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- Sleep Medicine Physician
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- No disclosures

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Notice of Requirements for Successful Completion:

Learners must participate in the full activity and complete the evaluation in order to claim continuing education credit/hours.

Presenter(s) Conflicts of Interest/Financial Relationships Disclosures:

Renae Dorrity MD, FAAFP – None

Disclosure of Relevant Financial Relationships and Mechanism to Identify and Mitigate Conflicts of Interest: No conflicts of interest

Non-Endorsement of Products: Accredited status does not imply endorsement by ADCES or Joint Accreditation of any commercial products displayed in conjunction with this educational activity

Off-label Use: NONE

3

Diabetes Mellitus Type 2 & Obstructive Sleep Apnea

- OSA increases risk of DM2
- DM2 increases risk of OSA

4

Goals:

- Better understanding of sleep and obstructive sleep apnea
- Understand how obstructive sleep apnea (OSA) increases risk of diabetes mellitus type 2 (DM2)
- Understand how DM2 increases risk of OSA
- Understand how treating OSA benefits DM2
- Understand how DM2 treatment can impact OSA

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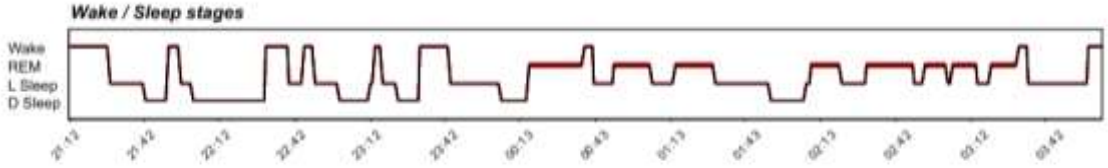
Sleep

- Wake
  - Fall asleep in 20-30 minutes
  - 20-30 minutes throughout the night is normal
- Stage N1: 5%
  - Drowsiness/Light sleep
  - May not perceive as sleep
- Stage N2: 45-50%
  - Light Sleep
- Stage N3: 20-25%
  - Slow Wave Deep Sleep
  - First half of night
  - Decreases with age
- Stage REM: 20-25%
  - "Rapid Eye Movement"
  - Dream Sleep
  - First REM 90-120 minutes
  - Second half of night



Hypnogram

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How Much Sleep Do I Need?

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Sleep-Related Breathing Disorders

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Sleep-Related Breathing Disorders

- Obstructive Sleep Apnea
- Central Sleep Apnea
- Sleep-Related Hypoventilation
- Sleep-Related Hypoxemia
- Snoring
- Catathrenia

ICSD-3-TR

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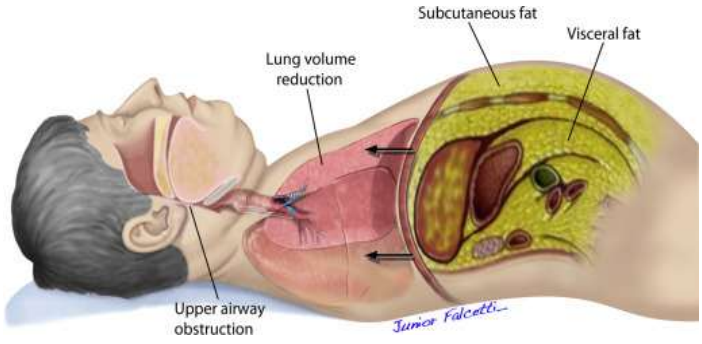
Sleep Related Breathing Disorders

- Obstructive Sleep Apnea
- Central Sleep Apnea
- Sleep-Related Hypoventilation
- Sleep-Related Hypoxemia



J Am Coll Cardiol. 2013 Aug 13;62(7):569-76

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Obstructive Sleep Apnea Screening

- Snoring
- Excessive Daytime Sleepiness/Tired
- Observed Apneas
- Hypertension/Elevated Blood Pressure
- Body Mass Index ≥ 35 kg/m^2
- Age ≥ 50 years
- Neck Circumference ≥ 17/15 inches
- Male Gender

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Obstructive Sleep Apnea Signs and Symptoms

- Waking gasping/short of breath
- Mouth breathing
- Nocturia
- Morning headaches
- Insomnia
- Restless sleep
- Bruxism/teeth grinding
- Gastroesophageal reflux

