

ResMed PAP Solution

Algorithms and Mask features

Hyo Yeol Kim

Department of Otorhinolaryngology-Head and Neck Surgery
Sungkyunkwan University School of Medicine
Samsung Medical Center, Seoul, Korea

Compliance를 규정하는 요소들

Pt Selection

Motivation

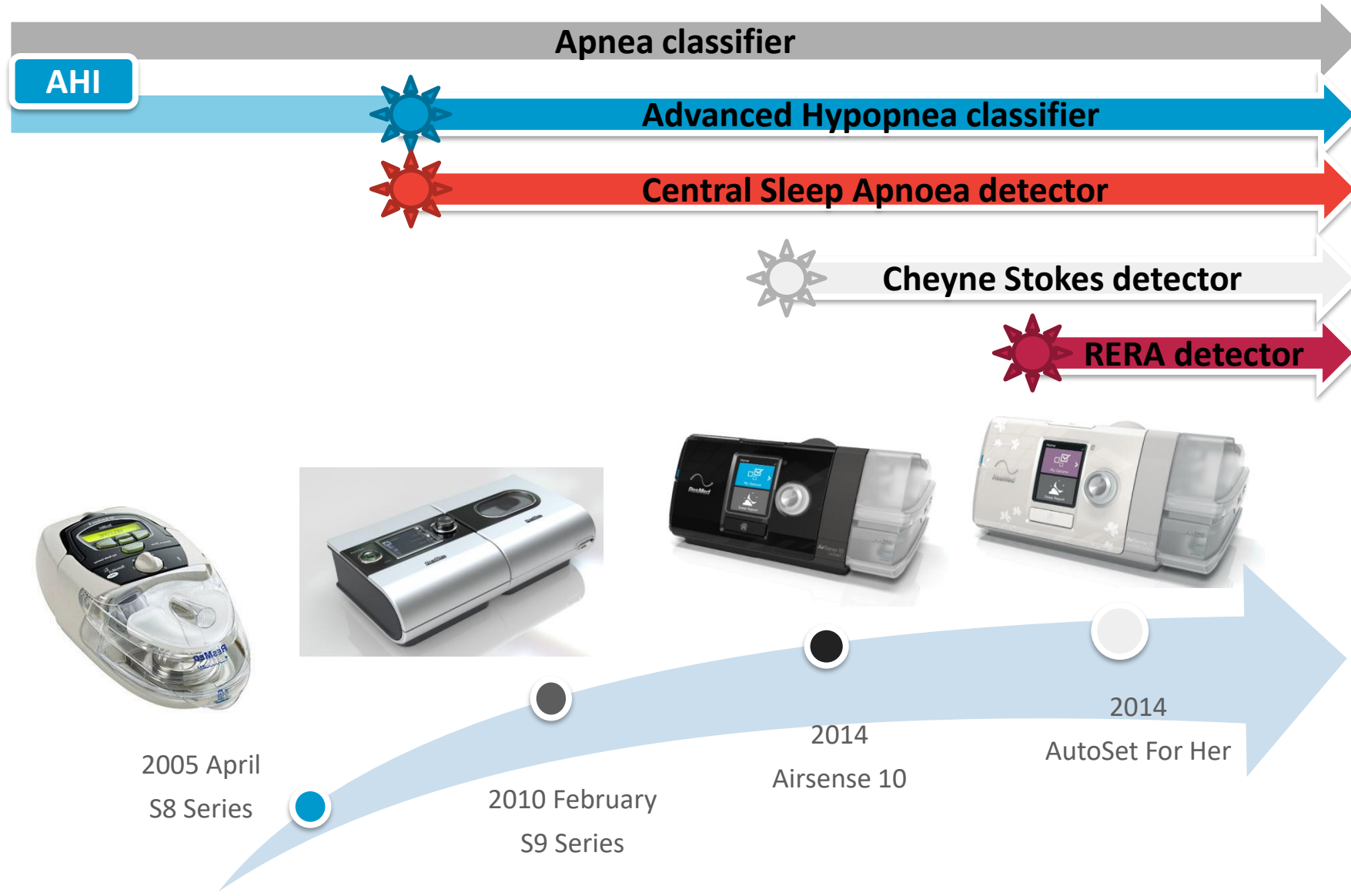
Resolution of Pt S/E

Machine Management

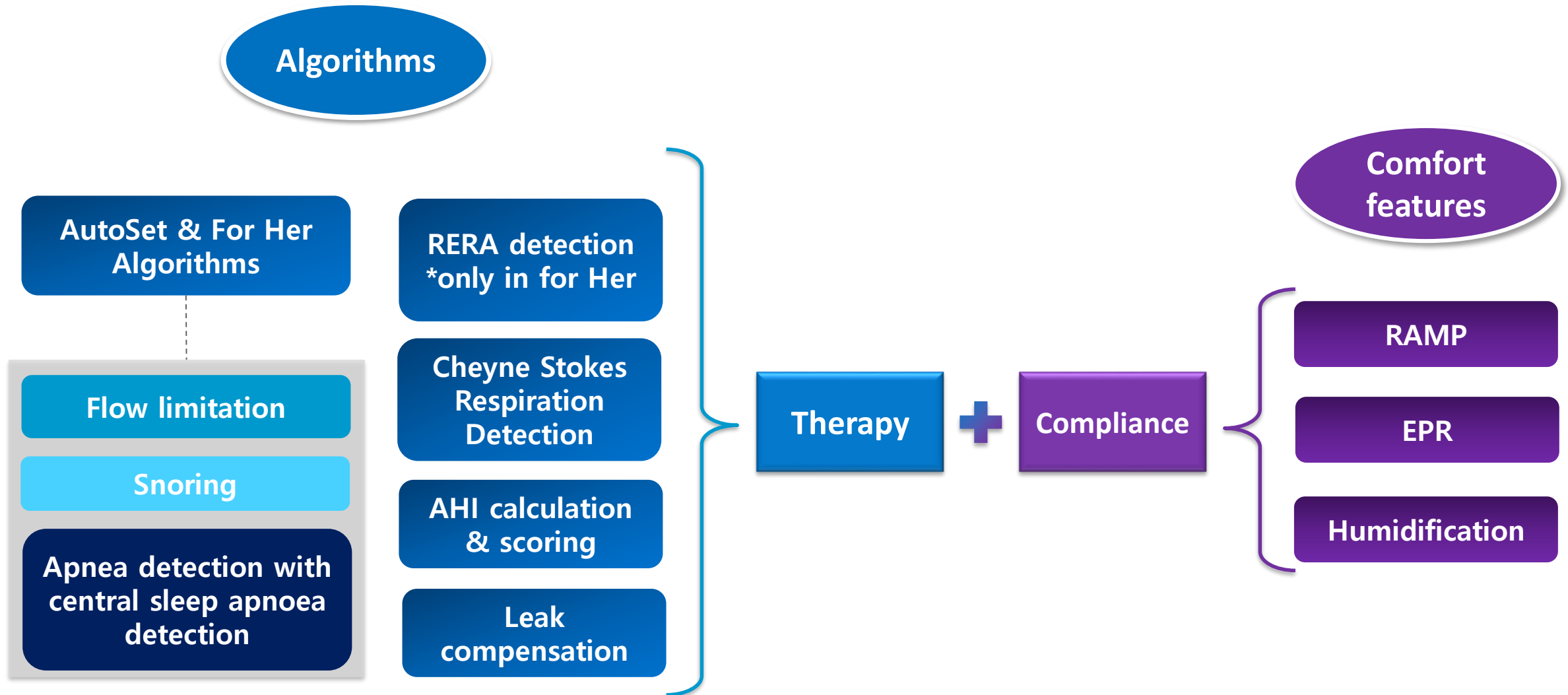
AirSense10 Algorithms and Comfort feature



Event detection - History



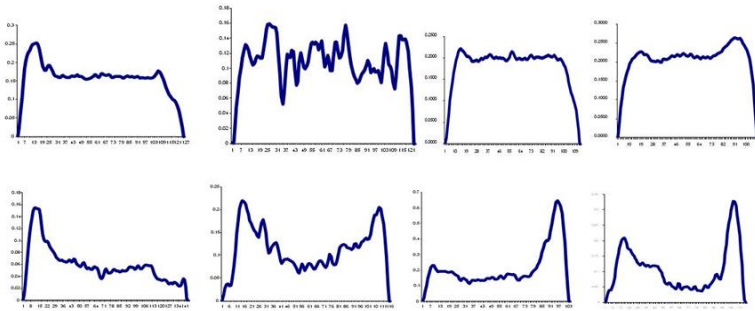
★ ResMed Algorithms and Comfort features



Sleep related Events Detection

Flow limitation

The algorithm is able to detect **multiple** flow limitation shapes



- 3 breaths moving average
- Several flow characteristics are considered to gauge **severity**

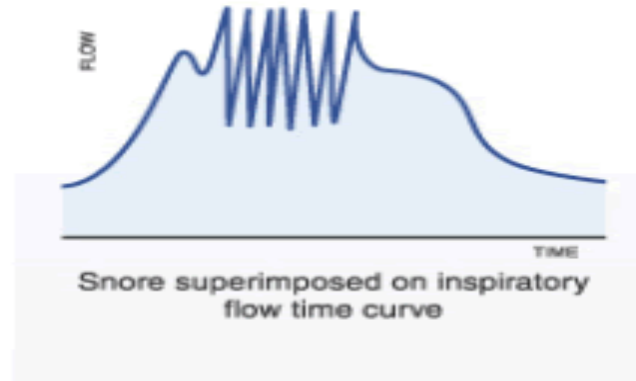
FL Severity

**=Tidal volume + Shape of flow curve
+ Inhalation stretching**

- Once the event is corrected, 20 minutes pressure decay time

Snoring

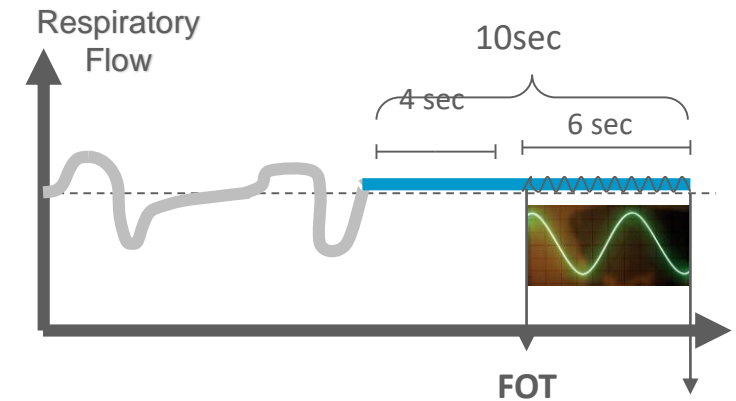
Noise fluctuation(vibrations) are detected using the pressure sensor in the flow generator



