



**THE OHIO STATE UNIVERSITY**

WEXNER MEDICAL CENTER

# Sleep and the Heart

Reversing the Effects of Sleep Apnea to Better Manage Heart Disease

Rami Khayat, MD

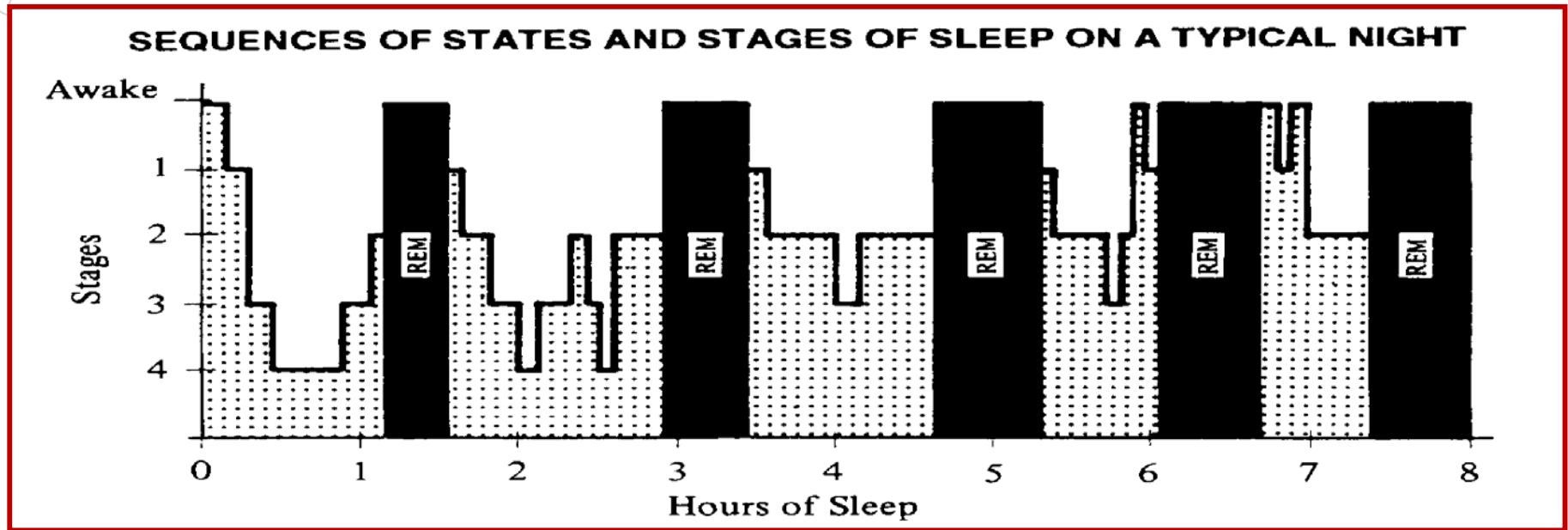
Professor of Internal Medicine

Director, OSU Sleep Heart Program

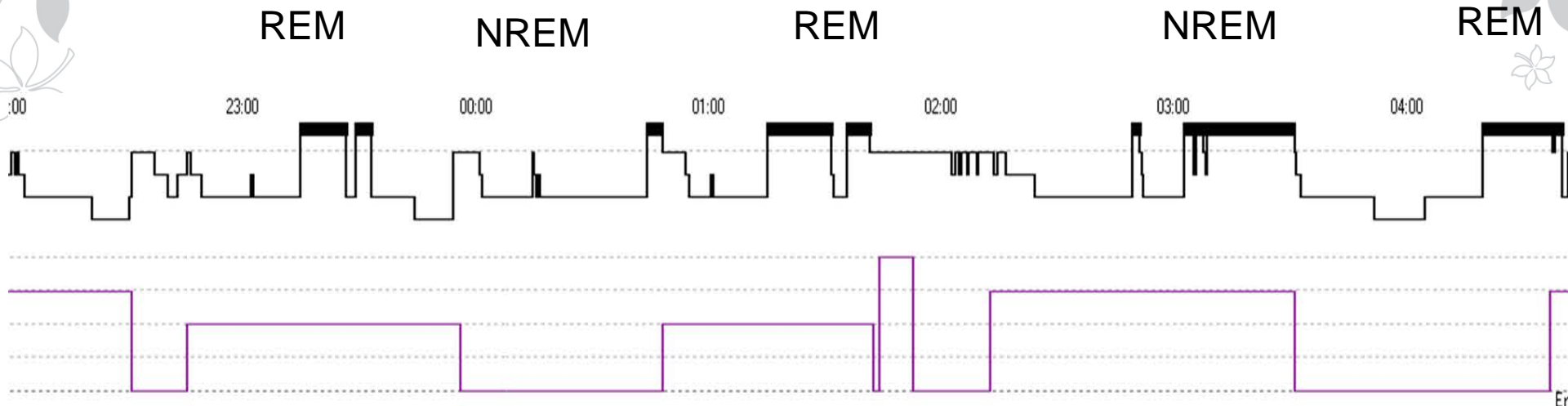
Medical Director, Department of Respiratory Therapy

The Ohio State University Wexner Medical Center

# Normal Sleep Pattern and Architecture



# Normal Changes in the Cardiovascular System during Sleep



## NREM

↓ HR  
↓ CO  
↓ BP  
↓ SVR

## Tonic REM vs. NREM

↓ HR  
↓ CO  
↓ BP  
↓ SVR

## Phasic REM vs. Tonic REM and NREM

↑ HR  
↑ CO  
↑ BP  
↑ SVR



# Types of Sleep Loss (debt)

- 1- Acute 24 hour sleep deprivation (Total)
- 2- Sub-acute: several days with significant sleep loss or restriction
- 3- Chronic: Sleep period reduction by 10-20% for months or years
- Sleep restriction
- Sleep “disruption” or “none-restorative” sleep due to sleep disorder



# Short Term Effects of Sleep Debt

- Personal Safety

- Doctors in training with sleep deprivation were more likely to:
  - Have complications of pregnancy
  - Be involved in a *motor vehicle accident*
- Sleep deprivation is a co-factor in 25% of all MVA's