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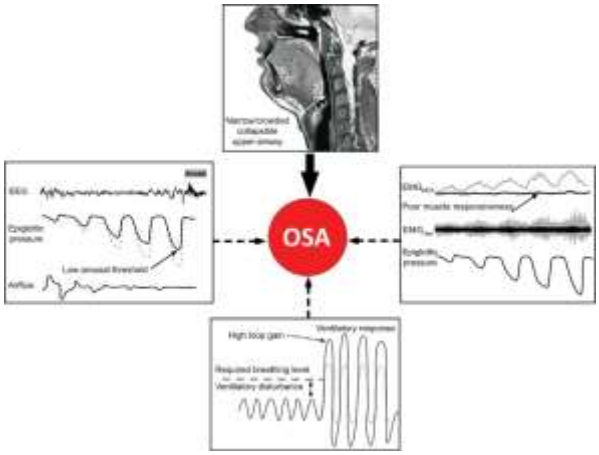
Obstructive Sleep Apnea

- Anatomical factors
- Impaired pharyngeal dilator muscle function
- Premature awakening to mild airway narrowing (low respiratory arousal threshold)
- Unstable control of breathing (high loop gain)



Nat Sci Sleep. 2018 Jan 23;10:21-34

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Anatomical Factors

JAMA. 2013;310(7):731–741

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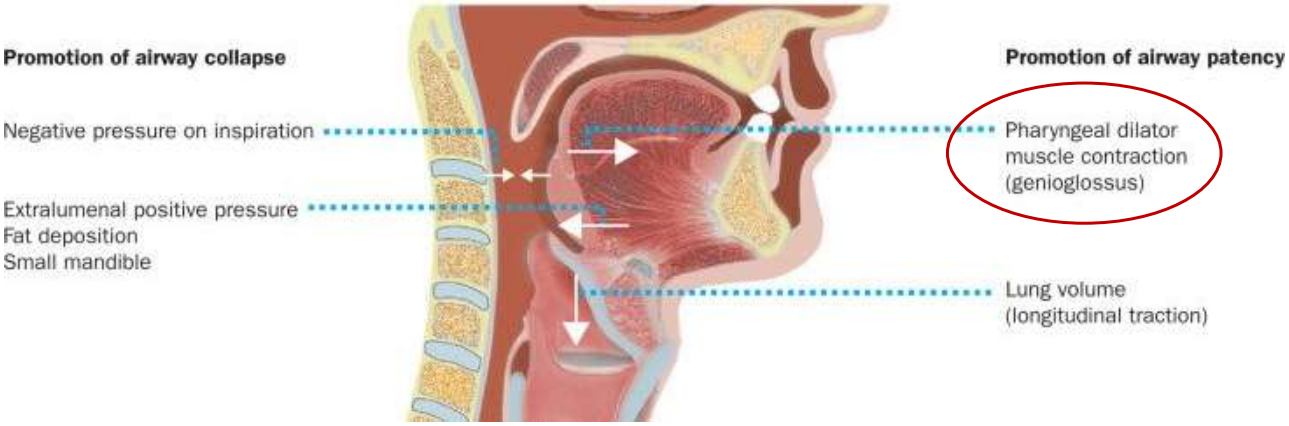

Pharyngeal Dilators

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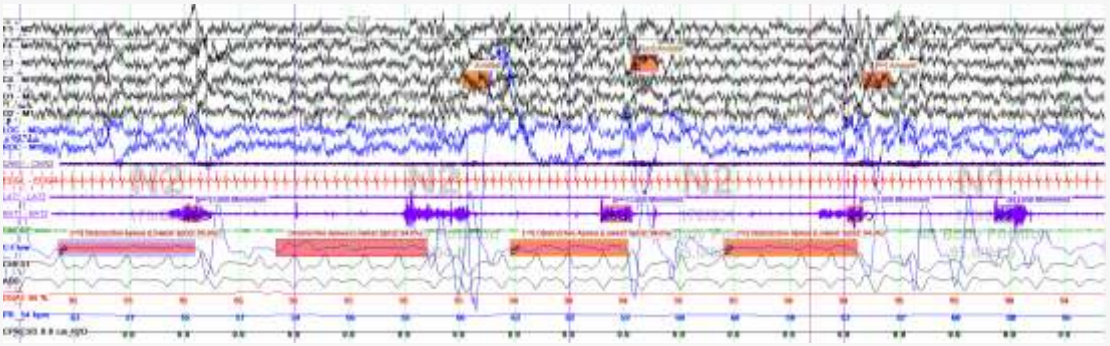

