SANRAI INTERNATIONAL

Precision in Pressure: The Impact of Advanced CPAP Event Detection on Cardiovascular Health and Hypertension Management

WHITE **PAPER**

Summary

Continuous Positive Airway Pressure (CPAP) is the gold standard for treating Obstructive Sleep Apnea (OSA), a condition inextricably linked to hypertension and cardiovascular risk. However, the efficacy of this therapy relies heavily on the device's ability to accurately detect and respond to respiratory events. Recent research highlights a critical challenge: unintentional air leaks, which are common in real-world settings, can severely disrupt device algorithms.

This white paper synthesizes recent findings to demonstrate how accurate event detection during leaks prevents unnecessary pressure escalation, resulting in optimized therapy for the patient. It continues on to examine the dangerous comorbidities associated with OSA and presents recent evidence from 2025 demonstrating how Continuous Positive Airway Pressure (CPAP) therapy serves as a critical intervention for lowering blood pressure and mitigating long-term cardiovascular risk.

Part I: Overcoming the Technical Barrier – Event Detection Under Real-World Leak Conditions

I. The Challenge: Unintentional Leaks in Real-World Therapy

While CPAP efficacy is well-established in controlled environments, real-life usage introduces a significant variable: unintentional leaks. All masks must have intentional leak to ensure carbon dioxide is not accidentally re-breathed. This leak varies based on the type of mask and must be accounted for by the CPAP device. These leaks, whether continuous or intermittent, complicate the monitoring and therapeutic landscape.

- **Prevalence of Leaks:** Unintentional leaks are a frequent occurrence in home CPAP therapy, stemming from mask fit issues or patient movement. Unless you have an absolutely perfect mask seal, there will be unintentional leaks. These types of mask leaks tend to be continuous. Patient movement or variations in exhalation patterns can cause intermittent leaks.
- **Disruption of Algorithms:** A 2025 study by Richard et al. demonstrated that leak patterns, particularly intermittent ones, significantly compromise the accuracy of auto-CPAP devices. The study found that specific leak patterns led to a "significant and systematic decrease in the devices' ability to accurately identify and classify respiratory events"[2].
- **Inconsistent Performance:** When subjected to rigorous bench testing using real-life leak profiles, many commercially available devices failed to maintain detection accuracy, with performance varying widely between manufacturers[2].

Table 1

		Baseline						
Resmed Airsense 11	OA	100	100	100	100	100	100	100
	CA	100	116.7	100	100	66.7	116.7	100
Philips Dreamstation 2	OA	100	100	100	100	66.7	100	100
	CA	100	116.7	100	66.7	66.7	100	83.3
Sanrai Reve	OA	100	100	100	83.3	83.3	100	100
	CA	100	100	100	100	183.3	100	100
Lowenstein Prisma Smart Max	OA	100	100	100	100	0	83.3	100
	CA	100	100	100	100	16.7	100	100
BMC G3 A20	OA	50	0	50	0	0	16.7	66.7
	CA	100	100	100	83.3	16.7	116.7	100

Overestimation
Good detection
Bad detection

% of detected events

This heatmap shown in Table 1 shows how 5 different devices perform in the presence of different types of unintentional leaks. There were 6 respiratory events (apneas and hypopneas) simulated during each leak type. The % shown is the percentage of accurately detected respiratory events. All devices will perform poorly with extreme intermittent leaks as shown in the 5th column.

The below Table 2 is the performance for the Reve Auto CPAP in this same study.

Table 2

	Baseline						
OA	100.0 %	100.0 %	100.0 %	83.3 %	83.3 %	100.0 %	100.0 %
CA	100.0 %	100.0 %	100.0 %	100.0 %	183.3 %	100.0 %	100.0 %
OH	100.0 %	100.0 %	100.0 %	133.3 %	216.7 %	100.0 %	100.0 %
CH	100.0 %	100.0 %	100.0 %	100.0 %	316.7 %	100.0 %	100.0 %

Overestimation
Good detection
Bad detection

% of detected events

The Reve Auto CPAP was the only device to accurately detect all obstructive and central obstructions as well as obstructive and central hypopneas during unintentional leaks. This level of detail is available on all standard reports and can be customized to show the most relevant residual AHI.

II. The Risk of Misclassification: When Central Apneas Mimic Obstructions

The most critical error induced by air leaks is the misclassification of respiratory events. Auto-adjusting CPAP (APAP) devices rely on distinguishing between Obstructive Apnea (airway collapse requiring pressure) and Central Apnea (lack of respiratory effort requiring no pressure increase).

