - Hypoxic non-hypercapnic respiratory failure, asthma exacerbation, post-extubation, post-operative, chest trauma-induced, palliation
- Chronic respiratory failure
 - Neuromuscular and chest wall diseases
 - Sleep-disordered breathing
 - Obstructive sleep apnea (OSA)
 - If CPAP >15 by AASM recommendation
 - Central sleep apnea (CSA)
 - Hyperventilation-related vs Hypoventilation-related
 - Obesity hypoventilation syndrome (OHS)

The aim of BPAP

- Gas exchange
 - To stabilize daytime PaCO₂ (nearly-normal or < 60mmHg)
 - To improve oxygenation ($\geq 90\%$ for $\geq 95\%$ of sleep time)
- To improve daytime symptoms
- To improve sleep quality

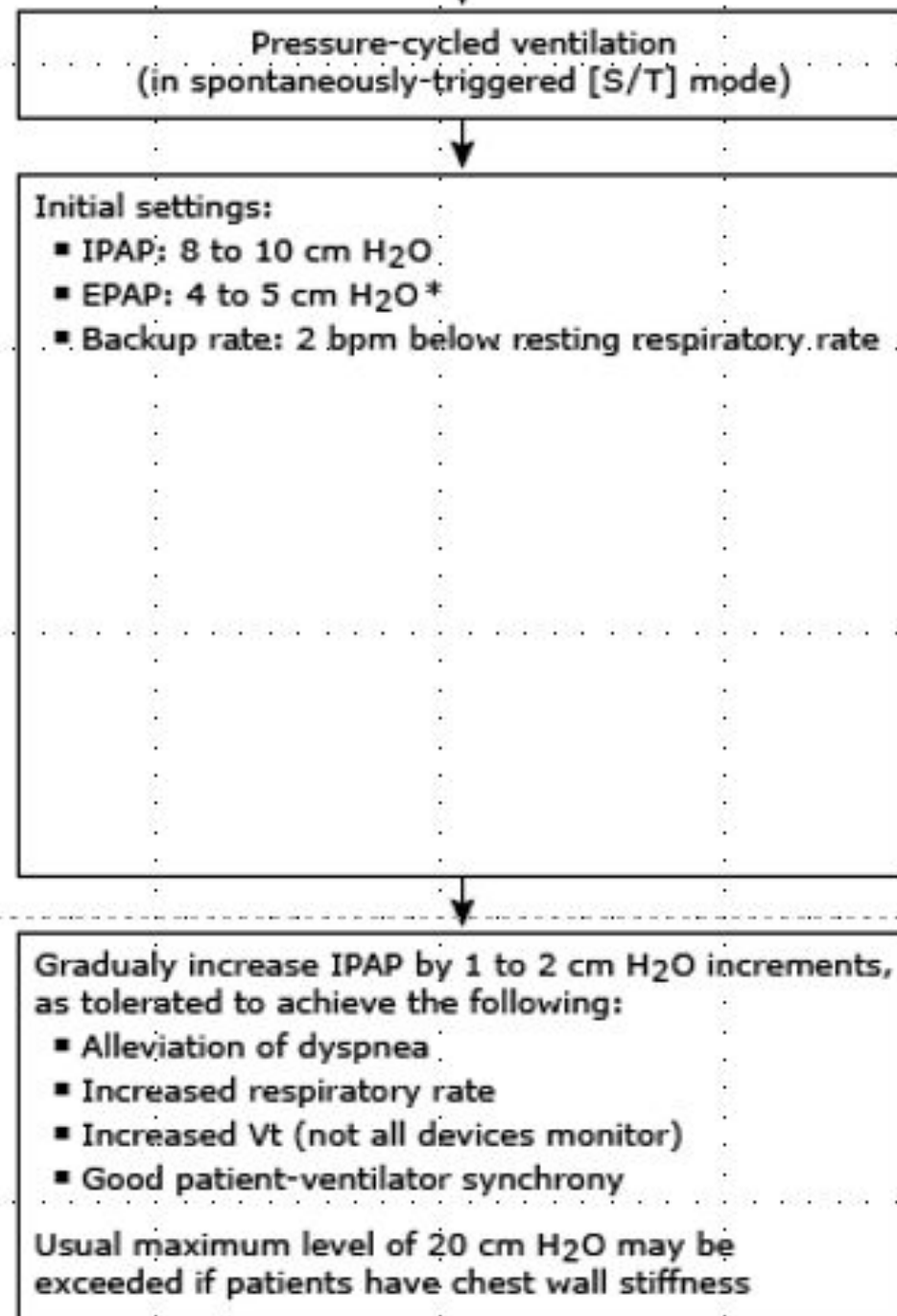
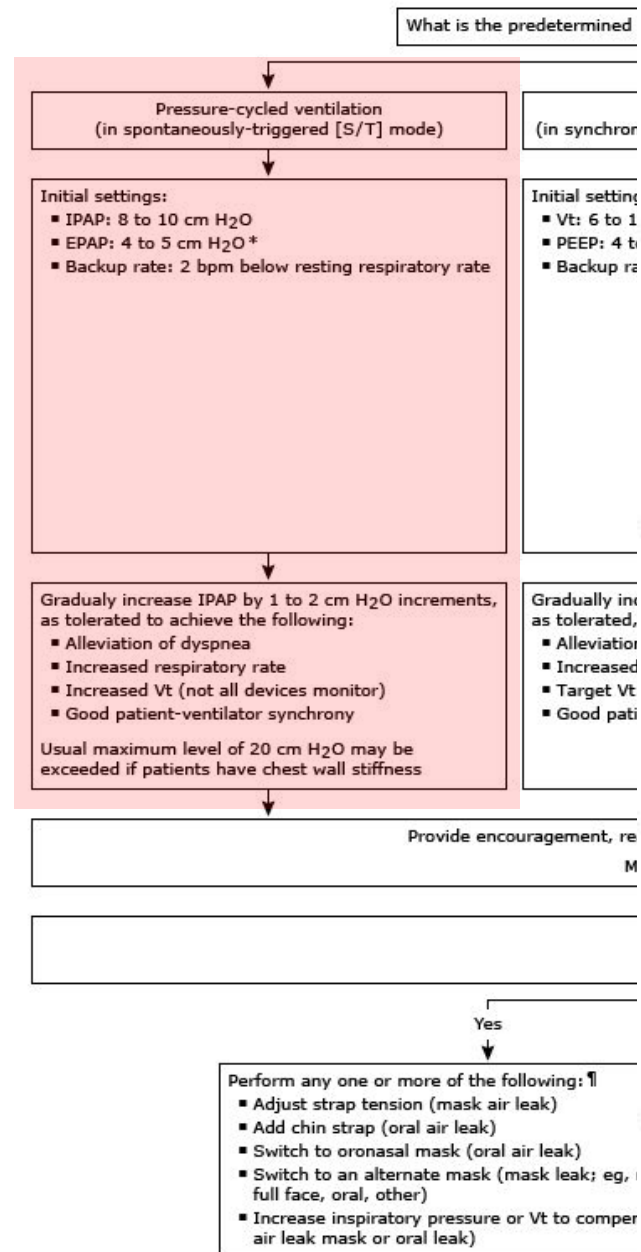
Chronic respiratory failure from neuromuscular and chest wall diseases