Arousal Threshold

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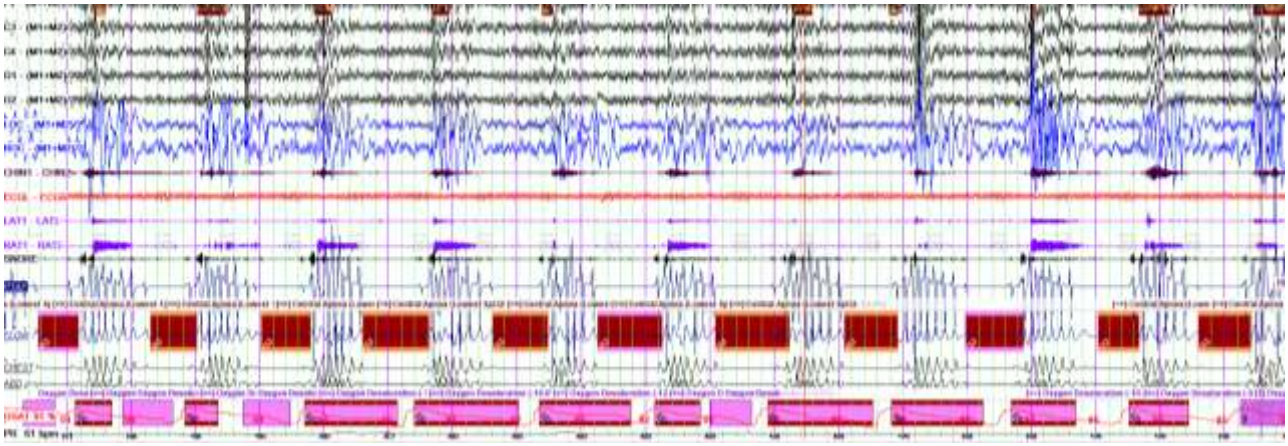

High Loop Gain

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Diagnosis

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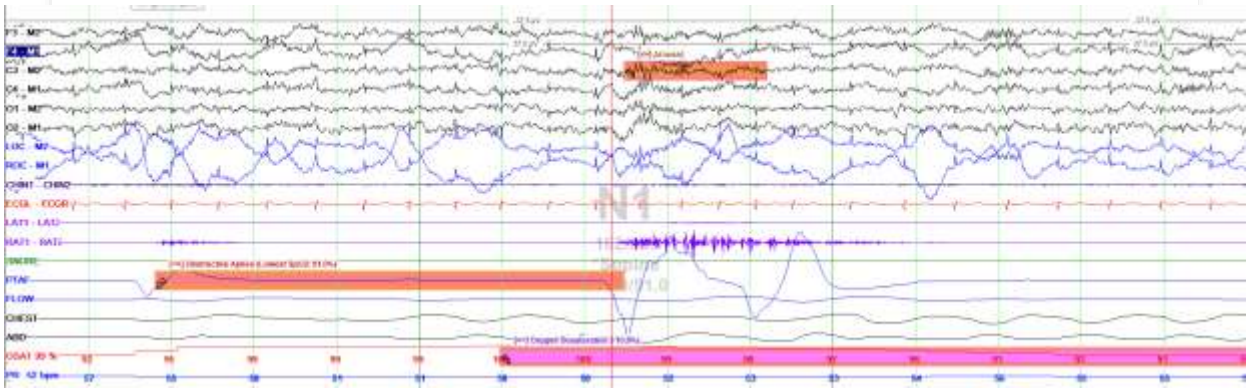
Polysomnogram



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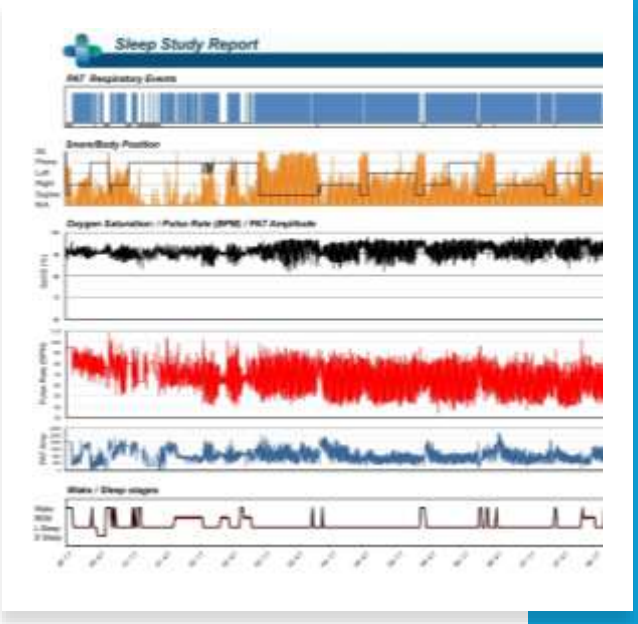
Home Sleep Tests



