



## OSA Part 1 – Pathogenesis, Risk Assessment, Diagnostic options

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### Learning objectives

- What is obstructive sleep apnea (OSA) in 2026?
- Who is at risk for OSA?
- How is OSA diagnosed?

### Sleep apnea is... everywhere!

Global Adults Affected (30-69 years) ~1 Billion  
Benjafield et al. Lancet Respir Med. 2019

Current and future estimates in the United States  
Boers et al. Lancet Respir Med. 2025

	2025	2050
AHI ≥ 5	60.7 million <b>35.6%</b>	76.6 million <b>46.2%</b>
AHI ≥ 15	41.0 million <b>23.9%</b>	52.9 million <b>32.0%</b>
AHI ≥ 30	20.6 million <b>12.1%</b>	28.1 million <b>17.0%</b>

### Sleep study results

AHI, RDI, REI

**\*AHI ≥ 5-15 with symptoms**

Patient reported or observed: <ul style="list-style-type: none"> <li>• Sleepiness or fatigue</li> <li>• Insomnia</li> <li>• Nocturia</li> <li>• Morning headaches</li> <li>• Impaired concentration, memory, driving, social function, or work-productivity</li> </ul>	Or observed: <ul style="list-style-type: none"> <li>• Waking up breath holding, gasping, or choking</li> <li>• Habitual snoring or breathing interruptions during sleep</li> <li>• Disruption of bedpartner's sleep</li> </ul>
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**ICSD-3 Text Revision 2023**

**Comorbidities** without symptoms **removed** from essential features:

HTN, ischemic heart disease, diabetes, or stroke

## What is an event?

- Apnea
  - Airflow cessation
- Hypopnea (Rule 1B, or 4% criteria)
  - Reduced airflow
  - Associated 4% oxygen desaturation
- Hypopnea (Rule 1A, or 3% criteria)
  - Reduced airflow
  - Associated 3% oxygen desaturation
  - or
  - Associated with an arousal caused by airflow

Each last  
at least 10  
seconds

## AHI (Apnea Hypopnea Index)

$$AHI = \frac{Apneas + Hypopneas}{Total\ sleep\ time}$$

## RDI (Respiratory Disturbance Index)

$$RDI = \frac{Apneas + Hypopneas + RERAs}{Total\ sleep\ time}$$

## REI (Respiratory Event Index)

$$REI = \frac{Apneas + Hypopneas}{Total\ Recording\ Time}$$

## The tale of 2 patients:

Patient 1:

Presents with snoring, witnessed apneas, and excessive daytime sleepiness

Sleep study  
AHI=30



Patient 2:

Presents with snoring, witnessed apneas, and excessive daytime sleepiness

Sleep study  
AHI=30

## The PALM Framework for OSA Pathogenesis

### Endotypes

J Carberry, J Amatoury, D Eckert. Chest 2018

1. Passive  $P_{crit}$  (Anatomy)
2. Arousal Threshold (Sleep Stability)
3. Loop Gain (Ventilatory Stability)
4. Muscle Responsiveness (Compensation)

## PALM: Anatomy, Passive $P_{crit}$

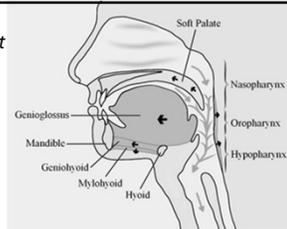
Underlying risk for all endotypes.

**How it causes OSA:** Collapsing forces and structural support are insufficient

- Influenced by genetics, weight, fluid shifts and tissue compliance
- A collapsible upper airway is bad
- $P_{crit}$  – Airway closes at this pressure
  - $P_{crit}$  used in research, not clinically
- Smaller UA size, larger lateral pharyngeal walls, larger tongue, larger soft palette

**What do we look for?**

- BMI, neck circumference, crowded oropharynx, nasal/septal deviation



## Mallampati Scoring

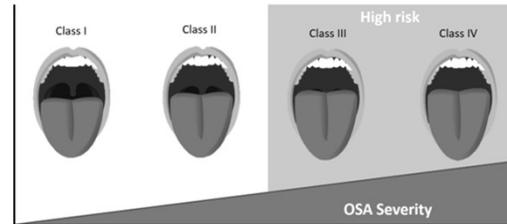


Image adapted from <https://commons.wikimedia.org/wiki/File:Mallampati.svg> - CC BY-SA 3.0  
Miller, J. N., & Berger, A. M. (2016). Screening and assessment for obstructive sleep apnea in primary care. *Sleep medicine reviews*, 29, 41-51.