- Decreased lung compliance
- ☐ **Chronic hypoventilation**
 - Daytime PaCO₂ \geq 45 mmHg
 - Nocturnal sustained O₂ desaturation (SpO₂ \leq 88% for $>$ 5 consecutive mins) AND symptomatic (morning headache, excessive daytime hyperventilation (EDS))
- **BPAP: augment ventilation (PS)**
- Goal:
 - To get adequate V_t
 - To normalize gas exchange
 - To improve daytime symptoms

How to prescribe BPAP

- Mask selection
- Traditional prescription by RT
 - Target: Vt 6-8 ml/kg IBW (ideal body weight)
 - 男性： (身高cm－80) *70% =標準體重(IBW)
 - 女性： (身高cm－70) *60% =標準體重(IBW)
 - Initial setting:
 - EPAP 4-5, IPAP 8-10
 - back-up rate setting: 2-4 bpm below spontaneous RR
 - Ti-min: 1.0, Ti-max: 1.5, rising time 3
 - Titrate IPAP according to symptoms, HR, RR, gas exchange, Vt, pt-machine interaction

Titration modules for noninvasive ventilation due to neuromuscular or chest wall conditions



Obstructive sleep apnea

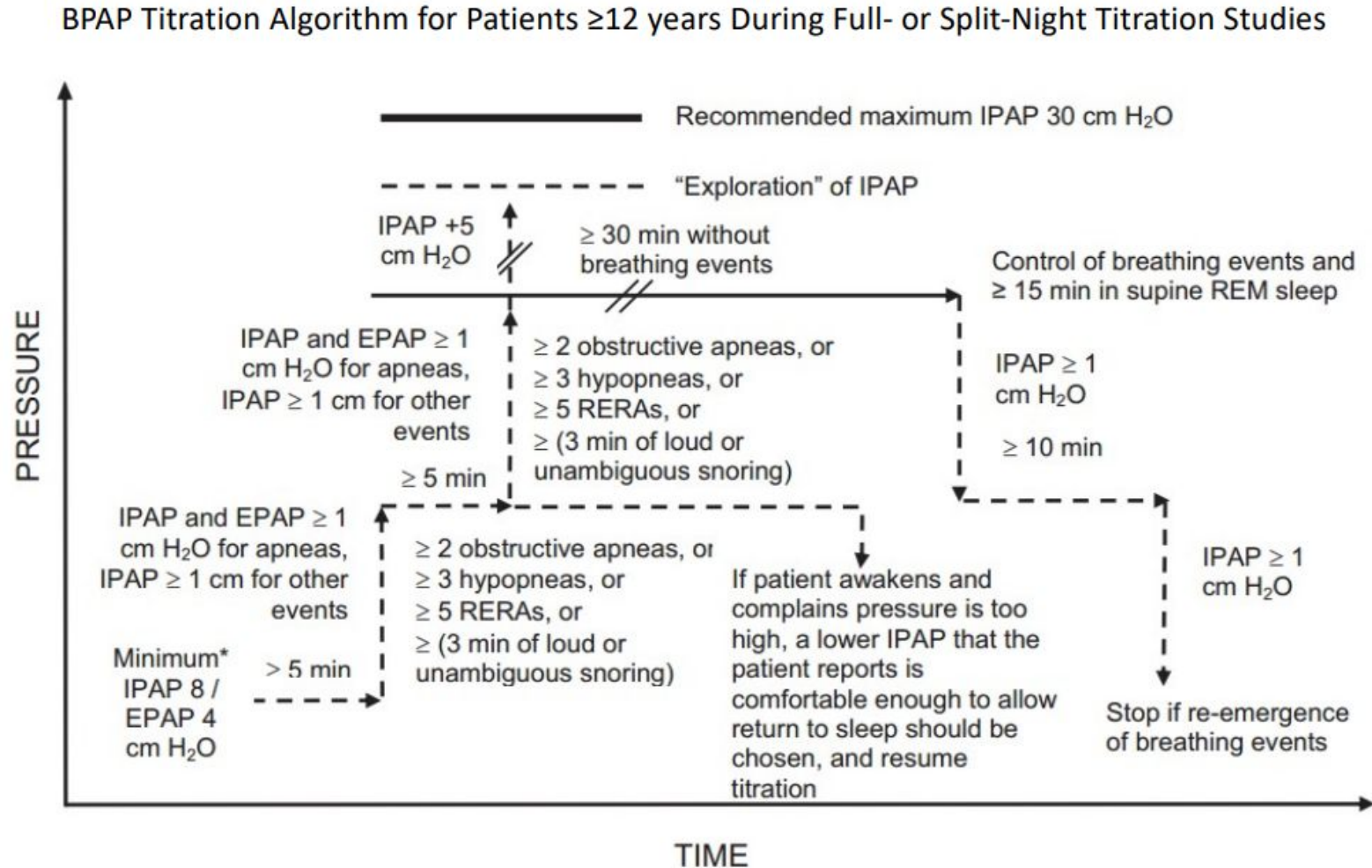
- Upper airway occlusion □ intermittent nocturnal O2 desaturation
- BPAP:
 - EPAP overcome upper airway occlusion
 - IPAP act to prevent obstructive hypopneas, RERAs, and snoring
- Goal:
 - to eliminate breathing events during sleep
 - To normalize nocturnal desaturation
 - To improve daytime symptoms and sleep quality
- OSA as second-line therapy
 - Uncomplicated OSA who fail or cannot tolerate CPAP
 - Complicated OSA (thought to have a predominance of CSA or hypoventilation)

Conditions defining complicated OSA

Category	Examples
Pulmonary diseases	Severe chronic obstructive pulmonary disease Chronic hypercapnic or hypoxemic respiratory failure
Cardiac diseases	Congestive heart failure
Neuromuscular diseases and hypoventilation syndromes	Central sleep apnea, obesity hypoventilation syndrome, neuromuscular diseases
Effects of drugs including substance use/abuse	Opioids, gabapentinoids, other respiratory depressants
Other conditions	Prior upper airway surgery

- **In-lab** BPAP titration

- AASM guideline to eliminate sleep-disordered breathing events (apnea, hypopnea, RERAs, snoring)



Central sleep apnea

- Hyperventilation or Hypoventilation related
- BPAP:
 - backup rate for apnea,
 - PS for hypoventilation
 - EPAP to open obstructive event at end of CSA which may lead ventilatory overshoot, hyperventilation, and oscillatory apneas
- Goal:
 - to eliminate breathing events during sleep
 - To normalize nocturnal desaturation
 - To improve daytime symptoms and sleep quality

Central sleep apnea with predominant hyperventilation

1. Central sleep apnea with Cheyne-Stokes breathing
2. Central sleep apnea due to high altitude periodic breathing
3. Treatment-emergent central sleep apnea