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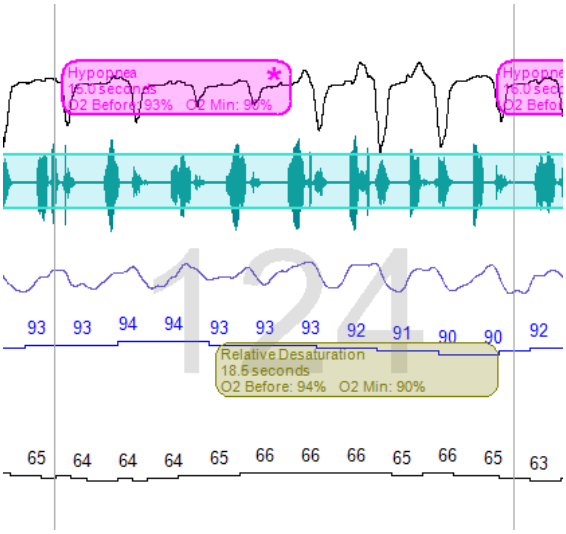

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Apnea-Hypopnea Index

- AHI
- # Apneas + # Hypopneas/Total Sleep Time
- 10 events + 40 events/5 hr = 10 events/hr

- Normal
  - 0-5 events/hr
- Mild Obstructive Sleep Apnea
  - 5-15 events/hr
- Moderate Obstructive Sleep Apnea
  - 15-30 events/hr
- Severe Obstructive Sleep Apnea
  - 30+ events/hr

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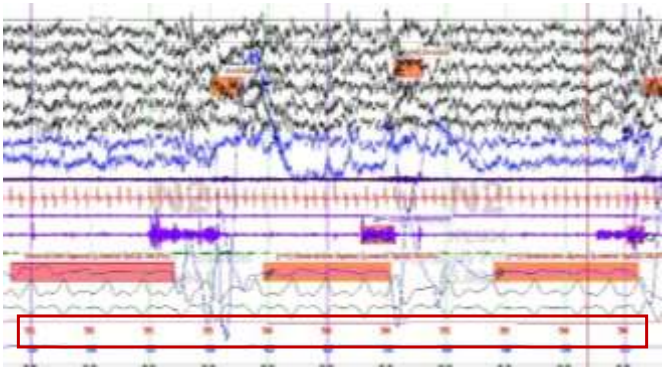
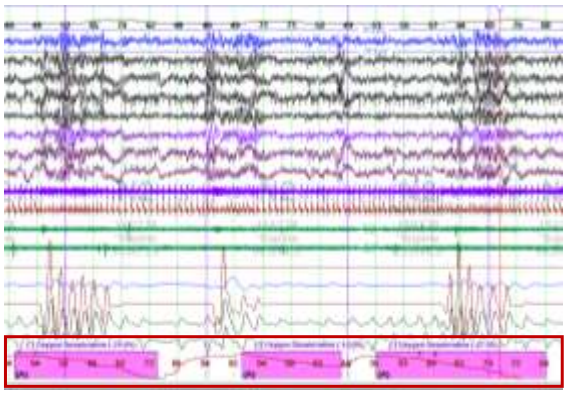
AHI versus Hypoxic Burden





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Adverse Effects of OSA

- Intermittent Hypoxia
- Intermittent Hypercapnia
- Cortical Microarousals
- Increased Oxidative Stress
- Inflammation
- Sleep Fragmentation

Chest. 2017 Nov;152(5):1070-1086

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Treatment

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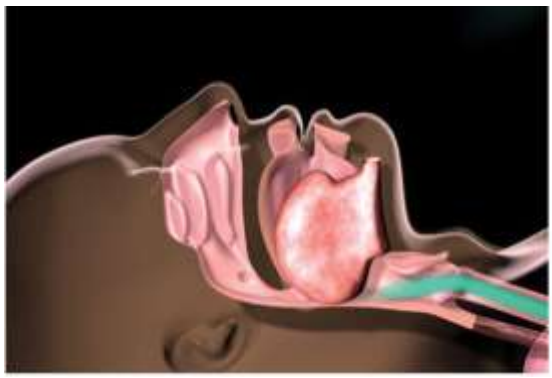