## So... what causes the initial collapse?

- Anatomy =  Airway is collapsible
- Once asleep = Muscle tone decreases from baseline

### Non-anatomical factors

1. Poor muscle responsiveness
2. Low arousal threshold
3. Unstable breathing (High loop gain)

Why is there stable breathing during parts of the night?

Answer: There are varying non-anatomic and compensating factors.

## PALM: The Low Arousal Threshold

Arousal threshold = level of effort required to wake the brain.

**How it causes OSA:** A low threshold leads to early arousals, preventing dilator muscle recruitment.

Association: COMISA (COMorbid Insomnia and Sleep Apnea)

### PALM: High Loop Gain (breathing instability)

Loop gain describes the ratio of  $\frac{\text{Response}}{\text{Disturbance}}$

**How it causes OSA:** A high loop gain leads to periodic breathing.

*What can you look for?*

- May be reported on sleep studies, under interpretation.
- Has a recognizable desaturation pattern on the hypnogram.

### Central sleep apnea

Absence of air-flow and respiratory effort

Examples:



- Cheyne-Stokes respiration in heart failure.



- Opiates causing ataxic (biot) breathing patterns

### PALM: Poor Muscle compensation

The upper airway muscles, such as the Genioglossus, respond reflexively to negative pressure.

- Genioglossus EMG (main airway dilator) **decreases** during sleep<sup>1</sup>
- Wake pharyngeal muscle dilator activity is **higher** in OSA patients<sup>2</sup>
- OSA patients reduce muscle tone on sleep **more** than controls

**How it causes OSA:** Failure to respond to negative pressure or CO<sub>2</sub>

<sup>1</sup>Remmers et al. 1978, <sup>2</sup>Mezzanotte, 1992

### The future?

**POP** - Polysomnography observed physiologic risk factors

**PUP** - endo-Phenotyping Using Polysomnography

**Example:**

PUP/PUPpy Algorithm, a breath-by-breath analysis of flow and effort.

Finsson et al. *Frontiers in Sleep*, 2023.

### OSA Phenotypes – symptom based

Phenotype	Features	Identification Metrics
<b>Excessively Sleepy (ES)</b>	Classical presentation of <b>excessive sleepiness</b> and <b>upper airway symptoms</b>	Epworth Sleepiness Scale (ESS) score > 10; high arousal index on PSG.
<b>Disturbed Sleep (DS)</b>	Potentially linked to a <b>low arousal threshold</b> .	Symptoms of insomnia (COMISA), frequent awakenings.
<b>Minimally Symptomatic (MS)</b>	May involve a <b>high arousal threshold</b> or lower chemosensitivity, allowing the patient to "tolerate" events without waking.	Lack of subjective sleepiness; often identified during screening for hypertension or atrial fibrillation.

Keenan et al. Sleep. 2018.

### Risk Factors for Sleep-Disordered Breathing

Physical exam findings	Cardio	Neuro	Endocrine	Obesity
Anatomical Indicator	High-Risk Threshold or Finding			
BMI	≥ 30			
Neck circumference	>16" (Women), >17" (Men)			
Mallampati Score	III or IV			
Friedman Tongue position	III or IV			
Jaw	Retrognathia or Micrognathia			
Eyes	Floppy eyelid syndrome			

### Risk Factors for Sleep-Disordered Breathing

Physical exam findings	Cardio	Neuro	Endocrine	Obesity
Condition	Estimated prevalence			
Atrial Fibrillation	>60% 50-90% are undetected <sup>1</sup>			
Hypertension Resistant Hypertension	50% Up to 71% <sup>2</sup>			
Heart Failure	71% 48% OSA, 23% CSA <sup>3</sup>			
Pulmonary hypertension	American Heart Association consensus = screen all for OSA <sup>4</sup>			

<sup>1</sup> Sousa et al. J Clin Med. 2025      <sup>2</sup> Wang et al. Clin Cardiol. 2022  
<sup>3</sup> Tao et al. Front. Endocrinol. 2024      <sup>4</sup> McLaughlin et al. JACC. 2009

### Risk Factors for Sleep-Disordered Breathing

Physical exam findings	Cardio	Neuro	Endocrine	Obesity
Condition	Estimated prevalence			
TIA or Stroke	71% - 72% (AHI > 5) <sup>1</sup>			
Hemorrhagic Stroke	82.7% (AHI > 5) <sup>1</sup>			
US Testing Rate	~6% of stroke patients are screened <sup>3</sup>			
Neuromuscular disease in children	>42% have sleep disordered breathing <sup>4</sup>			