- 1 breath moving average
- It measures oscillations in the flow-time curve
- Once the event is corrected, 20 minutes pressure decay time

Apnoea

A way to measure patient respiratory impedance at the top of the upper airway and determine if it is **open(detect as a CSA)** or **closed(detect as a OSA)**



Apnea type detected : OSA or CSA or Unknown

- Once the event is corrected, 40minutes pressure decay time

8개의 양압기 벤치 테스트 시뮬레이션 결과 레즈메드 AutoSet 알고리즘 2개 포함, 단 3개의 제품이 호흡정상화 증명

TABLE 1 Responses of automatic continuous positive airway pressure (APAP) devices to obstructive sleep apnoea simulated by the bench test

APAP device	P_{\max} cmH ₂ O	t_{\max} min	P_{mean} cmH ₂ O	Residual AHI events per h	Breathing normalisation
A1	17.9, 17.8	22.4, 19.0	14.6, 14.6	2.0, 2.0	Yes, yes
A2	15.4, 15.6	40.3, 57.7	13.4, 13.5	2.0, 1.5	Yes, yes
B	10.5, 10.5	130.6, 121.3	6.7, 7.9	74.5, 71.0	No, no
C	13.4, 13.9	28.0, 44.1	12.4, 12.2	3.0, 3.0	Yes, yes
D	10.7, 10.7	75.1, 103.7	9.7, 9.7	26.5, 32.5	No, no
E	10.4, 10.4	20.7, 18.9	10.2, 10.2	3.5, 2.5	No, no
F	11.9, 12.1	34.4, 36.0	10.1, 10.1	11.5, 13	No, no
G	10.5, 11.0	32.2, 83.2	9.9, 9.9	33, 26.5	No, no

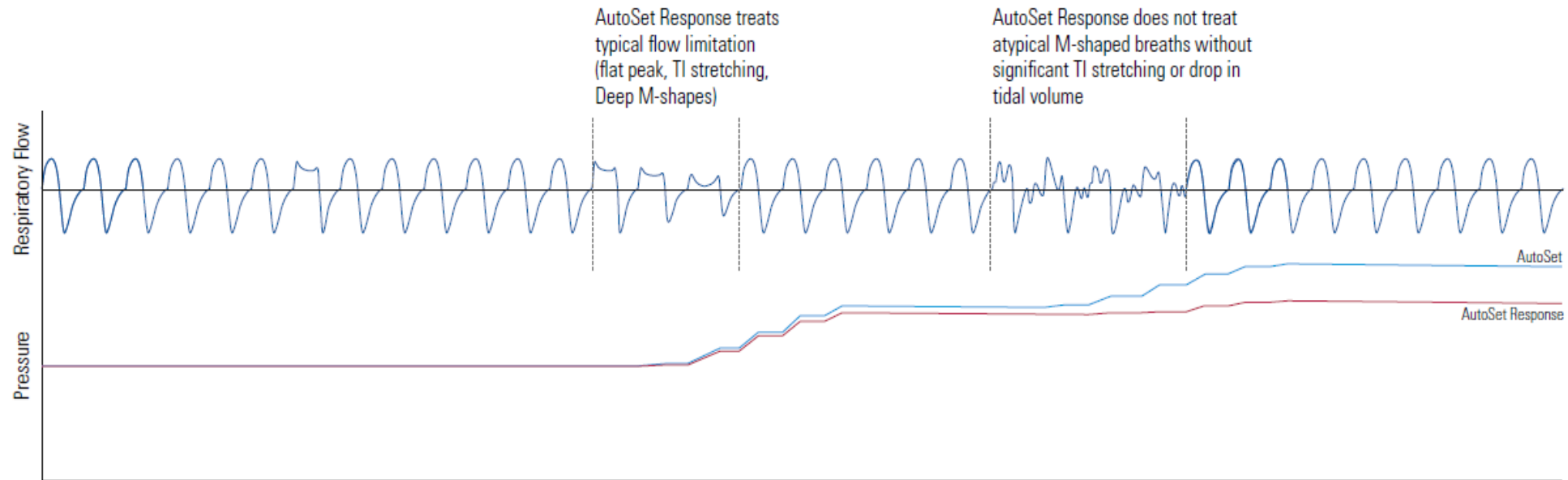
The two values for each variable correspond to the results obtained in the two test repetitions in each device. P_{\max} : maximum positive airway pressure applied; t_{\max} : time to reach $P_{\max} \pm 0.3$ cmH₂O; P_{mean} : mean positive airway pressure; AHI: apnoea-hypopnoea index; A1: AirSense 10, standard setting; A2: AirSense 10, response setting; B: Dreamstar; C: Icon; D: Resmart; E: Somnolance; F: System One; G: XT-Auto.

레즈메드
AutoSet 알고리즘 사용

Comparative assessment of several automatic CPAP devices' responses: a bench test study
ERS open research_2015

AutoSet Response : Standard vs Soft

Soft with gentler pressure increases for additional comfort for patient

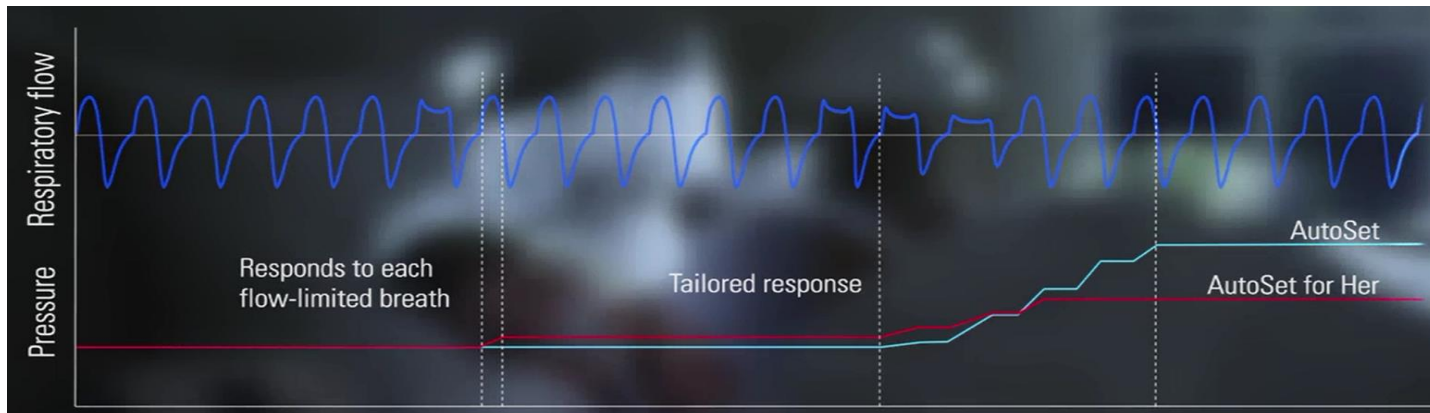


Note:

1. The standard Autoset reacts to all breath shapes(**blue line**).
2. The AutoSet Response(**red line**) reacts to the usual flow limitations only.
It is a softer response to flow limitation with an overall lower target pressure range.



- The Women may present differently (more flow limitation or RERAs).
- Some women may be disturbed by the changes in pressure when using AutoSet.
- The for Her algorithm : **Slower & Lower pressure rise and Slower decay**



Clinical evidence *Study Of A Novel Automatic Positive Airway Pressure Algorithm For The Treatment Of Obstructive Sleep Apnea In Women, N.McArdle, MD, SLEEP 2015;38(11):1775–1781.*

AfH is as effective as the standard AutoSet algorithm in controlling OSA. AfH may **reduce flow limitation more than the standard algorithm** and achieve control of OSA at a lower pressure to the women OSA patients.

ResMed Unique Solution



Female OSA patient
Start with: **AutoSet for Her**

Q: Is AHI too high?

NO

Continue on AutoSet For Her

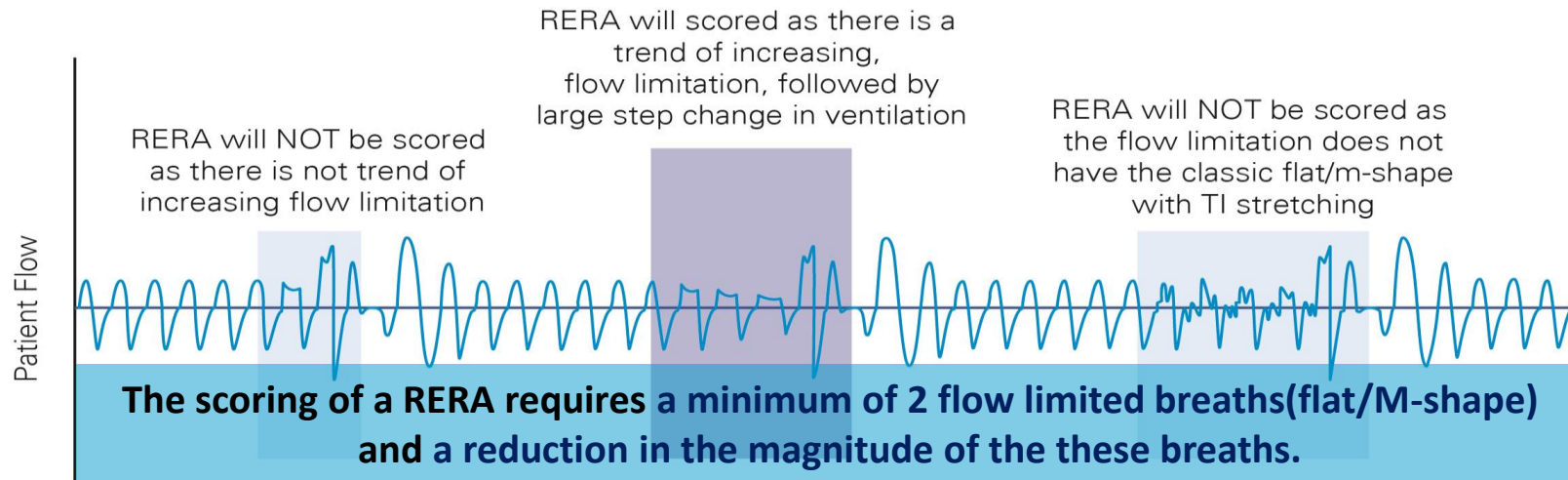
YES

- Trial Standard AutoSet



Respiratory Effort Related Arousals(RERAs) detector measures the number of events which disturb the patients breathing during their sleep.