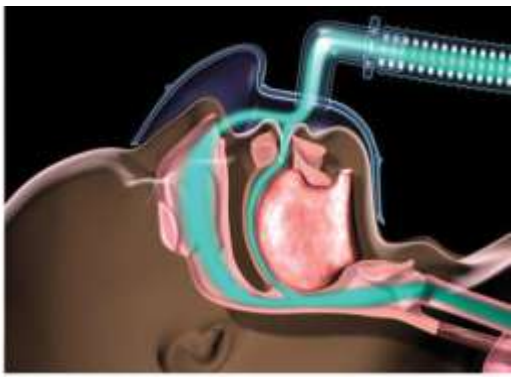

Positive Airway Pressure

- Continuous Positive Airway Pressure (CPAP)
- Bilevel Positive Airway Pressure (BiPAP)
  - Spontaneous or Spontaneous/Timed
- Adaptive Servo Ventilation (ASV)
- Coming soon: Kyrochronos Positive Airway Pressure (KPAP)

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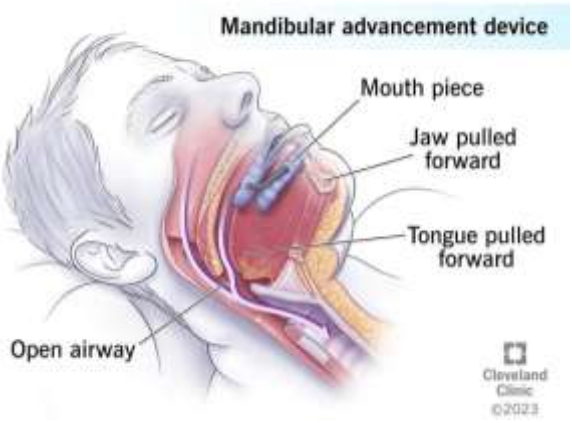

Oral Appliance Therapy

- Complete Airway Repositioning and/or Expansion (CARE)
- Mandibular Advancement Device (MAD)

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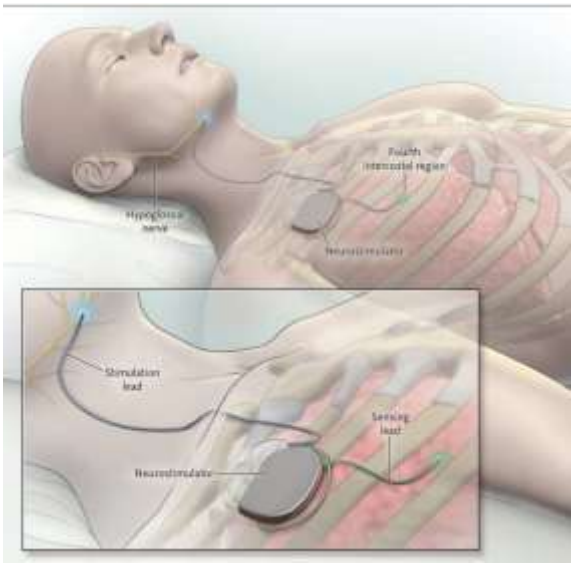

Hypoglossal Nerve Stimulator

- Generator detects inspiration
- Stimulates the hypoglossal nerve
- Genioglossus muscle sends the tongue forward
- Tongue relaxes during expiration

N Engl J Med 2014;370:139-49

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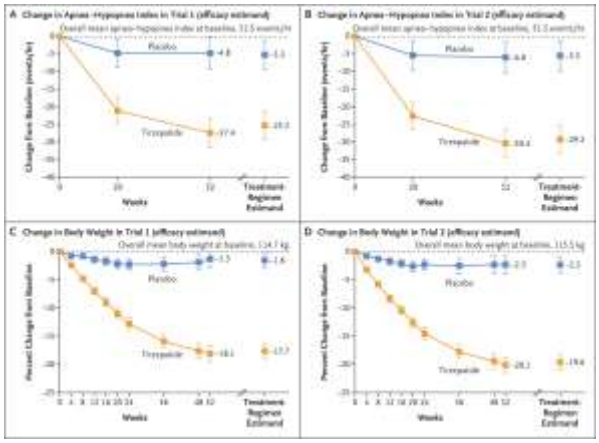