<sup>1</sup> Lio et al. J Stroke Cerebrovasc Dis. 2021      <sup>2</sup> Brown et al. Sleep Med. 2019  
<sup>3</sup> Hoque, R. JCSM. 2016      <sup>4</sup> Chidambaram et al. Children (Basel). 2023

### Risk Factors for Sleep-Disordered Breathing

Physical exam findings
Cardio
Neuro
Endocrine
Obesity

Condition	Estimated prevalence
Women with PCOS	37% <sup>1</sup>
Type 2 Diabetes	55-82% <sup>2</sup>
Acromegaly	44-87.5% <sup>3</sup>

<sup>1</sup>Jarfar et al. Front in Endo. 2025  
<sup>2</sup>Huang and Chen, J Diabetes Investig. 2016    <sup>3</sup>Wolters et al. JCEM. 2019

### Risk Factors for Sleep-Disordered Breathing

Physical exam findings
Cardio
Neuro
Endocrine
Obesity

Increased weight = increased OSA

10% weight ↑ ≈ ↑ AHI about 32%

10% weight ↓ ≈ ↓ AHI about 26%

Peppard, Paul E., et al. Jama. 2000

### Pregnancy and maternal risk

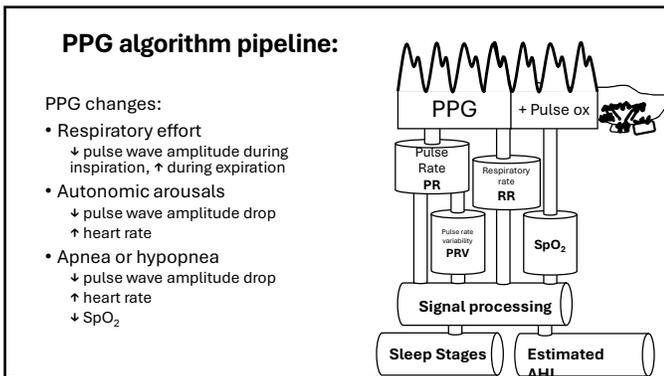
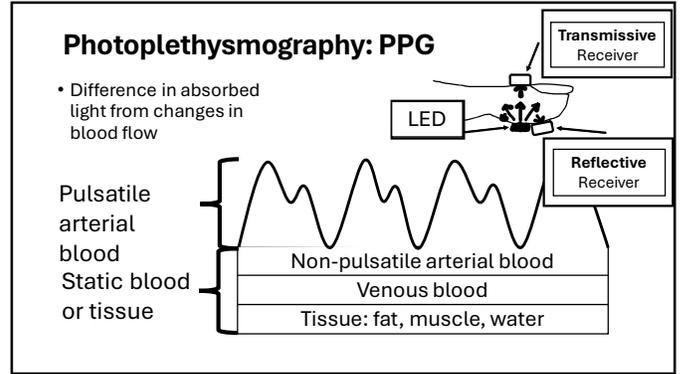
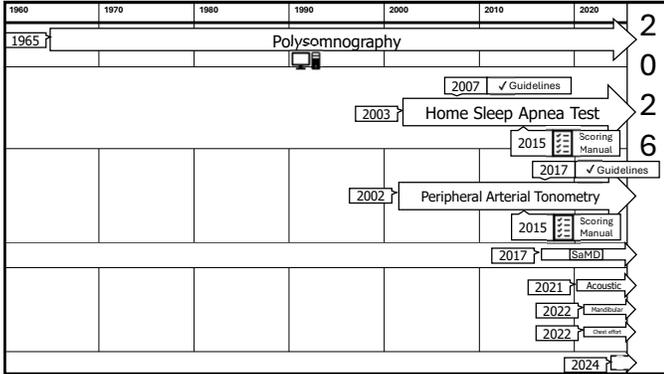
Condition	Estimated prevalence
1st Trimester Prevalence	10.5% <sup>1</sup>
3rd Trimester Prevalence	26.7% <sup>1</sup>
Hypertensive disorders of pregnancy/ Preeclampsia	CPAP recommended <sup>2</sup>

<sup>1</sup>Pien et al. Thorax. 2014                      <sup>2</sup>Tang et al. Reprod Biol Endocrinol. 2025