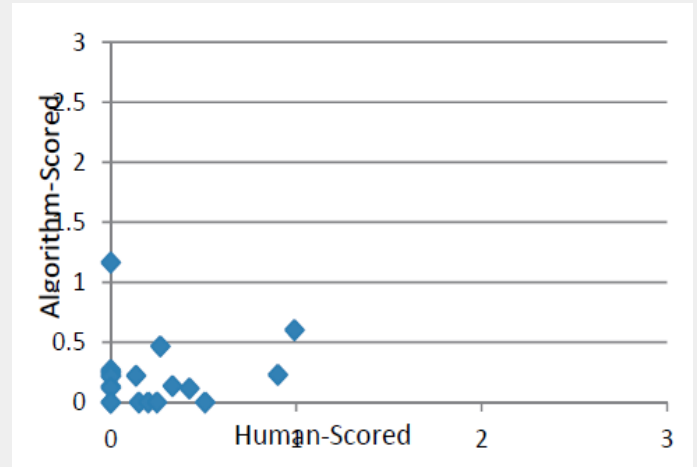
- This is important as many short apneas may not make the threshold to be identified and logged as an apnea(10sec) or hypopnea, and hence are overlooked in the overall assessment of sleep quality.
- It alerts the clinician to the presence of residual breathing issues and to the need to modify treatment.



RERA Detection – Clinical evidence

J. P. Armistead – White paper - AirSense™10 Apnea Hypopnea Index (AHI) Scoring and Advanced Event Detection – 2014

Shows that the RERA scored by the AutoSet for Her is accurately aligned with what a human scorer would select as a RERA



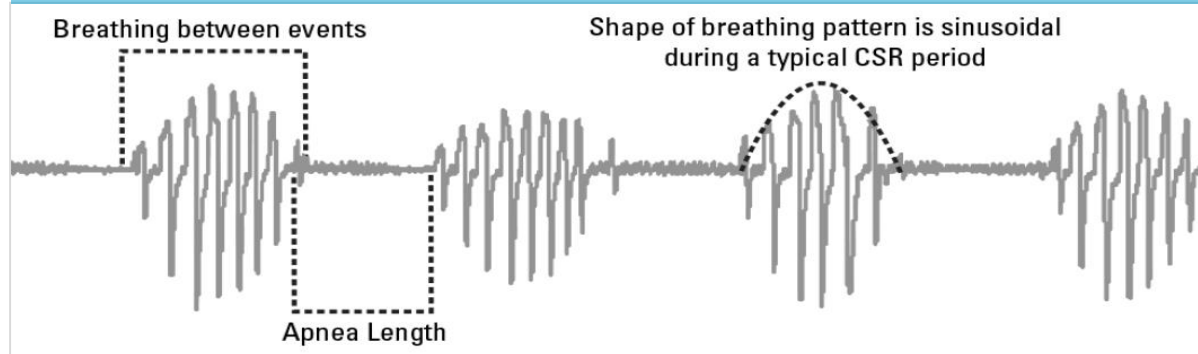
Non-parametric analysis of the data, comparing human (0.21 ± 0.3) and algorithm(0.22 ± 0.27) scoring showed no significant difference in the outcome, based upon the scoring method used ($p = 0.87$).

Cheyne-Stokes Respiration detection further enhances effective therapy management by providing additional clinical insights

Not all patients with **CSR/CSA will initially be diagnosed** or **prescribed ASV therapy**

- This means that some patients with CSR will end up on CPAP or AutoSet
- Reliably detecting CSR will allow for such patients **to be correctly treated**

The algorithm looks for breathing patterns representative of CSR over a minimum of 15 minutes

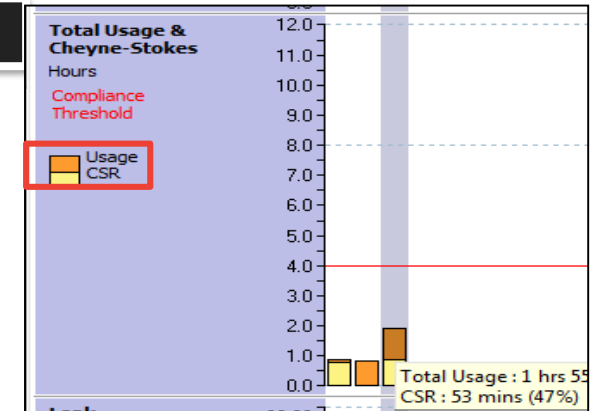


CSR Detection – Clinical evidence *Validation of a Cheyne-Stokes Respiration (CSR) detection algorithm for a CPAP device* 2014' ERS congress Abstract ID: 853722 Shows that this novel algorithm for detecting CSR breathing on the AirSense10 device is highly accurate and can be a useful tool for monitoring therapy.

AirView

Pressure - cmH2O	Median: 64.4	95th percentile: 107.2	Maximum: 100.6
Leaks - L/min	Median: 14.9	95th percentile: 16.4	Maximum: 18.1
Events per hour	AI: 13.4	HI: 19.9	AHI: 33.3
Apnea Index	Central: 70.6	Obstructive: 107.6	Unknown: 144.3
Cheyne-Stokes respiration (average duration per night)			2 hours 31 minutes (53%)

ResScan



AHI Scoring Accuracy

American Journal of Respiratory and Critical Care Medicine 2013;201:A3747



Accuracy of AHI Detection of the S9 AutoSet APAP Device



Gerhard Weinreich¹, Wang Yi¹, Jeffrey Armitstead^{2,3}, Peter Bateman³, Glenn Richards³, Helmut Teschler¹

¹Department of Pneumology, Ruhrlandklinik, West German Lung Center, University Hospital Essen, University Duisburg-Essen, Germany

²University of New South Wales, Sydney, Australia,

³ResMed Ltd, Sydney, Australia

Method :

- 150 subjects, overnight PSG for suspected OSA, during APAP titration.
- PSG: EEG, EMG, ECG, SpO2, position and (RIP) chest and abdomen as well as APAP device patient flow, leak and mask pressure.
- PSGs were manually scored using device flow for respiratory events according to the AASM 2007 recommended criteria.

PSG data(n=147)

AHI(per hour)	1.4(0.38-3.62)
AI(per hour)	0.3(0-1.14)
Arousal index(per hour)	9.3(6.6-14.4)
Sleep time(min)	272(230-294)
Sleep efficiency(%)	71(62-81)

Results

We included 147 patients in the study. The AHI was substantially reduced on therapy(AHI = 1.4/h, range 0.4-3.6/h).

Using a PSG cut-off of AHI>5/h for residual events, a device-reported value of 7/h was associated with a sensitivity of 93% and a specificity of 91%.

Device-reported CAI at a value and a specificity of 92% for detecting residual central sleep apnea.

Conclusions

The AHI reported by the AutoSet device was accurate and showed a high correlation with AHI determined using laboratory PSG.

Comparison table

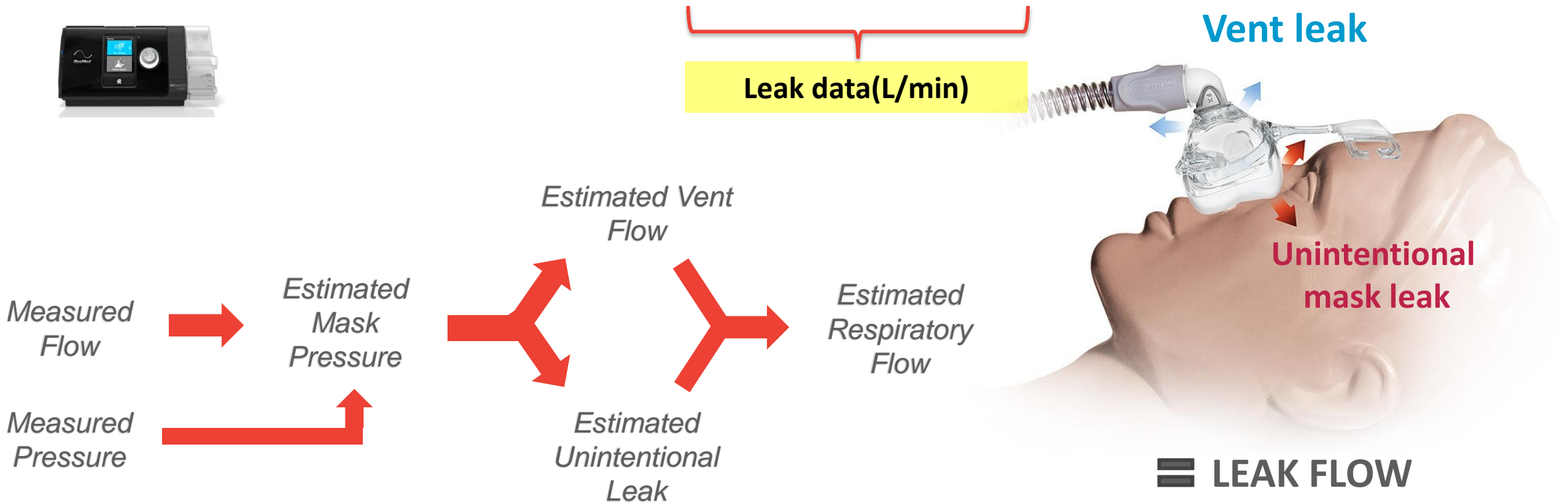
Appendix

	S9 AutoSet	AirSense AutoSet	AutoSet Response	AutoSet for Her
Flow limitation	✓	✓	✓	✓
Moving average	3 breaths	3 breaths	3 breaths	1 breath
Pressure increase cap	---	0.6 cmH2O per breath	0.6 cmH2O per breath	0.5 cmH2O per breath
Decay	20 minutes	20 minutes	20 minutes	60 minutes
Snoring	✓	✓	✓	✓
Moving average	5 breaths	1 breaths	1 breaths	1 breaths
Pressure increase cap	---		0.6 cmH2O per breath	0.5 cmH2O per breath
Decay	20 minutes	20 minutes	20 minutes	20 minutes
Apnoeas	Reacts to obstructive only	Reacts to obstructive only	Reacts to obstructive only	Reacts to obstructive only
Pressure response	Standard	Standard	Standard	Standard
Pressure increase cap	3 cmH2O per increment	3 cmH2O per increment	0.6 cmH2O per breath 3 cmH2O per increment	0.5 cmH2O per breath 2.5 cmH2O per increment
Decay	40 minutes	40 minutes	40 minutes	40 minutes