Tirzepatide

SURMOUNT-OSA

- Initiation dose
  - 2.5 mg once weekly for 4 weeks
- Titration dose
  - 5 mg once weekly for 4 weeks
  - 7.5 mg once weekly for 4 weeks
  - 10 mg once weekly for 4 weeks
  - 12.5 mg once weekly for 4 weeks
- Maintenance dose
  - 10-15 mg once weekly

N Engl J Med. 2024 Oct 3;391(13):1193-1205

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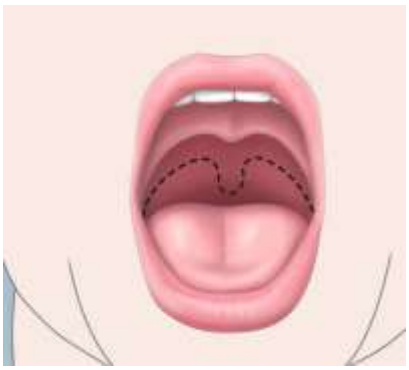

Surgical Treatments

- Tonsillectomy/Adenoidectomy
- Uvulopalatopharyngoplasty (UPPP)
- Maxillomandibular advancement surgery
- Septoplasty

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- Anatomical factors
  - Weight loss
  - Tirzepatide
  - Surgery
  - PAP therapy
  - Oral Appliance Therapy
- Impaired pharyngeal dilator muscle function
  - Hypoglossal nerve stimulation
- Premature awakening to mild airway narrowing
  - PAP therapy
- Unstable control of breathing (high loop gain)
  - Address the underlying condition

Addressing the Roots of Obstructive Sleep Apnea

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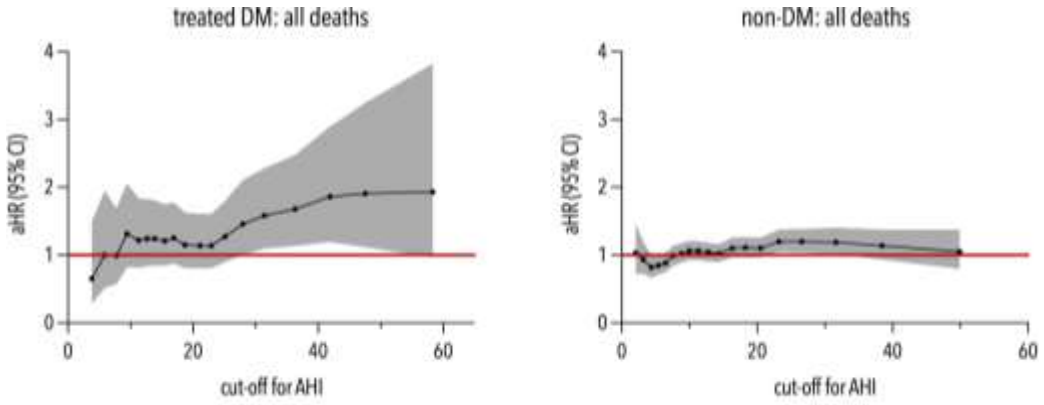
SDB increases Mortality in DM



J Clin Sleep Med. 2025;21(1):89–99

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SDB increases Mortality in DM

- Increased Mortality
  - AHI > 31 events/hr
  - Oxygen desaturation index > 13.3
- Decreased Mortality
  - SpO2 >91.4%
- No Impact on Mortality
  - Sleep efficacy <81.4%
  - REM sleep <14.9

J Clin Sleep Med. 2025;21(1):89–99

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Risk Factors for Metabolic Dysfunction

- Intermittent hypoxemia
- Short sleep duration/sleep restriction
- Fragmented sleep
- Irregular sleep pattern