### Newer screening tools

Screening Tool	Sensitivity (AHI ≥ 15)	Specificity (AHI ≥ 15)	LR+	LR-
STOP-Bang (Population estimate)	86%	44%	1.54	0.32
STOP-Bang (Sleep Clinic)	95%	27%	1.30	0.20
Samsung SAF	83%	88%	<b>6.72</b>	0.20
Apple SANF	66%	99%	<b>18.6</b>	0.36

STOP-Bang population estimate from Hoflinger et al. CHEST. 2022



### What is the intended use of each device?

Polysomnography	Home sleep apnea testing	Consumer devices
<ul style="list-style-type: none"> <li>✓ Gold-standard OSA</li> <li>✓ Gold-standard CSA</li> <li>✓ Other conditions                             <ul style="list-style-type: none"> <li>• Limb movements</li> <li>• REM behavior disorder</li> <li>• Other parasomnias</li> <li>• Part of narcolepsy/hypersomnia evaluation</li> </ul> </li> <li>✓ PAP titration studies</li> <li>+/- CO2 monitoring</li> </ul>	<ul style="list-style-type: none"> <li>✓ High risk for OSA</li> <li>+/- CSA</li> </ul> <p><b>PAT, SaMD, acoustic, mandibular, chest effort devices</b></p> <ul style="list-style-type: none"> <li>✓ High risk for OSA</li> <li>+/- CSA</li> </ul>	<ul style="list-style-type: none"> <li>+/- Some can alert user to very high risk for OSA</li> </ul>

**Traditional HSAT (Home Sleep Apnea Test)**

- Airflow
- △ • Respiratory effort
- Blood oxygenation

**In-laboratory polysomnography**

- Airflow
- △ • Respiratory effort
- Blood oxygenation
- EEG → Sleep staging
- EOG → REM sleep
- ECG → Single lead
- EMG → Detect leg movements
- +/- CO2 monitoring

<i>Directly measured signals</i>	<b>PPG +/- PAT</b> (Peripheral Arterial Tonometry)
<ul style="list-style-type: none"> <li>• Airflow</li> <li>△ • Respiratory effort</li> <li>• Blood oxygenation</li> </ul>	 • Pulse wave amplitude  • Blood oxygenation
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> <li>• EOG → REM sleep</li> <li>• ECG → Single lead</li> <li>• EMG → Detect leg movements</li> <li>+/- CO2 monitoring</li> </ul>	 • PPG  • Accelerometer (Most)
	<p><b>Examples:</b>                      WatchPAT, NightOwl, Belun Ring, SleepImage SaMD, TipTraQ, EnsoSleep PPG</p>

<i>Directly measured signals</i>	<b>PAT/PPG + ECG</b> (SANSa, ANNE Sleep)
<ul style="list-style-type: none"> <li>• Airflow</li> <li>△ • Respiratory effort</li> <li>• Blood oxygenation</li> </ul>	 • Pulse wave amplitude  • Blood oxygenation
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> <li>• EOG → REM sleep</li> <li>• ECG → Single lead</li> <li>• EMG → Detect leg movements</li> <li>+/- CO2 monitoring</li> </ul>	 • PPG  • Accelerometer  • 1-lead ECG

<i>Directly measured signals</i>	<b>PAT + EEG, EOG (Somfit)</b>
<ul style="list-style-type: none"> <li>• Airflow</li> <li>△ • Respiratory effort</li> <li>• Blood oxygenation</li> </ul>	 • Pulse wave amplitude
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> <li>• EOG → REM sleep</li> <li>• ECG → Single lead</li> <li>• EMG → Detect leg movements</li> <li>+/- CO2 monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• Blood oxygenation</li> <li>• Frontal EEG, EOG</li> <li>• Accelerometry</li> </ul>

<i>Directly measured signals</i>	<b>Acoustic</b>
<ul style="list-style-type: none"> <li>• Airflow</li> <li>△ • Respiratory effort</li> <li>• Blood oxygenation</li> </ul>	<ul style="list-style-type: none"> <li>• Acoustic airflow</li> <li>△ • Suprasternal pressure</li> </ul>
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> <li>• EOG → REM sleep</li> <li>• ECG → Single lead</li> <li>• EMG → Detect leg movements</li> <li>+/- CO2 monitoring</li> </ul>	

<i>Directly measured signals</i>	<b>PPG + Acoustic (AcuPEbble, BresDX1)</b>
<ul style="list-style-type: none"> <li>• Airflow</li> <li>△ • Respiratory effort</li> <li>• Blood oxygenation</li> </ul>	<ul style="list-style-type: none"> <li>• Acoustic airflow</li> <li>△ • Suprasternal pressure</li> <li>• Blood oxygen</li> </ul>
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> <li>• EOG → REM sleep</li> <li>• ECG → Single lead</li> <li>• EMG → Detect leg movements</li> <li>+/- CO2 monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• PPG</li> <li>• Accelerometer</li> </ul>