- **The Misclassification Error:** Under conditions of unintentional leakage, algorithm performance degrades. Richard et al. reported that "some devices consistently misclassify central apneas as obstructive apneas"[2].
- **The Pressure Consequence:** This differentiation is pivotal for auto-titration. If a device correctly identifies a Central Apnea, it should maintain current pressure, as increasing pressure does not resolve central events and may exacerbate them. Conversely, if a Central Apnea is misclassified as Obstructive, the device will respond by raising the pressure. As noted by Richard et al., "we can assume that this misclassification would likely lead to an inappropriate increase in auto-adjusting pressure"[2].

- The Reve Auto CPAP differentiates central from obstructive apnea using a clinically validated algorithm that detects cardiogenic oscillations in the CPAP flow signal, which serve as a specific indicator of central apnea, as evidenced by Ayappa et al.[4]

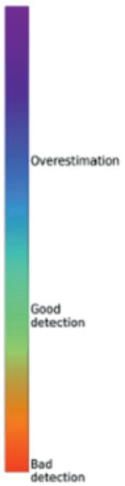
III. The Solution: Advanced Algorithms and Lower Therapeutic Pressures

The goal of APAP therapy is to deliver the minimum pressure required to keep the airway open. Achieving this goal requires algorithms capable of ignoring the "noise" of leaks.

- **Benchmarking Success:** Recent evaluation of the algorithm found in the Reve Auto CPAP by Sanrai illustrates that highly accurate detection is achievable. In bench tests, the device demonstrated "no impact of moderate leaks on the detection and classification of central apneas"[1].

Table 3

Leak pattern	Baseline	C1	C2	I1	I2	I3	C3
Obstructive apnea	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)
Central apnea	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	8 / 6 (133%)	6 / 6 (100%)	6 / 6 (100%)
Obstructive hypopnea	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	7 / 6 (117%)	10 / 6 (167%)	9 / 6 (150%)	6 / 6 (100%)
Central hypopnea	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	6 / 6 (100%)	9 / 6 (150%)	6 / 6 (100%)	6 / 6 (100%)



% of detected events

This table 3 shows the results of subsequent bench testing for the Reve Auto CPAP, showing excellent results with perfect detection for consistent leaks and very good results for detections during intermittent leaks. Overall, this bench test is consistent with the paper by Richard et. al. in showing accurate detection of all possible events during various leak patterns except the most extreme intermittent leak as shown in I2.

- **Preventing Runaway Pressure:** Crucially, when the device correctly identified central apneas, it exhibited "no pressure increase, as expected"[1]. Even in scenarios where leaks were present, accurate classification ensured that the pressure remained stable at the therapeutic baseline (e.g., 10~cmH_2O) rather than ramping up unnecessarily in response to false obstructive signals[1].

- **Optimized Therapy:** By calibrating both the mask leakage and the circuit resistance, the Reve Auto CPAP is better able to identify leakages during therapy. Then, by filtering out effects from leaks and correctly identifying central events, advanced algorithms prevent the device from delivering indiscriminately high pressures. This results in a therapy profile that applies pressure only when an obstruction is genuinely present.

Practical Implications for Clinicians

Managing the 'High Leak' Patient When reviewing telemonitoring data, clinicians often focus on the Apnea-Hypopnea Index (AHI). However, high leak rates should serve as a primary clinical red flag. Rather than simply widening the pressure range—which may exacerbate leaks and discomfort—clinicians should prioritize devices with highly accurate algorithms. Ensuring the device can accurately detect leaks prevents inappropriate pressure spikes, preserves natural sleep stages, and directly supports the patient's cardiovascular health.

Part II: The Clinical Imperative – CPAP as a Tool for Cardiovascular Risk Reduction

I. The Danger of Untreated OSA: A Cluster of Comorbidities

The physiological stress of OSA drives a spectrum of severe comorbidities, which are the primary drivers of poor prognosis and mortality in this population. Evidence establishes clear links between OSA and major cardiovascular conditions:

- **Hypertension:** More than half of all patients with OSA suffer from hypertension.
- **Cardiovascular Disease:** OSA is associated with arrhythmias, stroke, and heart failure.
- **Metabolic & Stroke Risk:** The condition is inextricably linked to prevalent and incident hypertension, creating a dangerous feedback loop that exacerbates overall cardiovascular risk.

II. The Hypertension Connection

Hypertension is the most common comorbidity in OSA patients. The relationship is mechanical and direct: the intermittent hypoxia caused by apnea events increases mean systolic and diastolic blood pressure. This change is dose-dependent, meaning the severity and duration of hypoxic exposure directly correlate with the rise in blood pressure.

Furthermore, OSA patients frequently exhibit specific, high-risk phenotypes of hypertension, including:

- **Diastolic Hypertension**
- **Nocturnal Hypertension:** A failure of blood pressure to "dip" naturally during sleep.
- **Resistant Hypertension:** Blood pressure that remains high despite medication.