Chest. 2017 Nov;152(5):1070-1086

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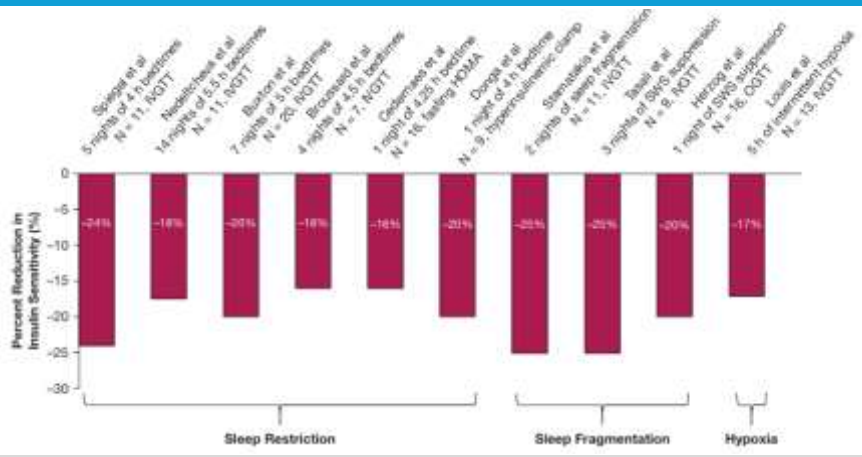
Insulin Sensitivity and Sleep Disturbances



Chest. 2017 Nov;152(5):1070-1086

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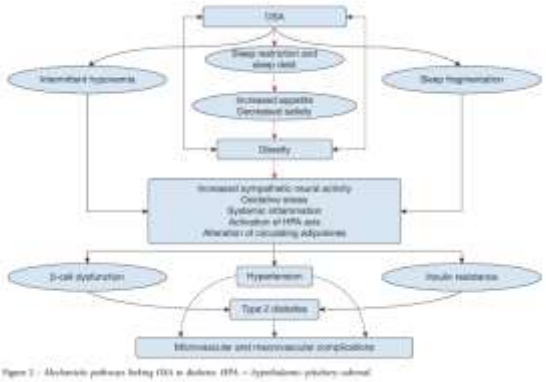

Metabolic Dysfunction

- Increased Sympathetic Activity
  - Inhibition of glucose regulating hormones
    - Pancreatic insulin secretion
    - Hepatic glucose production
    - Adipocyte regulation of energy balance
    - GLP-1/GIP
- Oxidative Stress
  - Weakens respiratory muscles and reduces muscle contractility
- Systemic Inflammation
- Hypothalamic-Pituitary-Adrenal Axis
  - Increased cortisol

Chest. 2017 Nov;152(5):1070-1086

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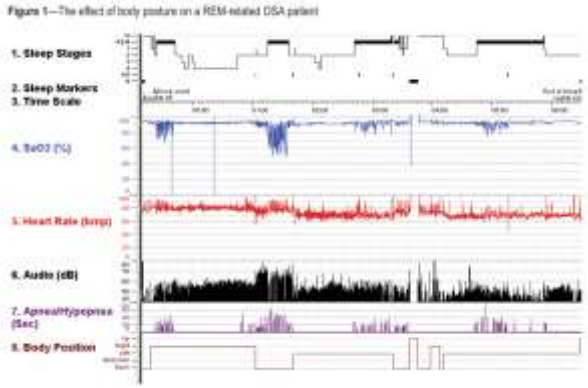

REM-Related Obstructive Sleep Apnea

- Associated with increased HbA1c
- Associated with insulin resistance
- Mean glucose was 38% higher in REM sleep
- No decline in interstitial glucose concentration
- Taking PAP off later part of night may leave REM OSA vulnerable

Chest. 2017 Nov;152(5):1070-1086

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Effect of Diabetes Mellitus on Sleep

- Neuropathy
  - Affects loop gain/periodic breathing
- Insulin resistance desensitizes ventilatory responses to hypercapnia
  - Increased collapse during sleep
- Leptin Resistance
  - Impairs neuromechanical control of upper airway muscles
- Insulin Therapy
- Obesity
  - Weight promoting diabetes medications

Diabetes Care. 2018 Oct;41(10):2111-2119

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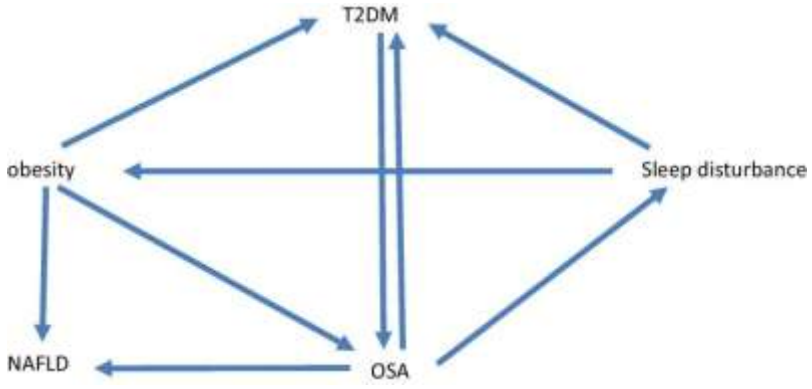
The OSA – DM2 – Obesity Trio



Curr Diab Rep. 2023 Jul;23(7):165-171.