<i>Directly measured signals</i>	<b>Mandibular Movements</b>
<ul style="list-style-type: none"> <li>• Airflow</li> <li>△ • Respiratory effort</li> <li>• Blood oxygenation</li> </ul>	<ul style="list-style-type: none"> <li>△ • Respiratory effort</li> </ul>
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> <li>• EOG → REM sleep</li> <li>• ECG → Single lead</li> <li>• EMG → Detect leg movements</li> <li>+/- CO2 monitoring</li> </ul>	<ul style="list-style-type: none"> <li>△ • Marker for arousals</li> </ul>

Directly measured signals	PPG + Mandibular Movements (Sunrise)
<ul style="list-style-type: none"> <li>• Airflow</li> </ul>	
<ul style="list-style-type: none"> <li>△ • Respiratory effort</li> </ul>	 • Respiratory effort
<ul style="list-style-type: none"> <li>• Blood oxygenation</li> </ul>	PPG: Blood oxygen
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> </ul>	 • PPG and MM (arousals)
<ul style="list-style-type: none"> <li>• EOG → REM sleep</li> </ul>	 • Accelerometer, gyroscope
<ul style="list-style-type: none"> <li>• ECG → Single lead</li> </ul>	
<ul style="list-style-type: none"> <li>• EMG → Detect leg movements</li> </ul>	
<ul style="list-style-type: none"> <li>+/- CO2 monitoring</li> </ul>	

Directly measured signals	Chest effort
<ul style="list-style-type: none"> <li>• Airflow</li> </ul>	 • Airflow
<ul style="list-style-type: none"> <li>△ • Respiratory effort</li> </ul>	 • Respiratory effort
<ul style="list-style-type: none"> <li>• Blood oxygenation</li> </ul>	
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> </ul>	
<ul style="list-style-type: none"> <li>• EOG → REM sleep</li> </ul>	
<ul style="list-style-type: none"> <li>• ECG → Single lead</li> </ul>	
<ul style="list-style-type: none"> <li>• EMG → Detect leg movements</li> </ul>	
<ul style="list-style-type: none"> <li>+/- CO2 monitoring</li> </ul>	

Directly measured signals	PPG + Chest effort (Wesper Lab)
<ul style="list-style-type: none"> <li>• Airflow</li> </ul>	 • Airflow
<ul style="list-style-type: none"> <li>△ • Respiratory effort</li> </ul>	 • Respiratory effort
<ul style="list-style-type: none"> <li>• Blood oxygenation</li> </ul>	• Blood oxygen
<ul style="list-style-type: none"> <li>• EEG → Sleep staging</li> </ul>	 • PPG
<ul style="list-style-type: none"> <li>• EOG → REM sleep</li> </ul>	 • Accelerometer
<ul style="list-style-type: none"> <li>• ECG → Single lead</li> </ul>	
<ul style="list-style-type: none"> <li>• EMG → Detect leg movements</li> </ul>	
<ul style="list-style-type: none"> <li>+/- CO2 monitoring</li> </ul>	

### Home devices to assess risk for sleep apnea

- Prescription options
  - Under-mattress mat: Withings Sleep Rx
  - Smartphone: Drowzle
- Available to consumers
  - Smartwatch apps:
    - Samsung Galaxy Watch: Sleep Apnea Feature
    - Apple Watch: Sleep Apnea Notification Feature

### Considerations when using derived signals

- Performance varies by device, mechanism, signal processing
  - Some use “optimal device-AHI cutoffs”
  - Some report only the 3% or 4% criteria for hypopneas
  - Varying ability to detect central sleep apnea
  - Consider if the training and validation datasets match test population
- PPG:
  - Reliable in atrial fibrillation? Chronotropic medications?
  - PPG affected by skin tone
  - Incomplete reporting... positional sleep apnea?

Chiang A. et al. JCSM. 2024.