- Performance

**Institutional data reflects work related injuries are more prevalent in nurses who work overtime...**

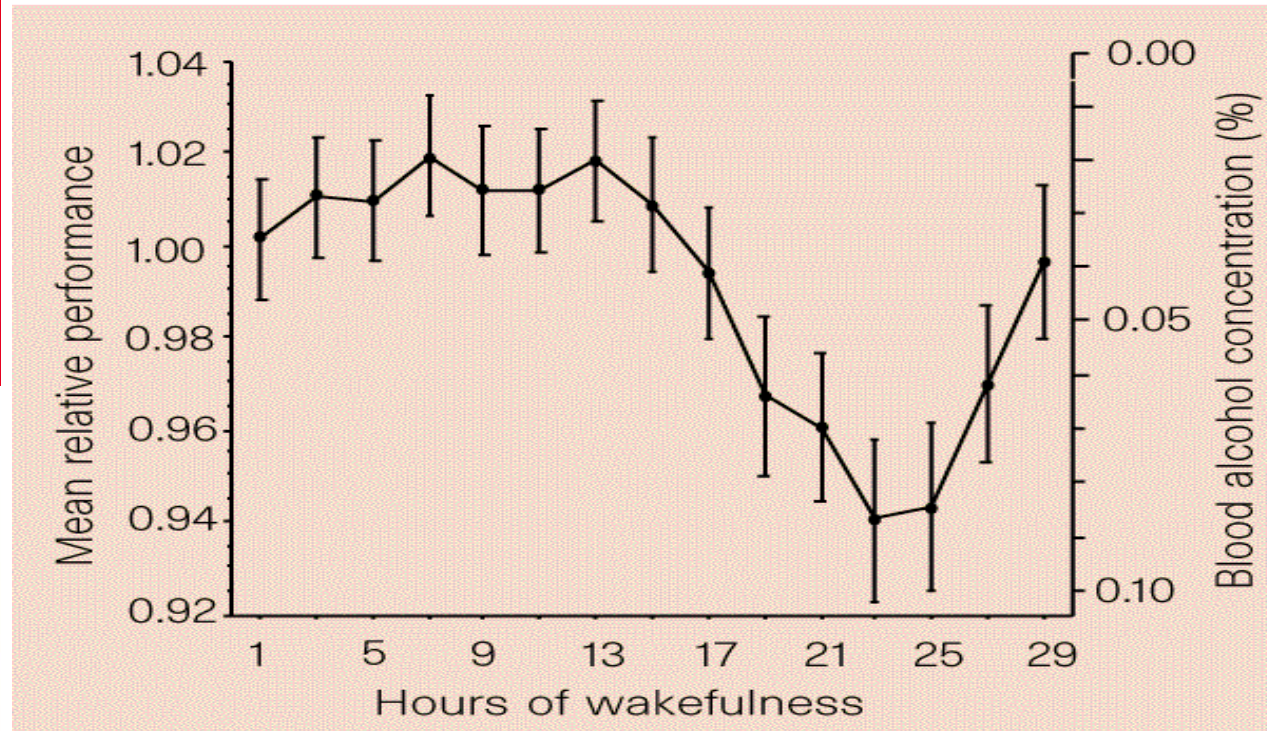
- Mood

- Higher scores on **depression** scales
- Increased **stress, anger, confusion and frustration**





# Sleep Deprivation and Psychomotor Performance



Dawson. Nature 1997



THE OHIO STATE UNIVERSITY  
WEXNER MEDICAL CENTER

# Long term Consequences of Sleep Loss; Restriction; and Deprivation

- Cognitive and executive impairment
- Depression
- Dementia
- Metabolic disturbances
- Cardiovascular disease
- Death
- Personal and societal safety



# Sleep Debt and Recovery

Sleep debt results in impairment in neurocognitive function-memory, recall, processing, and decision making

- Adult daily sleep need is an average of **7-9** h and is required to perform at optimal levels
- Sleeping less than the average required sleep contributes to “sleep debt”
- Recovery “make-up” sleep is likely only partially helpful in reversing the negative effects of sleep debt





# Impact of Heart Disease

- Cardiovascular disease (CVD) accounts for nearly 801,000 deaths in the US (1/3 of all deaths)
- 2,200 Americans die of CVD each day (1 death every 40 seconds)
- CVD claims more lives each year than all forms of cancer and Chronic Lower Respiratory Disease combined.
- About 92.1 million American adults are living with some form of CVD or the after-effects of stroke.
- Direct and indirect costs of CVD and stroke are estimated to total more than \$316 billion.
- By 2030, total direct medical costs of CVD are projected to increase to about \$920 billion.