Leak Detection Algorithm

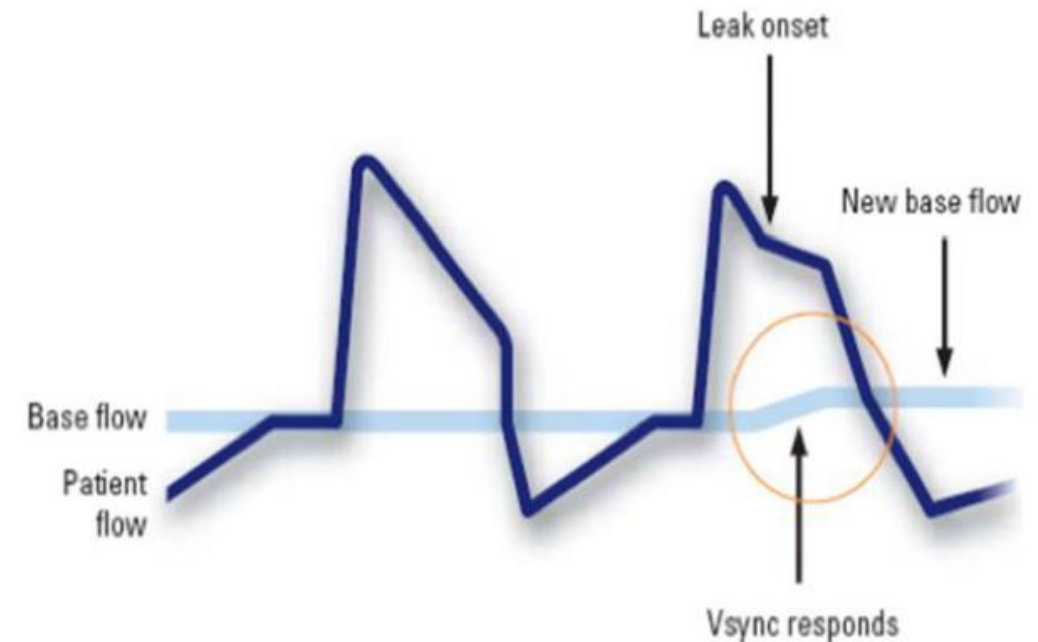
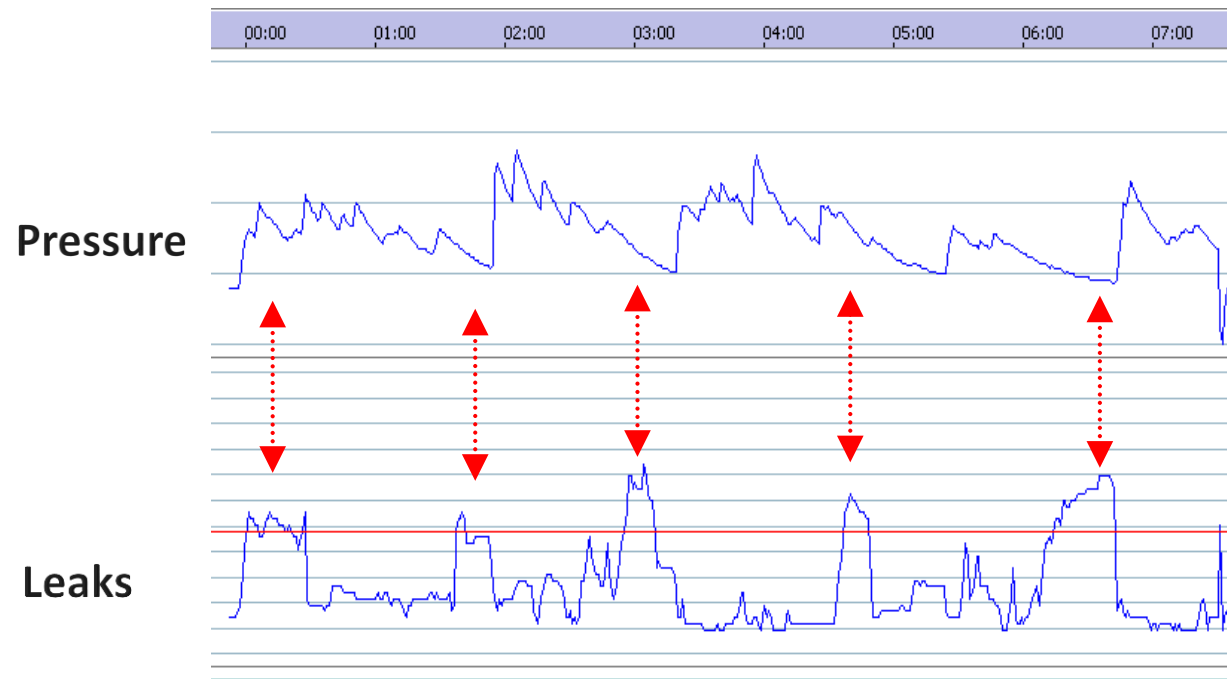
Algorithm path : Estimating Respiratory Flow(with Flow Sensor)

$$\text{Total Flow(Device)} = \text{Patient Flow} + \text{Vent Leak} + \text{Unintentional Mask Leak}$$



Leak Compensation

- The AutoSet is capable of compensating for leaks up to 1 L/s
- For leaks above 0.5L/s, as flow curve becomes harder to read, algorithm responsiveness is de-weighted and pressure response to any event softened to prevent waking up the patient by increasing the leak.



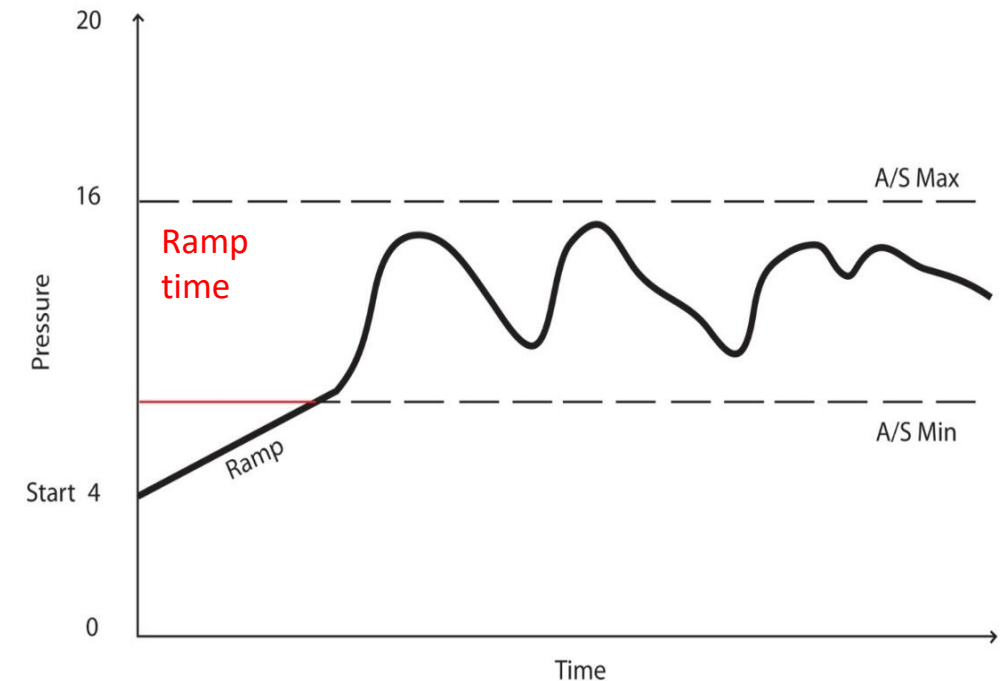
Comfort Feature 1 : RAMP

RAMP

Designed to make the beginning of therapy more comfortable, Ramp Time is the period during which the pressure increases from a low start pressure to the prescribed treatment pressure.