### Take home points for OSA assessment

- Consumer or risk assessment devices
  - Detect risk, **NOT** a diagnosis
- Choice of diagnostic sleep testing should be based on the intended purpose
  - Newer, FDA-approved HSAT devices are designed for simple, high-risk obstructive sleep apnea evaluation
  - Awareness is needed regarding individual device limitations



### Treatment Updates for Obstructive Sleep Apnea

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### Treatment Options

- Positive Airway Pressure
- Dental Devices
- Hypoglossal Nerve Stimulation
- Medications

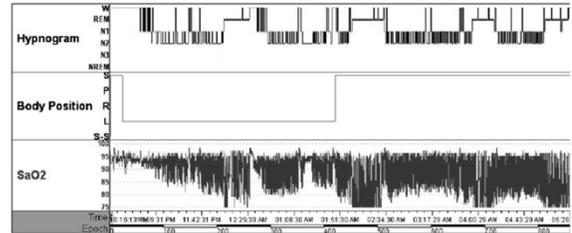
## Positive Airway Pressure

- Continuous
- Bilevel
- Kairos
  - End-expiration
  - Equal efficacy
  - Improved comfort
  - Less leak

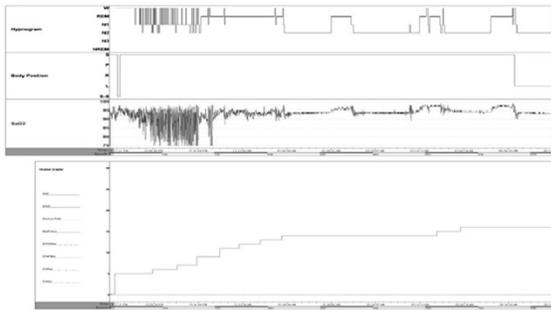


<https://swcofusa.com/sleep-apnea-csa-treatment/>

## Positive Airway Pressure



## Positive Airway Pressure



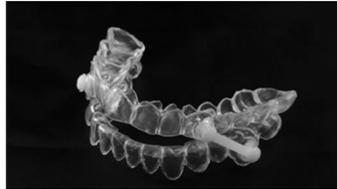
## Positive Airway Pressure

- Adherence
- Recall

## Oral Appliances

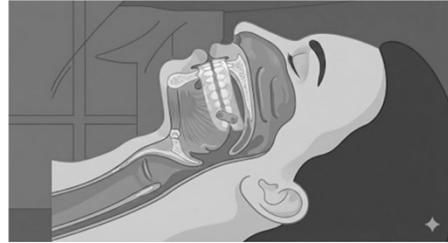


<https://www.doneskey.com/the-silent-partner/>



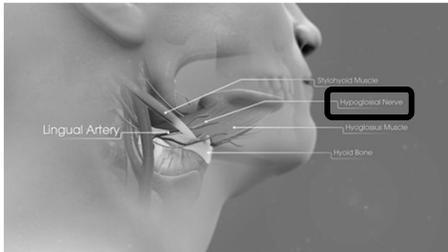
<https://chestnutdental.com/wp-content/uploads/2024/07/dental-appliance-treatment-for-sleep-apnea-1024x576.jpg>

## Oral Appliances



[https://lh3.googleusercontent.com/gg-dll/ADl\\_d\\_cjEzDd15fop3b-h5M-AeP61r\\_5cPBIA\\_0XmmexQw0ZXRejw0db56-XsMh6POCWEZ-R-LwUS71HFGBLodRuxqbg-cAHFOU700hG66J9p11y-EXFfIT8kDyo6S\\_LihGXyPyciQxcs9w4Z2ugwG4-RYcWc8DIOAcE2jhcXr4sMw#s=1024-f](https://lh3.googleusercontent.com/gg-dll/ADl_d_cjEzDd15fop3b-h5M-AeP61r_5cPBIA_0XmmexQw0ZXRejw0db56-XsMh6POCWEZ-R-LwUS71HFGBLodRuxqbg-cAHFOU700hG66J9p11y-EXFfIT8kDyo6S_LihGXyPyciQxcs9w4Z2ugwG4-RYcWc8DIOAcE2jhcXr4sMw#s=1024-f)

## Hypoglossal Stimulation



## Hypoglossal Stimulation

> *Am Rev Respir Dis.* 1989 Nov;140(5):1279-84. doi: 10.1164/ajrccm/140.5.1279.