# Sleep Duration and Quality: Impact on Lifestyle Behaviors and Cardiometabolic Health

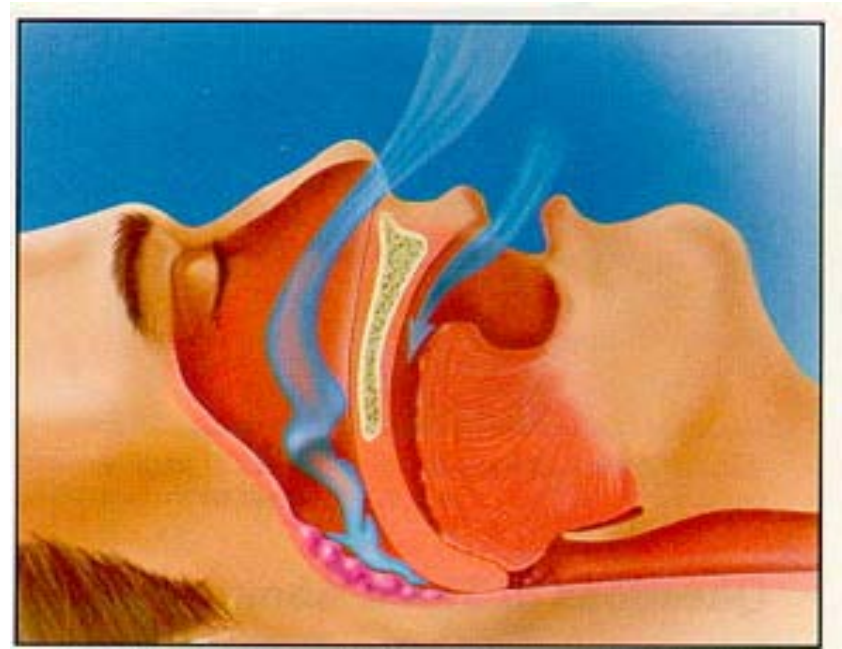
A Scientific Statement From the American Heart Association

- **ABSTRACT:** Sleep is increasingly recognized as an important lifestyle contributor to health. However, this has not always been the case, and an increasing number of Americans choose to curtail sleep in favor of other social, leisure, or work-related activities. This has resulted in a decline in average sleep duration over time. Sleep duration, mostly short sleep, and sleep disorders have emerged as being related to adverse cardiometabolic risk, including obesity, hypertension, type 2 diabetes mellitus, and cardiovascular disease. Here, we review the evidence relating sleep duration and sleep disorders to cardiometabolic risk and call for health organizations to include evidence-based sleep recommendations in their guidelines for optimal health.



# Obstructive Sleep Apnea (OSA)

- Intermittent closure of the upper airway during sleep
- Arousals from sleep
- Oxygen desaturation during sleep





## Risk Factors for OSA

- Increased weight (BMI>30)
- Age>65 yrs
- Male sex (2-3:1)
- Menopausal women
- Neck size
  - Male neck size  $\geq 17$  in. Female  $\geq 16$  in.
- Upper airway anatomy
- Family history -inc by 2-4 fold
- Race
  - Africa Am/Mexican/East Asian/Pacific Islander





# Signs and Symptoms of OSA

- Snoring
- Non-refreshing sleep/daytime sleepiness
- Witnessed apneas
- Insomnia
- Restless sleep
- Nocturnal heartburn
- Morning headaches
- Nocturia
- Dry mouth/sore throat/ nasal congestion
- Mood, memory and learning problems
- **None at all!**