Ramp Time

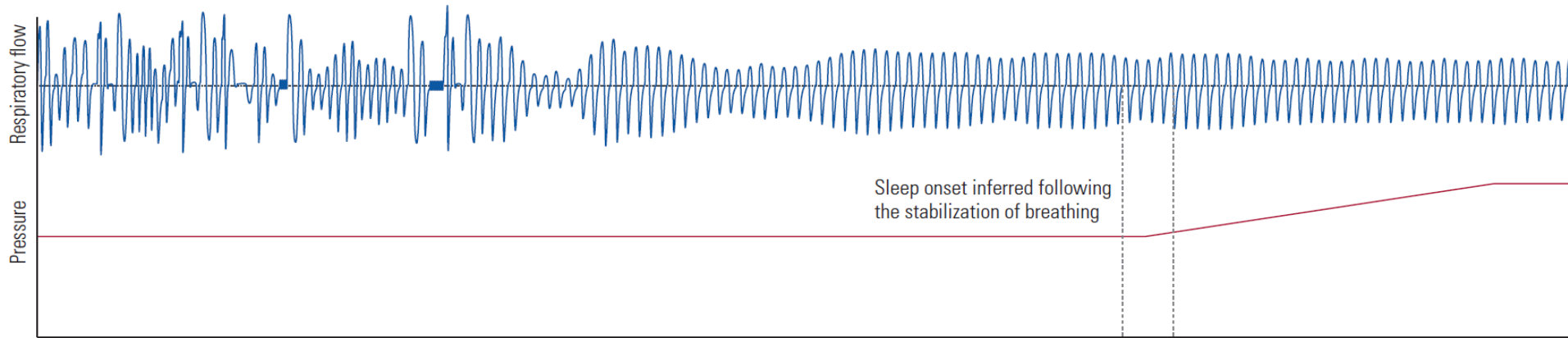
- **Setting options : OFF, 5-45min, AUTO**
- Ramp Time : 5 to 45 minutes
- AutoRamp : detect when you have fallen asleep (<30min) , then automatically rise to the prescribed treatment pr.
 - 3 OA or OH events within 2 minutes
 - 5 consecutive snore breaths
 - 30 stable metronomic (consistent) breaths



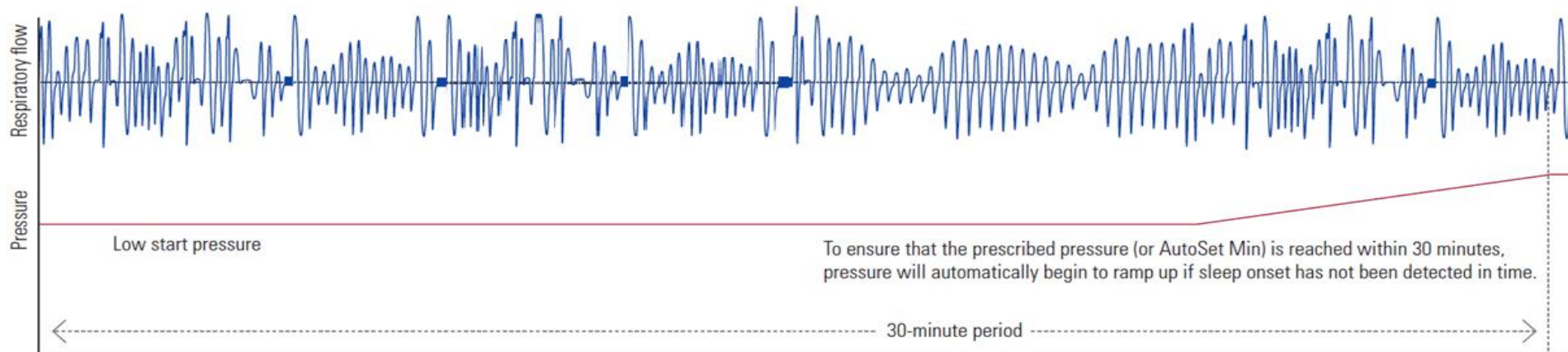
AutoRamp with Sleep Onset Detection

Patient always get to their therapy pressure **within 30 minutes**

Sleep onset detected increases pressure 1cm per min



No Sleep onset detected increases 1 cm per min to reach pressure within 30 minutes



Comfort Feature 2 : EPR

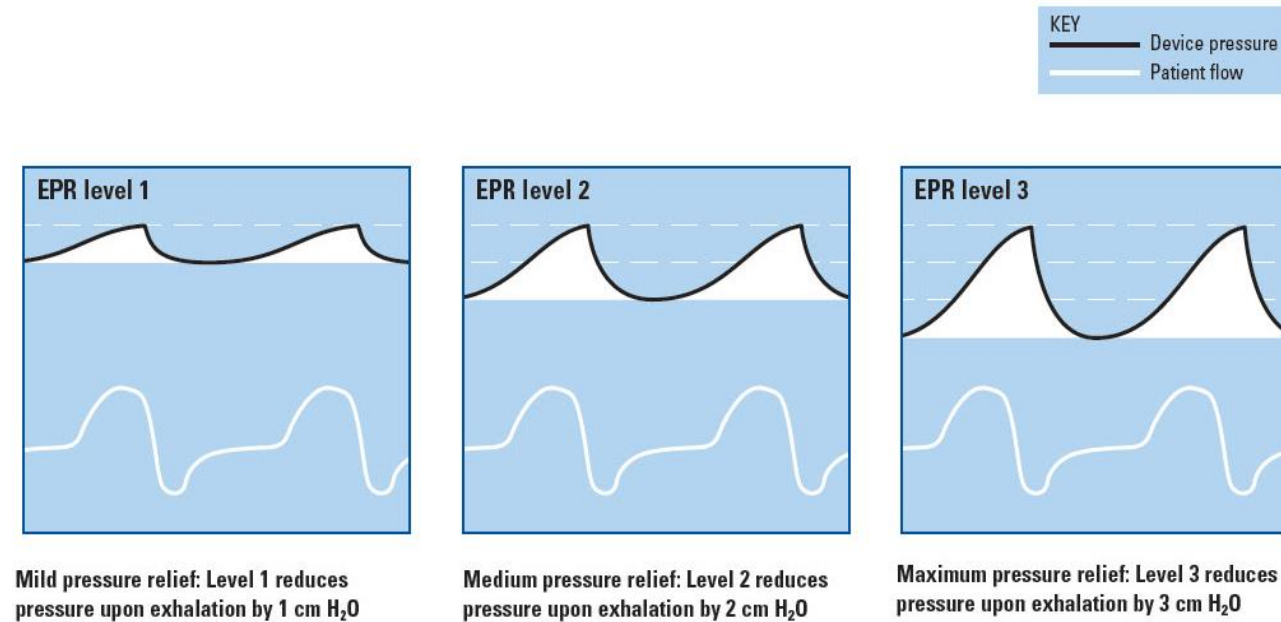
EPR with Easy-Breathe technology

Provides three levels of pressure relief to choose from and a variety of customizable comfort features

- Enhanced comfort
- Smoother, a more naturally pressured delivery
- Three predictable levels of pressure relief

EPR

- **Setting option : RAMP ONLY, FULL TIME ,OFF**
- Can be set to a **level of 1, 2 or 3 cm H₂O**



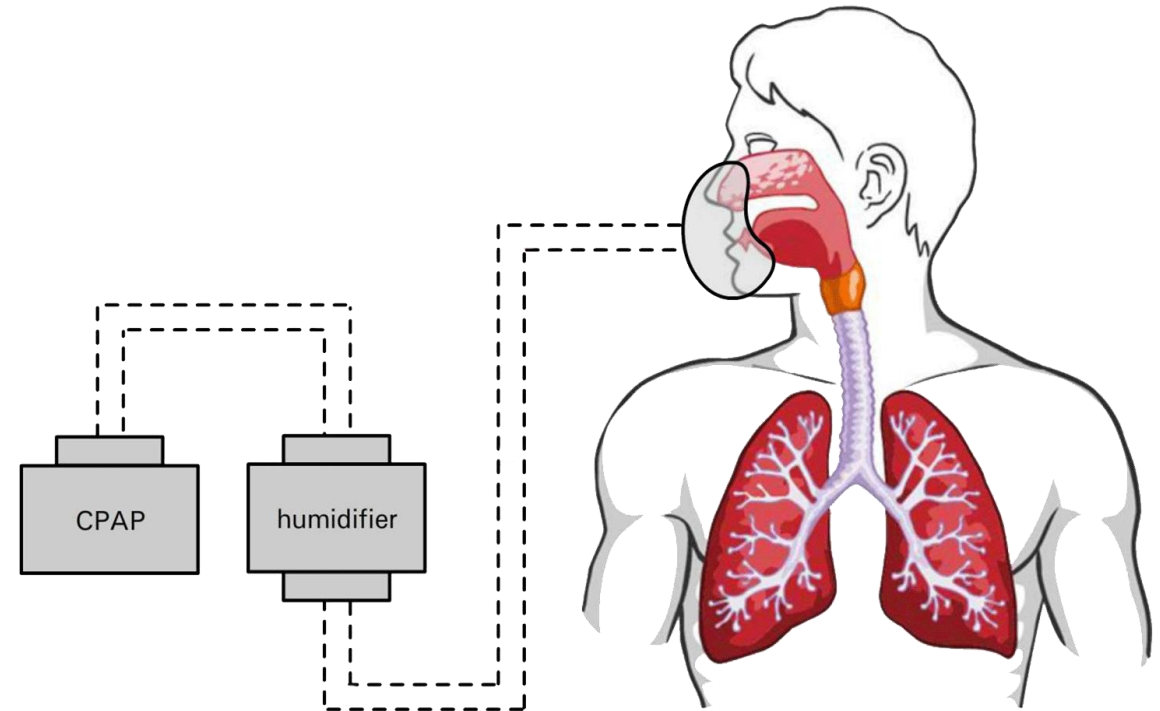
Comfort Feature 3 : Humidification

Why is Humidification Essential?

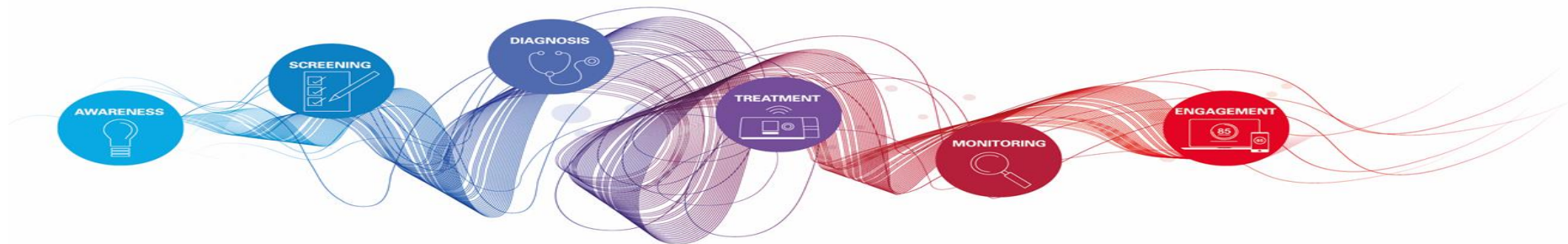
Humidification gives optimal comfort to the patients and it makes improvement of compliance.