### Effects of electrical stimulation of the genioglossus on upper airway resistance in anesthetized dogs

H Miki<sup>1</sup>, W Hida, C Shindoh, Y Kikuchi, T Chonan, O Taguchi, H Inoue, T Sakishima

Affiliations + expand > *Am Rev Respir Dis.* 1993 May;147(5):1144-50. doi: 10.1164/ajrccm/147.5.1144. PMID: 2817589 DOI: 10.1164/ajrccm/14

### Effect of electrical stimulation of the hypoglossal nerve on airflow mechanics in the isolated upper airway

A R Schwartz<sup>1</sup>, D C Thul, B Russ, M Seeliger, X Yuan, R G Brower, S Permutt, R A Wise, P L Smith

Affiliations + expand > *Am Rev Respir Dis.* 1992 Oct;146(4):1030-6. doi: 10.1164/ajrccm/146.4.1030. PMID: 8484623 DOI: 10.1164/ajrccm/147.5.1144

### The effects of transcutaneous electrical stimulation during wakefulness and sleep in patients with obstructive sleep apnea

L C Edmonds<sup>1</sup>, B K Daniels, A W Stanson, P F Sheedy 3rd, J W Shepard Jr

Affiliations + expand PMID: 1416392 DOI: 10.1164/ajrccm/146.4.1030

## Hypoglossal Stimulation

Clinical Investigations: Sleep/Breathing: Articles

### The Effect of Electrical Stimulation on Obstructive Sleep Apnea Syndrome

Christian Guilleminault MD<sup>1</sup>, Nelson Powell MD<sup>2</sup>, Bruce Bowman PhD<sup>3</sup>, Riccardo Stoohs MD<sup>4</sup>

Show more ▾



<https://ars.els-cdn.com/content/image/1-62.0-S0012369215454777-gr2.jpg>



<https://ars.els-cdn.com/content/image/1-62.0-S0012369215454777-gr1.jpg>

## Hypoglossal Stimulation

Arch Otolaryngol Head Neck Surg. 1997 Jan;123(1):57-61.  
doi: 10.1001/archotol.1997.01900010067009.

### Direct hypoglossal nerve stimulation in obstructive sleep apnea

D W Eisele<sup>1</sup>, P L Smith, D S Alam, A R Schwartz

Affiliations + expand

PMID: 9006504 DOI: 10.1001/archotol.1997.01900

Clinical Trial

Arch Otolaryngol Head Neck Surg. 2001 Oct;127(10):1216-23.

doi: 10.1001/archotol.127.10.1216.

### Therapeutic electrical stimulation of the hypoglossal nerve in obstructive sleep apnea

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## Hypoglossal Stimulation

- Unilateral
- Bilateral

## Unilateral Hypoglossal Stimulation

- Age  $\geq$ 18 yrs old
- Age 13-18, Down Syndrome
- AHI 15-100 (<25% central or mixed)
- AHI 10-50 (Down Syndrome)
- CPAP intolerance – Inability or unwillingness to use
- Body Mass Index  $\leq$ 40 kg/m<sup>2</sup>
- Free of Complete Concentric Collapse (CCC) at the Palate



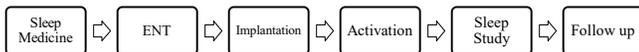
## Hypoglossal Stimulation



## Hypoglossal Stimulation

- STAR (Stimulation Therapy for Apnea Reduction)
  - Inclusion criteria
    - AHI 20-50, BMI <32, CPAP intolerance
  - Exclusion criteria
    - Complete concentric collapse
- Median AHI reduction from 29.3 to 9.0 events per hour

## Unilateral Hypoglossal Stimulation

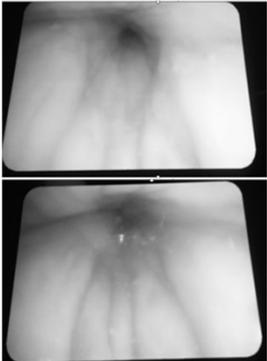


## Sleep Medicine

- Troubleshoot PAP device, alternative treatments
- Education about hypoglossal stimulation, process
- Update Sleep Study >2 years
  - Severity criteria, central sleep apnea
- Body Mass Index <=40 kg/m<sup>2</sup>

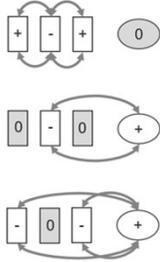
**ENT**

- Assessment
- Drug Induced Sleep Endoscopy



**Implantation**

- 2 incisions
- Implantable Pulse Generator
- Stimulating Lead



**Activation**

- Healing
- Neurapraxia



[https://commons.wikimedia.org/wiki/File:Unilateral\\_hypoglossal\\_nerve\\_injury.jpeg](https://commons.wikimedia.org/wiki/File:Unilateral_hypoglossal_nerve_injury.jpeg)