Central sleep apnea with predominant hypoventilation

1. Central apnea due to a medical disorder without Cheyne-Stokes breathing
2. Central sleep apnea due to a medication or substance
3. Primary central sleep apnea
4. Primary central sleep apnea of infancy*
5. Primary central sleep apnea of prematurity*

BPAP treatment for central sleep apnea

- Hyperventilation-related
 - CSA with heart failure
 - CPAP as first-line then BIPAP-S/T or ASV (for LVEF > 45%)
 - CPAP with supplemental oxygen is better than BPAP-S/T (for LVEF ≤45%)
 - Treatment-emergent CSA
 - BPAP-S/T or ASV, not BPAP-S
- Hypoventilation-related
 - CSA and opioid use
 - BPAP better than CPAP □ high PS needed
 - Rare etiology of CSA
 - CPAP firstly then ASV or BPAP

Hypoventilation syndrome

- Idiopathic and congenital central alveolar hypoventilation syndrome
- Hypoventilation
- BPAP: PS to augment ventilation
- Goal:
 - To stabilize daytime PaCO₂
 - To eliminate nocturnal O₂ desaturation
 - To improve daytime symptoms
- Obesity hypoventilation syndrome
 - Coexisting OSA
 - CPAP as first-line therapy
 - With sleep related hypoventilation only
 - BPAP as first-line therapy

Follow up of BPAP

- Initial trial phase (1 wk) □ Adaptation phase (few wks to months) □ Follow-up
- Adaptation phase: greatest challenge in gaining acceptance
- Assessment:
 - Hours of nightly use
 - Symptoms of hypoventilation (fatigue, early morning headache/dyspnea, EDS) when adequate compliance ($> 4\text{hr/n}$)
 - HR, gas exchange (ABG, VBG, PtcCO_2)
 - Intolerance or complications
 - Target of gas exchange:
 - $\text{PaCO}_2 < 60\text{ mmHg}$ with controlled symptoms of hypoventilation
 - $\text{SpO}_2 > 90\%$ during 95% sleep time
- Frequency and intensity of monitoring
 - Starting therapy (every few wks)
 - Stable on therapy (twice yearly)
 - Deteriorating clinically (every few days or wks)

Effective assessment

- **No improvement**, common factors:
 - Poor adherence or low number of used hours
 - Excessive air leak during inspiration
 - Inappropriate setting with insufficient minute volume
 - Others
 - Rebreathing CO₂ (EPAP > 4 to assure adequate bias flow to remove CO₂ from the circuit)
 - Residual obstructive events during sleep (auto-EPAP)
- **Worsening of symptoms**
 - Deteriorated lung function
 - Faulty equipment
 - Worsening OSA
 - Medication changes
 - New comorbidity

Complication	Occurrence (%)	Possible Remedy		
Mask related				
Discomfort	30-50%	Check fit, adjust strap, new mask type	Principles of mechanical ventilation. 3e	
Facial skin erythema	20-34%	Loosen straps, apply artificial skin		
Claustrophobia	5-10%	Smaller mask, sedation		
Nasal bridge ulceration	5-10%	Loosen straps, artificial skin, change mask type		
Acneiform rash	5-10%	Topical steroids or antibiotics		
Air pressure or flow related				
Nasal congestion	20-50%	Nasal steroids, decongestant/antihistamine		
Sinus/ear pain	10-30%	Reduce pressure if intolerable		
Nasal/oral dryness	10-20%	Nasal saline/emollients, add humidifier, decrease leak		
Eye irritation	10-20%	Check mask fit, readjust straps		
Gastric insufflation	5-10%	Reassure, simethicone, reduce pressure if intolerable		
Air leaks	80-100%	If using nasal mask, reduce pressure slightly		
Major complications				
Aspiration pneumonia	< 5%	Careful patient selection		
Hypotension	< 5%	Reduce pressure		
Pneumothorax	< 5%	Stop ventilation if possible, reduce pressure, if not, use thoracostomy tube if indicated		

Alarms

Fixed alarms

Power fail

Blocked tube

Tube disconnected

System fault (system error)

Adjustable alarms

High Leak

Non-vented mask

Low Minute Ventilation

Apnea

Low SpO₂

Oximeter sensor disconnected

Oximeter sensor failure

Take home message

- BPAP can augment ventilation, overcome upper airway occlusion, and provide backup rate during apnea
- BPAP is indicated for chronic respiratory failure due to neuromuscular and chest wall diseases, sleep disordered breathing, such as OSA, CSA, and hypoventilation syndrome
- Follow-up is important for BPAP adherence and compliance, especially at adaptation phase

The End

Thanks for your attention!