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Table 1: HbA1c, FBG, FINS, and HOMA-IR and its comparison pre- and post-treatment

Characteristics	*n*	Pretreatment	Posttreatment	*P*
BMI (kg/m², mean±SD)	40	29.80 ± 3.50	29.72 ± 3.55	0.191
HbA1c (%, mean (range))	40	8.70 (7.40, 10.40)	6.95 (6.38, 7.52)	<0.001
FBG (mmol/L, mean±SD)	40	9.35 ± 2.89	6.68 ± 1.19	<0.001
AHI, mean±SD	40	30.66 ± 2.79	3.95 ± 0.35	<0.001
SBP (mmHg, mean±SD)	40	129.53 ± 3.75	129.19 ± 3.77	0.83
DBP (mmHg, mean±SD)	40	86.51 ± 7.44	86.16 ± 7.78	0.83
TC (mmol/L)	40	6.07 ± 2.31	4.82 ± 1.09	0.219
TG (mmol/L)	40	2.64 ± 2.03	2.26 ± 1.43	0.307
LDL-C (mmol/L)	40	3.28 ± 1.10	2.64 ± 0.68	0.001
FINS (μU/ml)	40	8.06 (5.19, 13.70)	8.30 (5.09, 11.30)	0.442
HOMA-IR	40	3.57 (1.95, 5.08)	2.48 (1.38, 3.90)	0.013

BMI: Body mass index; HbA1c: Glycated hemoglobin; FBG: Fasten blood glucose; HOMA-IR: Homeostasis model assessment insulin resistance; AHI: Apnea-hypopnea index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; TC: Total cholesterol; TG: Triglyceride; FINS: Fasting insulin; LDL-C: Low density lipoprotein-cholesterol.

Effect of PAP on Blood Glucose Levels

Chin Med J 2015;128:2301-6

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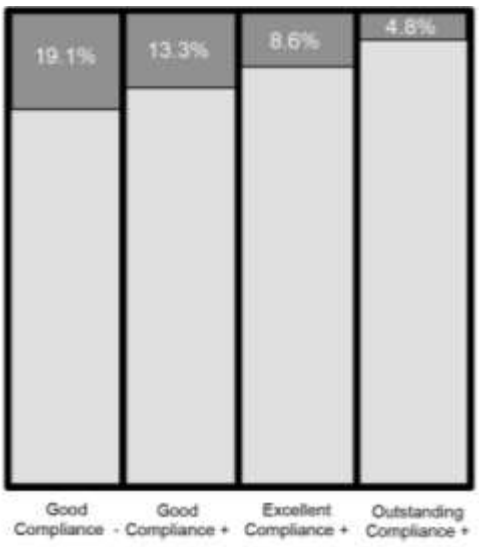

Effect of PAP on Blood Glucose Levels

J Clin Sleep Med. 2017 Mar 15;13(3):455-466

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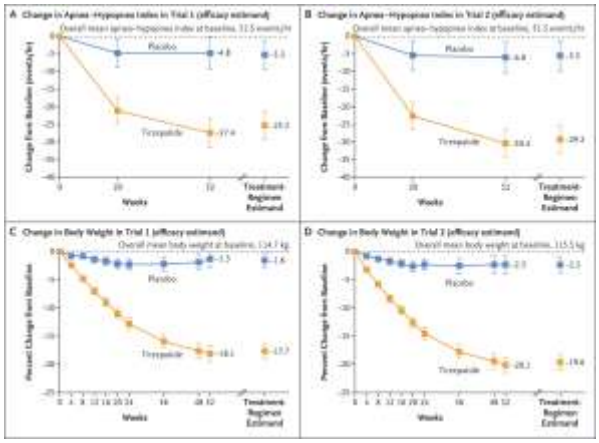

Effect of Treatment of DM2 on OSA

- SURMOUNT-OSA
- Improvement in OSA most likely related to change in weight

N Engl J Med. 2024 Oct 3;391(13):1193-1205

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Questions?

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