III. The Solution: Evidence of Blood Pressure Reduction with CPAP

CPAP is the first-line therapy for moderate to severe OSA. A 2025 prospective cohort study by Coiffier et al., published in the Annals of the American Thoracic Society, provides robust evidence of CPAP's efficacy in reducing blood pressure using high-dimensional home blood pressure monitoring (HBPM).

1. Significant Reductions in Blood Pressure

The study analyzed over 36,000 home blood pressure measurements and found that CPAP therapy significantly improved blood pressure trajectories over the first 6 months of treatment, which was the duration of the study.

- **Morning and Evening Reductions:** Both systolic and diastolic blood pressure decreased significantly at 1, 3, and 6 months compared to baseline.
- **Therapeutic Range:** There was a significant increase in the percentage of blood pressure measurements falling within the normal ("therapeutic") range after 3 months of CPAP use compared to one month. Further, blood pressures kept improving throughout the entire study with the greatest reductions at 6 months.

2. The Challenge of Morning Blood Pressure

The study highlighted a critical physiological nuance: morning blood pressure values remained consistently higher than evening values throughout the therapy. This is attributed to the "non-dipping" nocturnal blood pressure patterns common in OSA and elevated sympathetic tone in the early morning caused by sleep apneas.

- **Clinical Importance:** Morning blood pressure is a strong predictor of stroke and major adverse cardiovascular events.
- **Therapy Impact:** While morning BP is harder to control, CPAP therapy did successfully lower these critical values over the 6-month period, demonstrating its value in mitigating this specific high-risk factor.

3. Predictors of Success

The effectiveness of CPAP in lowering blood pressure was heterogeneous, with certain factors predicting better outcomes. Patients who were younger, had no history of hypertension, and—crucially—managed to avoid weight gain saw the most significant improvements. This suggests that while CPAP is a powerful tool for blood pressure reduction, it is most effective when integrated into a holistic management plan that includes weight control.

Part III. The Mechanism – How Algorithmic Precision Drives Clinical Success

The clinical success of CPAP therapy in managing hypertension is not merely a function of pressure delivery, but of pressure appropriateness. When algorithms fail to distinguish between obstructive and central events during a leak, a 'Cycle of Failure' is initiated:

Inaccurate Detection: The device misinterprets a leak or central event as an obstruction.

Pressure Over-titration: The device inappropriately increases pressure (Runaway Pressure), which can also result in sleep arousals.

Patient Discomfort: Excessive pressure leads to aerophagia, increased mask displacement, and mouth dryness.

Low Therapy Adherence: The patient removes the mask or reduces nightly usage to avoid discomfort.

Sustained Sympathetic Activation: Sub-optimal usage fails to suppress the nocturnal surges in heart rate and blood pressure, negating the cardiovascular benefits of the therapy.

Advanced algorithms, like the one utilized in the Reve Auto CPAP, break this cycle by maintaining detection stability. By preventing inappropriate pressure escalation, these devices ensure higher patient comfort and, consequently, the long-term adherence required to achieve the 24-hour blood pressure reduction identified in recent Coiffier study[3].

Clinically, effective blood pressure reduction relies on consistent and tolerated therapy.

Adherence: High CPAP adherence is a known predictor of blood pressure response[3].

Efficacy: Treating Central Apnea with higher pressure is ineffective. By keeping pressures lower and appropriate (i.e., only treating actual obstructions), the therapy targets the specific pathology (OSA) that drives sympathetic overdrive.

Consequently, "good CPAP therapy"—defined by accurate event detection and appropriate pressure delivery—creates the physiological conditions necessary for the significant blood pressure improvements observed in the study[3].

Conclusion

This white paper demonstrates that one of the essential components of an Auto CPAP is the accuracy of the algorithm. The precision in pressure results in better management of hypertension. By accurately classifying events even under significant real-world leak conditions, advanced technology prevents the 'runaway pressure' that compromises patient adherence. When therapy is precise, adherence is sustained, and the measurable reduction in blood pressure becomes a clinical reality—offering a powerful, non-pharmacological, non-surgical tool for mitigating long-term cardiovascular risk.

References

1. *Evaluation Protocol for an Auto-Adjusting CPAP Device on a Test Bench: 'Nea' by Sefam Final Report,* 16 Dec 2024.
2. *Richard, M., et al. Performances of Auto-CPAP Devices Under Real-Life Leak Patterns: A High-Fidelity Modeling Approach.* Archivos de Bronconeumología, 2025.
3. *Coiffier, O., et al. Home Blood Pressure Trajectories during 6 Months of Continuous Positive Airway Pressure Therapy.* Annals of the American Thoracic Society, 2025.
4. *Ayappa, I., et al. Cardiogenic oscillations on the airflow signal during continuous positive airway pressure as a marker of central apnea.* Chest, 1999.