ResMed Humidification System

- Default setting of **27°C** and automatically target of **85% RH**
- Delivering range between 75% - 95% RH
- Keeping clear of 100% avoiding rainout



Connected Care Solution



★ ResMed Monitoring Solutions

Connected Care; Integrated Care

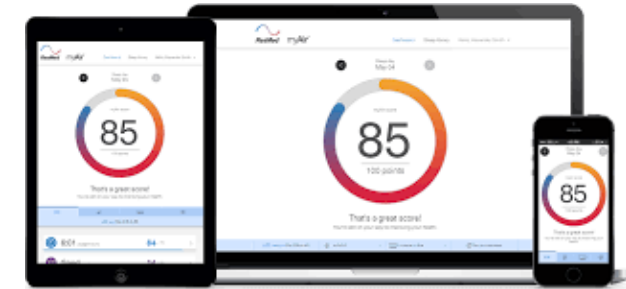
3G



의료진 및 HCP 사용

3G

myAir™



환자(양압기 사용자) 사용

AirView Data Utilization

Compliance Check

사용량 29/10/2019 - 27/11/2019	
사용 일 수	14/30 일 (47%)
>= 4 시간	9 일 (30%)
< 4 시간	5 일 (17%)
사용 시간	63 시간 31 분
평균 사용 (중 일 수)	2 시간 7 분
평균 사용 (사용 일 수)	4 시간 32 분
사용 중간값 (사용 일 수)	4 시간 30 분
총 사용 시간 (마지막 리셋 이래의 값 - 27/11/2019)	182 시간

AirSense 10 AutoSet	
일련번호	00072599986
모드	AutoSet
최소 압력	5.2 cmH2O
최대 압력	20 cmH2O
EPR	플타임
EPR 레벨	3
반응	소프트

치료	
압력 - cmH2O	중간값: 9.3 제95위 백분위수: 10.6 최대: 11.3
누출 - L/min	중간값: 0.0 제95위 백분위수: 6.0 최대: 13.7
시간당 이벤트	AI: 6.1 HI: 0.0 AHI: 6.1
무호흡 지수	중앙: 4.3 폐쇄성: 1.4 알 수 없음: 0.3
제안-스트레스호흡 (아간당 평균 지속시간)	20 분 (8%)
SpO ₂ - %	시간 < 88%: 18 분 중간값: 92 95번째 %: 97

사용 - 시간

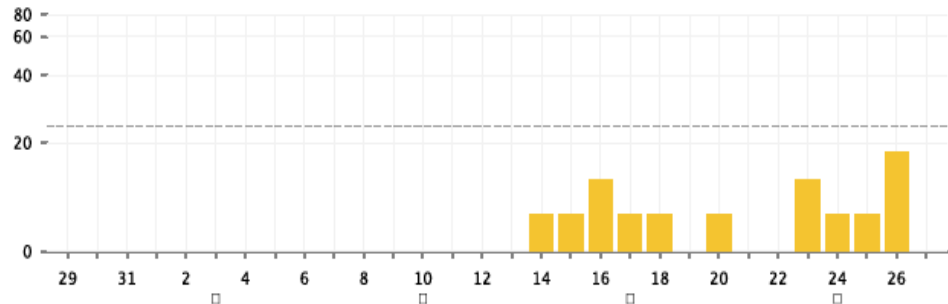


1. **순응도 평가 지표로 사용** : 보험 기준인 연이은 30일 중 1일 4시간 이상 사용한 날(70% 이상)
2. **순응이 지속되는지 확인** : 비순응일 경우, 추가로 다른 데이터를 살펴봐야 함

Leak Check

설정 임계값	24.0 L/min
최대 (평균)	13.7
95번째 % (평균)	6.0
중간값 (평균)	0.0

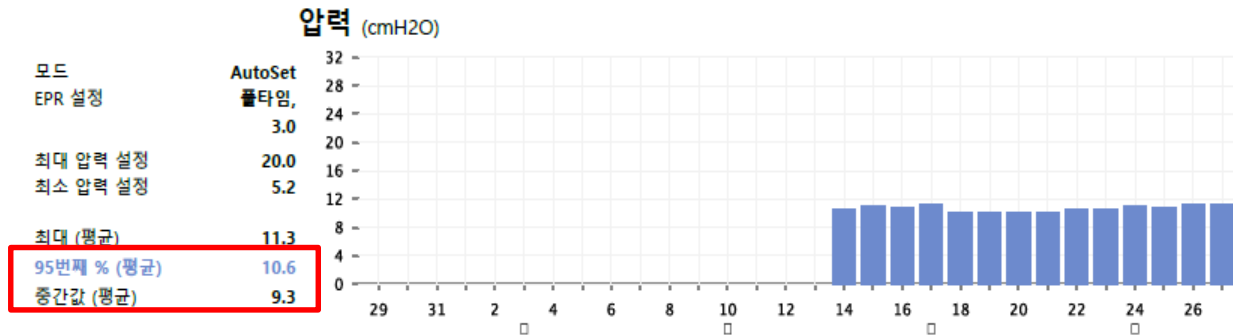
누출 (L/min)



1. **누출이 정상 범위(95번째 % : 24L/min, 중간값 : 12L/min 이내)인지 확인** : 누출이 많을 경우, 순응 및 부작용 등에 영향을 끼치기 때문에 확인 후 교정해야 함
2. **누출의 양상 확인** : Fluctuation 없이 Stable한 누출 양상인지, Mouth Leak 혹은 Mask Leak 어떤 것에 해당하는 지 확인하여 적절한 증재가 필요함

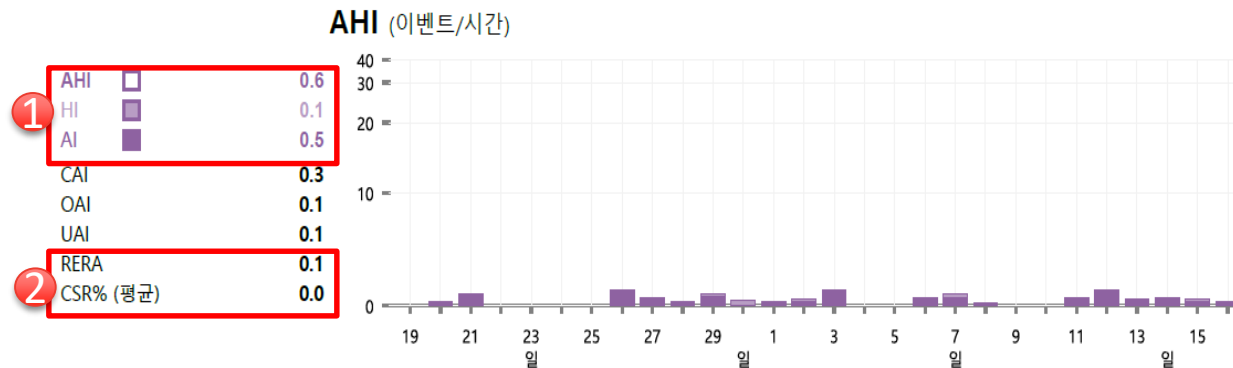
AirView Data Utilization

Pressure Check



APAP의 경우, 95번째 %와 중간값을 통해 환자에게 적절한 압력 범위를 찾아줄 수 있다!

AHI Check



1 Residual AHI 확인 : 처방된 압력에 AHI가 5미만인지, 치료가 되고 있는지 확인

2 AHI - CSA/CSR 여부 확인 : 총 AHI에서 CAI가 차지하는 비중이 50%이상이거나, CAI>5 이상인 경우 CSA를 의심해볼 수 있으며, CSR 여부도 동시에 확인 가능(CSA 치료 - ASV 양압기 사용으로 적절한 치료 적용)

RERA 여부 확인 : RERA 양상이 몇 번정도 나타나는지 확인하여 좀 더 깊이있는 관리 및 치료 도모

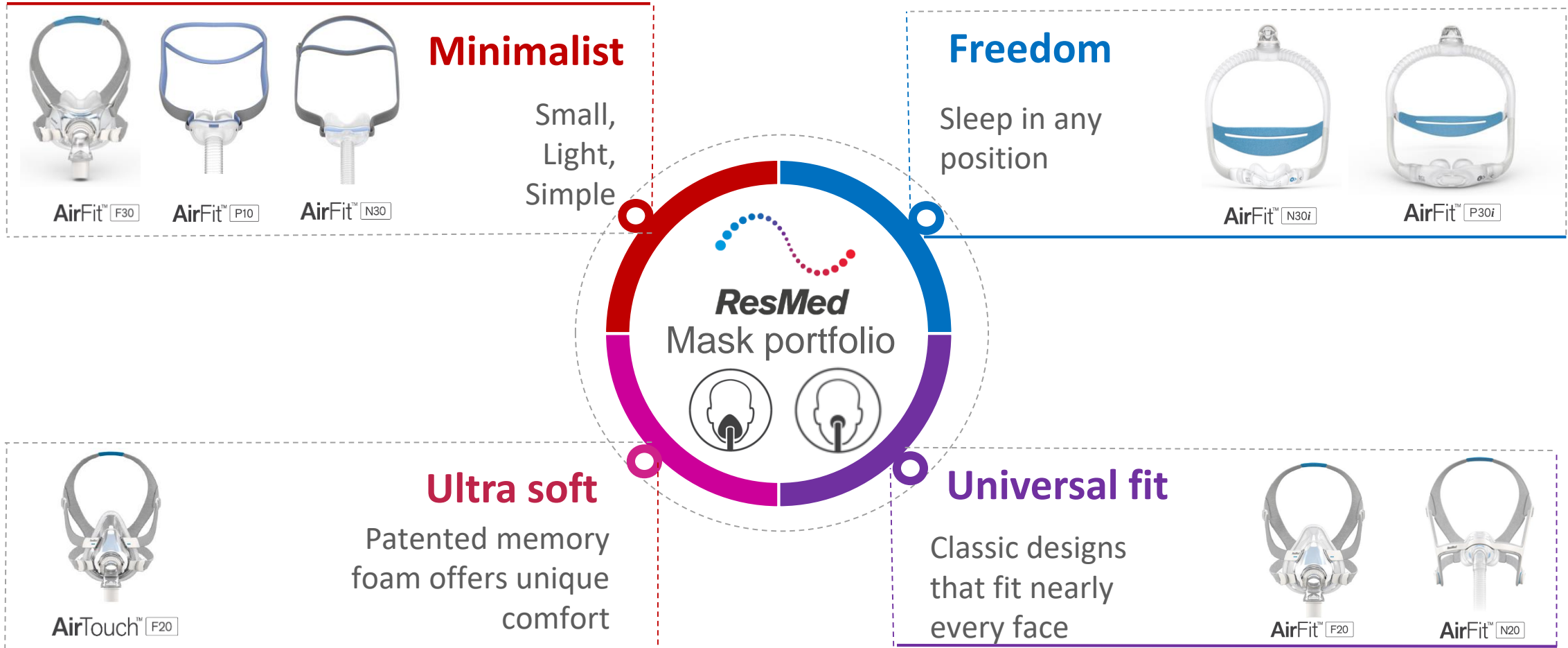


ResMed Mask features



ResMed makes choosing the right mask easy!