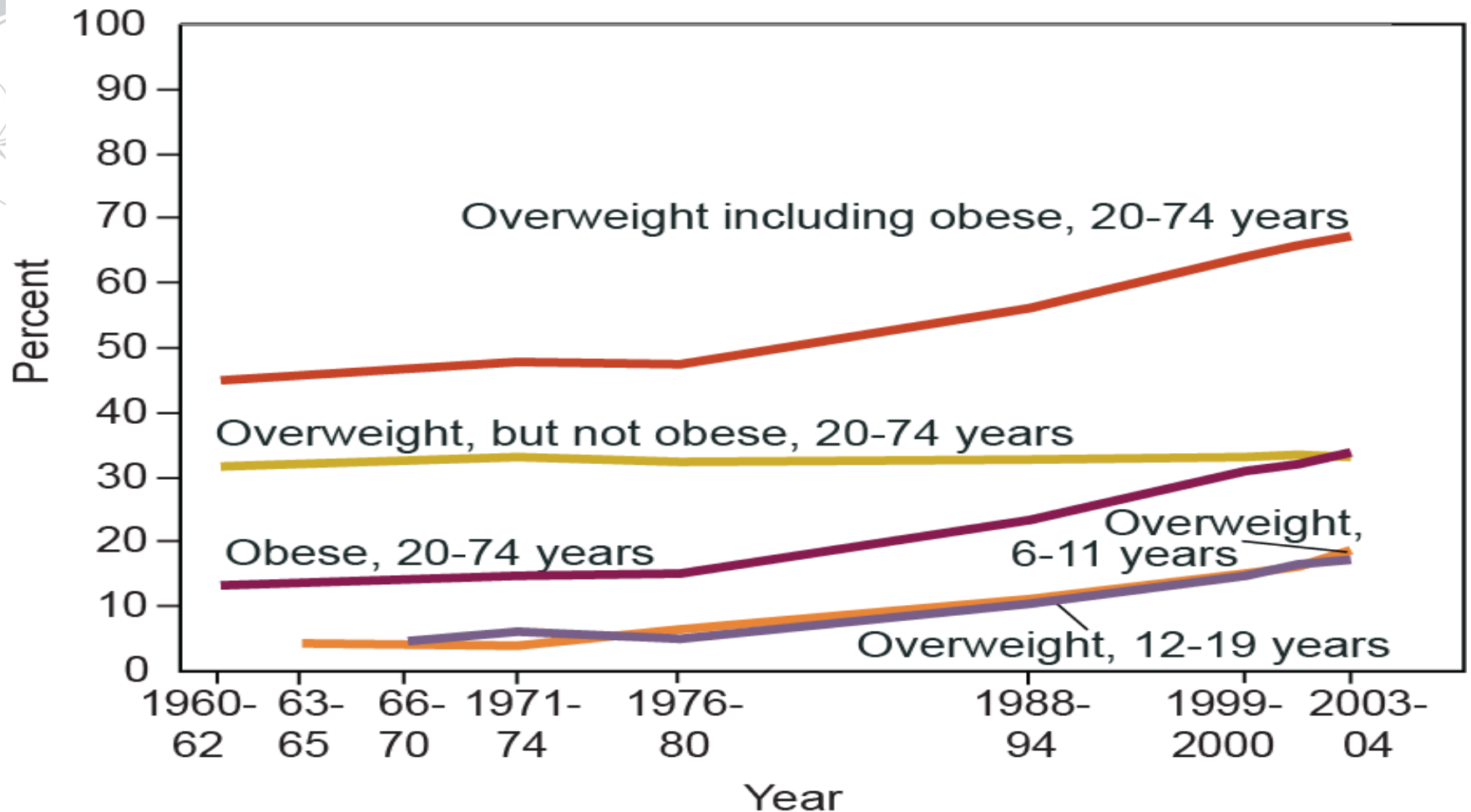


# Prevalence of OSA

- In 1993, OSA (defined as AHI > 5 events/hour of sleep) is present in:
  - 24% men and 9% women 30-60 years
  - 31% men and 16% women 50-60 years
- Increased age and weight of the population likely increased the prevalence of OSA
- In individuals with CVD, the prevalence of OSA exceeds 50%