**Activation**

- Settings
- Waveform Testing
- Education

## Sleep Study

- Home Sleep Apnea Test
- In-laboratory Polysomnogram

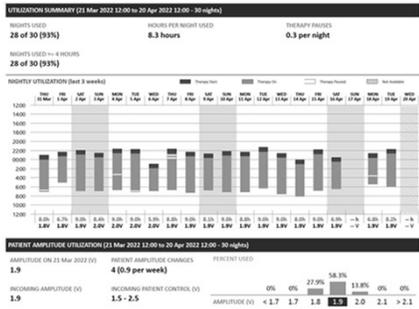
## Sleep Study

Hypoglossal nerve stimulation titration table

TK	HNS V	TIME AT LEVEL	SLEEP STAGES					RESPIRATORY EVENTS					AROUSALS		SAO2 LOWEST DESAT
			TST (mins)	REM (mins)	REM SUPINE (mins)	NREM (mins)	SLEEP EFFIC.	APNEAS OA	CA	MA	HYP. (A)	AHI (TA)	HYP. (TB)	AHI (TB)	
2.0	130.9	78.8	0.0	0.0	78.8	0	0	0	12	62.6	13	48.1	19.8	26	85.0
2.0	37.1	24.5	0.0	0.0	24.5	0	0	0	13	71	11	66.1	48.8	20	83.0
2.1	46.5	35.5	0.0	0.0	35.5	0	0	0	43	63.7	36	71.4	28.6	16	87.0
2.2	31.9	29.4	0.0	0.0	29.4	0	4	0	38	91.3	31	78.8	12.3	6	84.0
2.3	37.3	35.3	0.0	0.0	35.3	0	4	0	39	83.7	29	71.4	24.6	13	87.0
2.4	30.8	29.8	0.0	0.0	29.8	0	17	0	22	79.9	22	62.9	20.17	13	84.0
2.5	29.4	17.7	0.0	0.0	17.7	0	11	0	24	78.6	20	78.5	20.32	6	84.0
2.6	35.8	35.8	0.0	0.0	35.8	0	0	0	26	84.7	31	71.2	3.00	2	85.0
2.7	107.2	109.8	21.5	21.5	79.3	0	0	0	12	65.6	4	56.8	3.00	2	87.0
										7.1	2.4				88.0

## Follow up

- Continue to assess tolerance/comfort
- Tongue Movement
- Waveform
- Usage Download



## Bilateral Hypoglossal Stimulation

- Battery-Free stimulator implant (paddle)
- Single incision
- External sleep wearable battery (activation chip)
- MRI compatibility at 1.5T and 3T
- Continuous stimulation

## Bilateral Hypoglossal Stimulation

<https://doi.org/10.1093/slm/aaq118>

JCSM | Journal of  
Clinical Sleep Medicine

SCIENTIFIC INVESTIGATIONS

**Bilateral hypoglossal nerve stimulation for obstructive sleep apnea:  
a nonrandomized clinical trial**

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- 63.5% patients with >50% AHI reduction to <20 events/hr
- Mean AHI reduction 18.3 events/hr

## Bilateral Hypoglossal Stimulation

- Eligibility criteria
- Age >22
- AHI 15-65
- CPAP intolerance
- BMI <32

## Bilateral Hypoglossal Stimulation

- Contraindications
  - Central or Mixed AHI  $\geq$  25%
  - Compromised neurological control of the upper airway
- Warnings
  - Age < 22 or > 75
  - BMI > 32
  - AHI outside of 15-65
  - Complete Concentric Collapse

## Medication

- Tirzepatide – Dual Agonist
  - Glucose-Dependent Insulinotropic Polypeptide (GIP) Receptor
  - Glucagon-like Peptide-1 (GLP-1) Receptor

## Medication

The New England Journal of Medicine | NEJM Clinical | NEJM Evidence | NEJM AI | NEJM Catalyst  
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ORIGINAL ARTICLE | f x in W

### Tirzepatide for the Treatment of Obstructive Sleep Apnea and Obesity

This article has been corrected. VIEW THE CORRECTION

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## Medication

- SURMOUNT-OSA
  - Reduced AHI by 20-24 events per hour compared to placebo = 58.7% reduction in baseline
  - With and without CPAP
  - 50% of patients – AHI <5 or 5-14 with normal Epworth Sleepiness Scale
- FDA indication December 20, 2024

## Medication

- Contraindications
  - Personal or family history of medullary thyroid cancer
  - Multiple endocrine neoplasia syndrome type 2 (MEN2)
- Cautions
  - Gastrointestinal side effects
  - Pancreatitis
  - Gallbladder disease
  - Acute Kidney Injury
  - Hypoglycemia