ResMed offers a portfolio of **high-performing, comfortable mask options** to meet the needs of every patient.





Minimalist

Small. Light. Simple.

For many users, their primary driver for mask choice is simple: less mask on their face. Small, lightweight, less footprint, easy to use and minimal noise – that's the identity of the minimalist category.

Masks in this category are as streamlined as they come. They're designed to fit more seamlessly into people's lives and to allow for minimal disruption to their normal sleep routine.

AirFit™ P10

Great for patients who want a quiet, smaller-style mask or get claustrophobic with larger masks



3-Part simplicity

QuietAir™ woven-mesh venting system

QuietFit™ elastic headgear

Lightweight integrated flexible tube



ResMed

Mask
Portfolio



Freedom

These masks allow users to sleep closer to their partner and in whichever position they prefer. With a modern look that breaks all the stereotypes of CPAP, this category can also help in the ongoing fight against CPAP mask stigma.

AirFit™ N30i

AirFit™ P30i

Great for patients who are active sleepers, prefer a nasal cushion(N30i)/quieter and pillow cushion(P30i) or who wear glasses, watch TV in bed or sleep on their stomach



Pinhole vent
(quiet system)



Flexible, ribbed
Frame for
conformity to
different head sizes

QuietAir™ woven-
mesh venting
system

Universal Fit

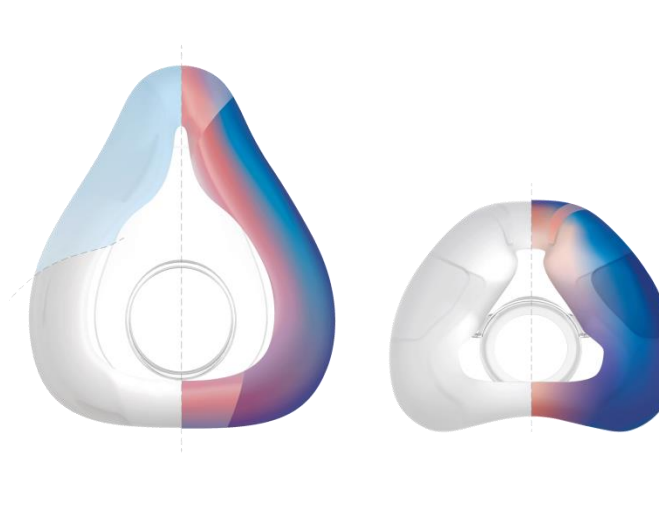
Tried and true – any patient, any pressure. As the CPAP mask space becomes increasingly specialized with niche products, the AirFit20 series will continue to endure as an indispensable part of our HMEs' businesses.

With a near 97% fit range across various nationalities,¹⁻³ these are the masks RTs will continue reaching for with confidence.

AirFit™ F20

AirFit™ N20

Great for patients who have a wider nasal bridge and those with pressure settings of 14cmH₂O or more



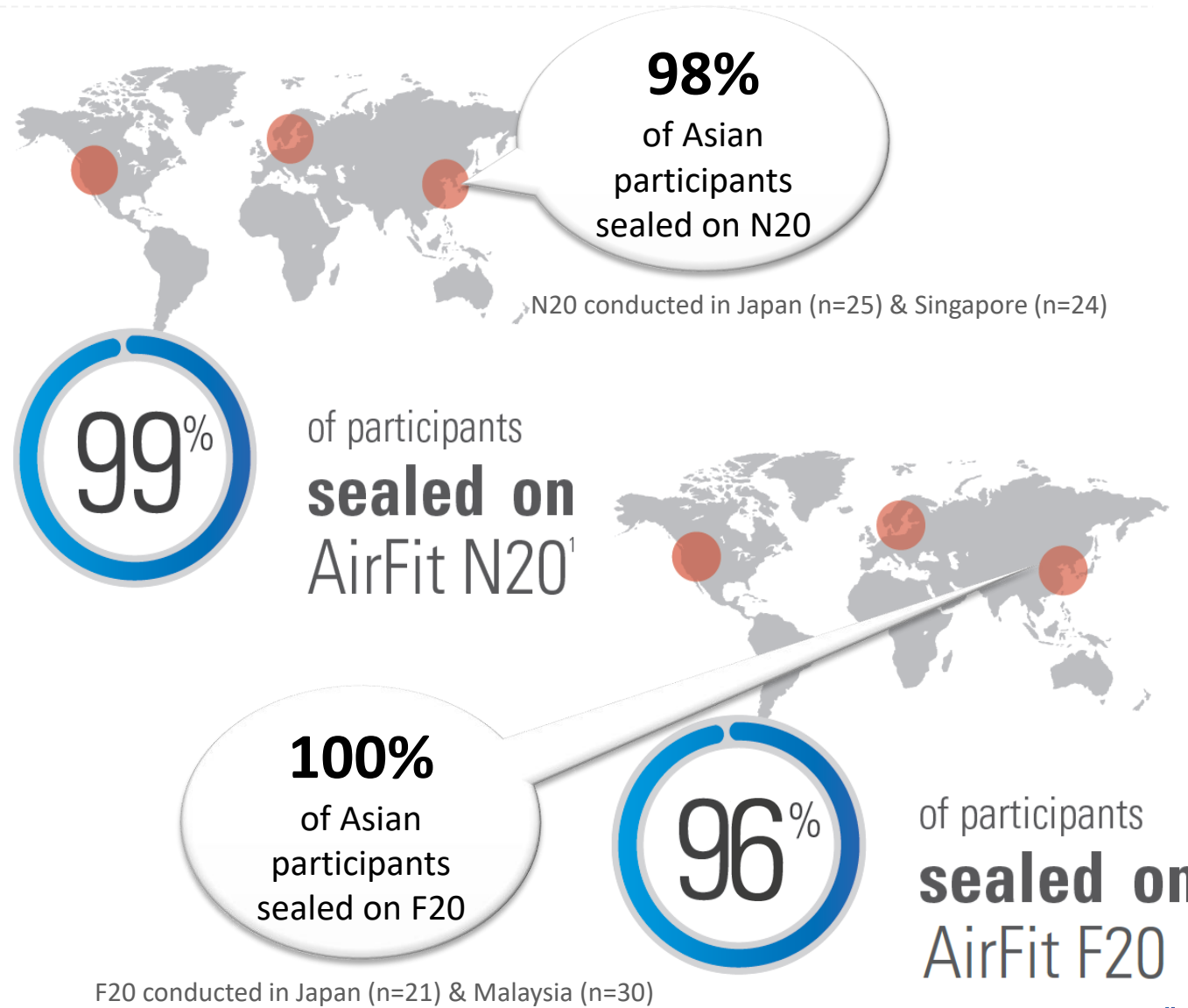
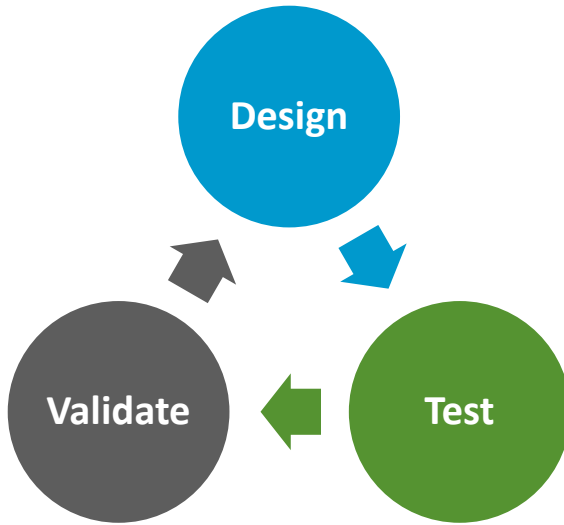
Infinity Seal Cushion
(optimal stability and fit)

A frame with built in
plush foam and soft
headgear

Strong Magnetic clips

1 ResMed AirFit F20 internal Australian fitting study of existing CPAP patients conducted between March–April 2016. 2 ResMed AirFit F20 internal USA fitting study of existing CPAP patients conducted April 2016. 3 ResMed AirFit F20 internal EU and APAC fitting study of existing CPAP patients conducted June 2016.

Asian Fit



Minimalist category

Small. Light. Simple.

Freedom category

Sleep in any position.

Ultra Soft category

Patented memory foam offers unique comfort.

Universal Fit category

Classic designs that fit nearly every face.

mouth open:



Full face



UltraSoft Memory Foam



mouth
Closed:



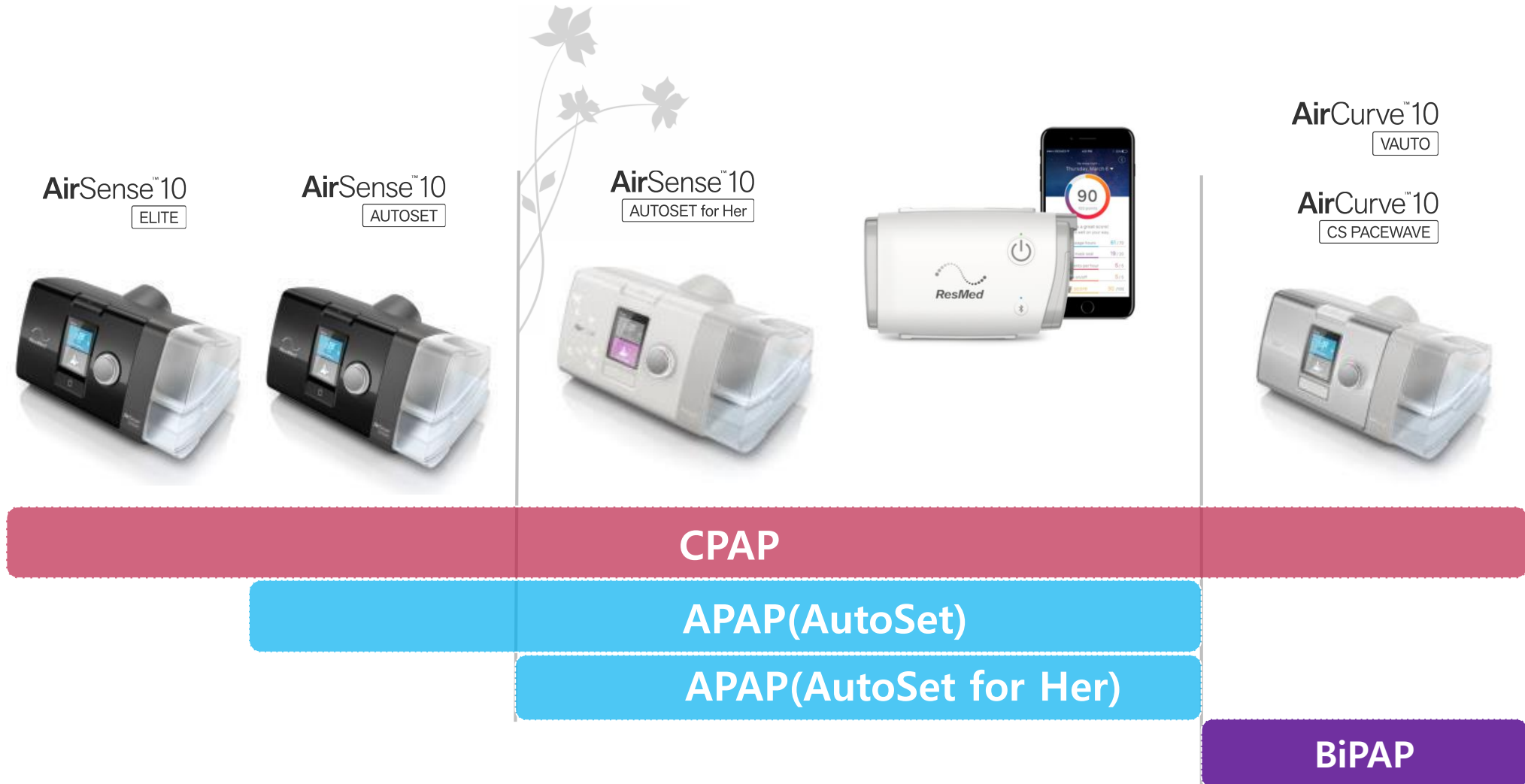
Nasal
Pillow



감사합니다.



ResMed PAP Therapy Solution

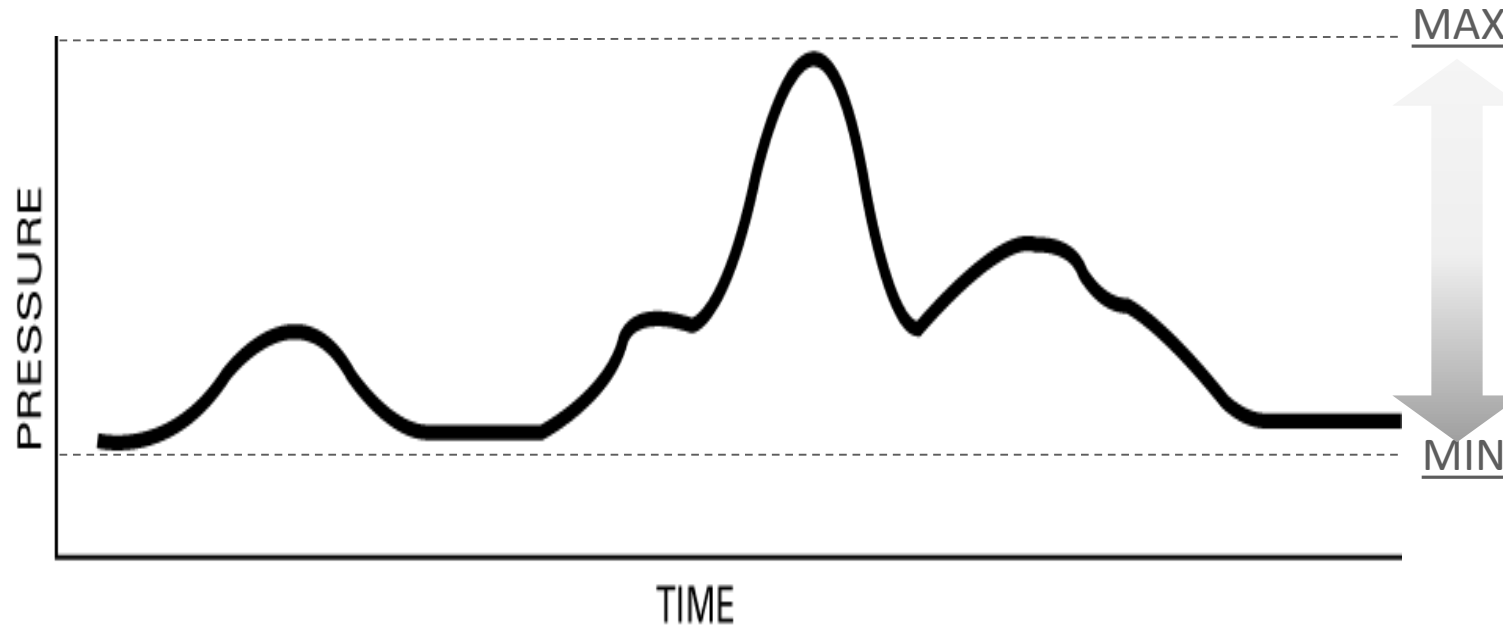


AirSense10 AutoSet Algorithms

AutoSet algorithm is a special '*auto-titrate*' algorithm to calculate and adjust the treatment pressure as required



Pressure changes
per Breath



Flow limitation

Snoring

Obstructive
Apnoeas

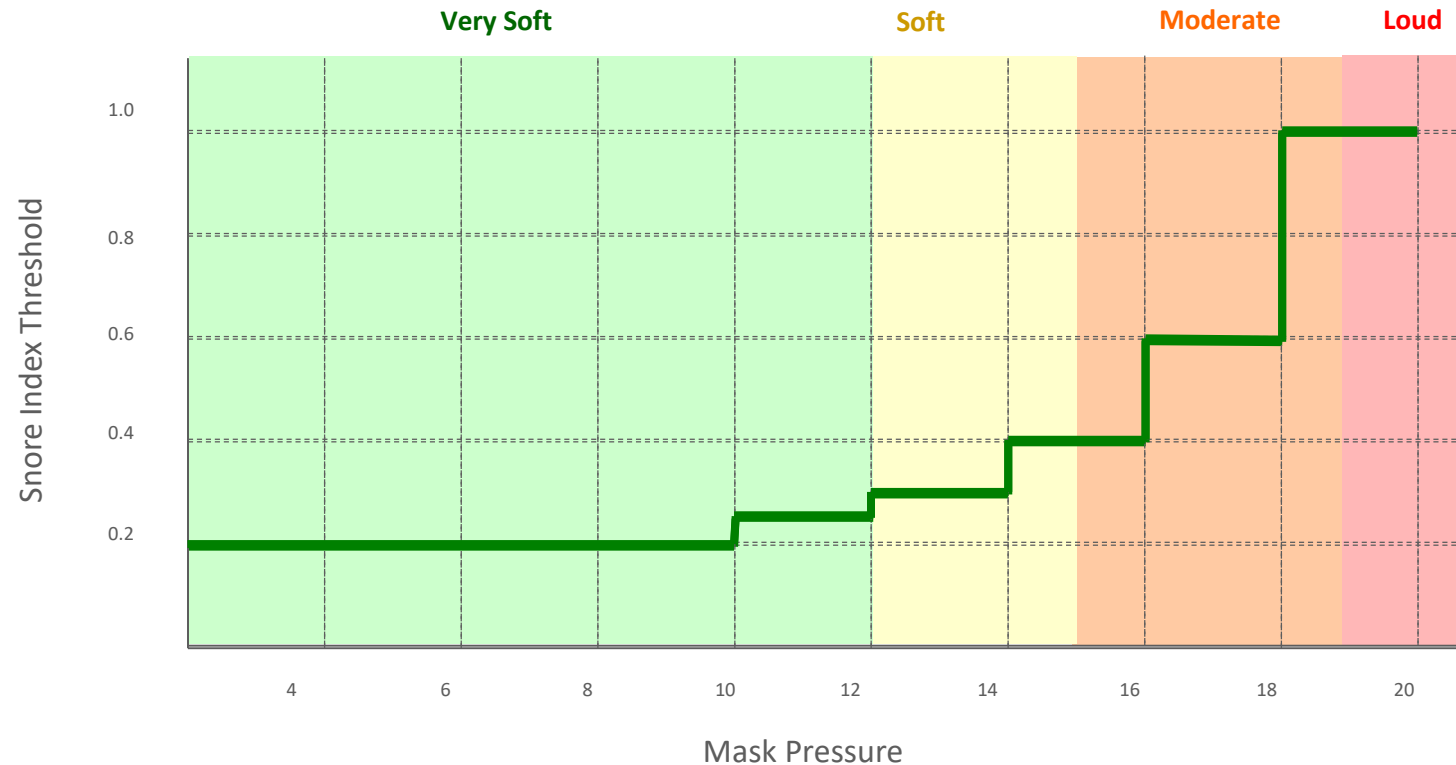
Snoring

Appendix

Noise fluctuations (vibrations) are detected using the pressure sensor in the flow generator.

Snore is measured on a relative scale using “units.”

Limited to 30-300 Hz



➔ If the device records and increase in tidal volume, pressure won't increase as this is likely to be a sigh rather than snoring

What is the pressure increase per unit of snore?

Answer: 1.5 cm H₂O per unit above the threshold