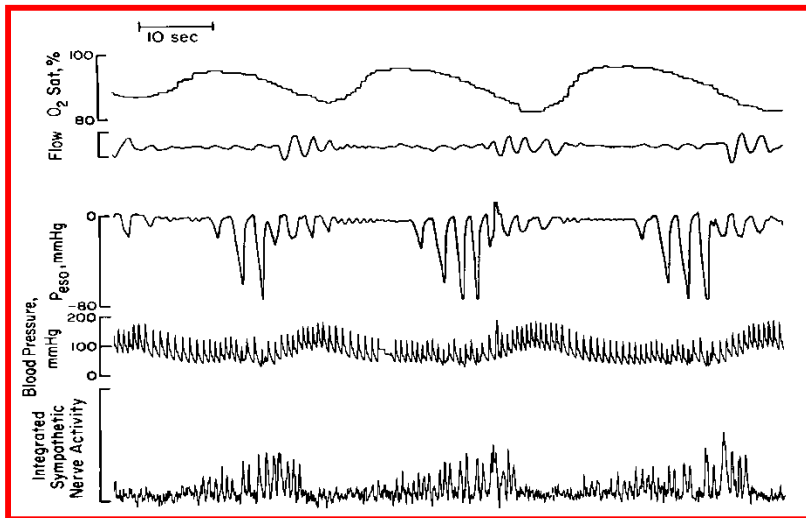
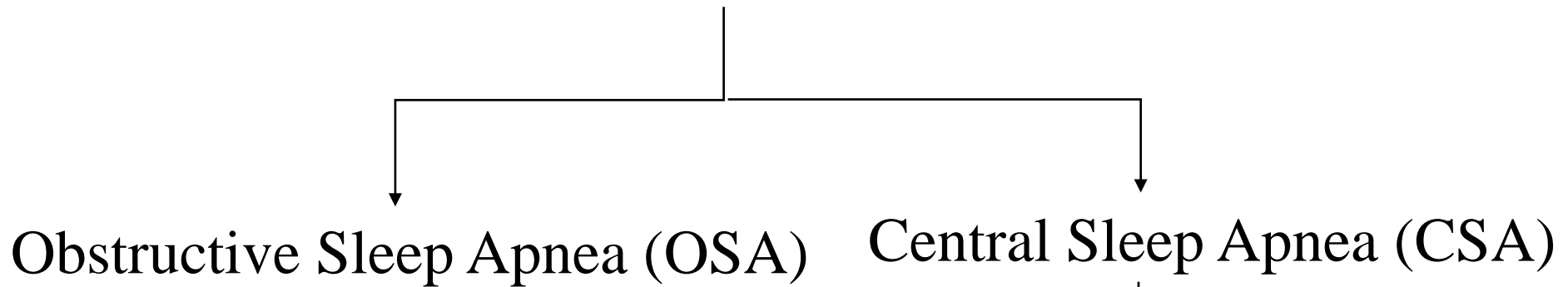
# Overweight and obesity



SOURCES: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2006*, Figure 13. Data from the National Health and Nutrition Examination Survey.



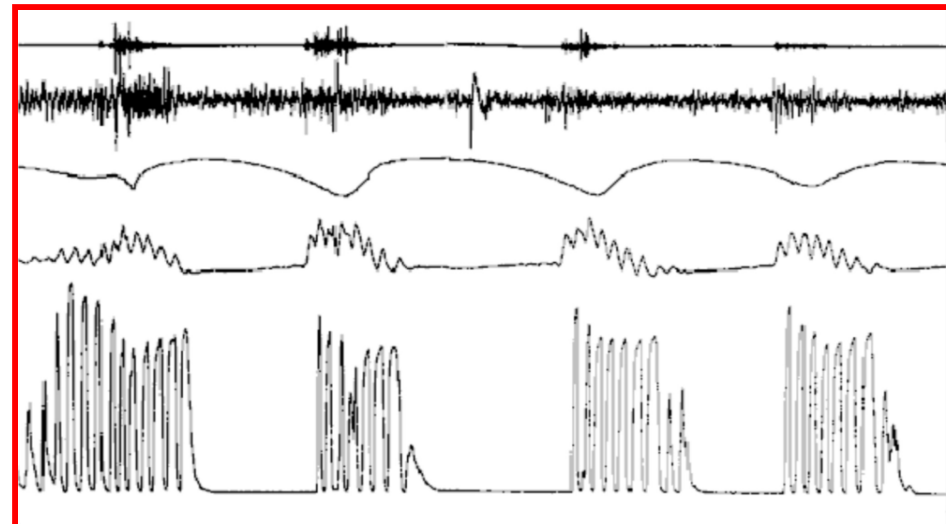
# Types of Sleep Apnea



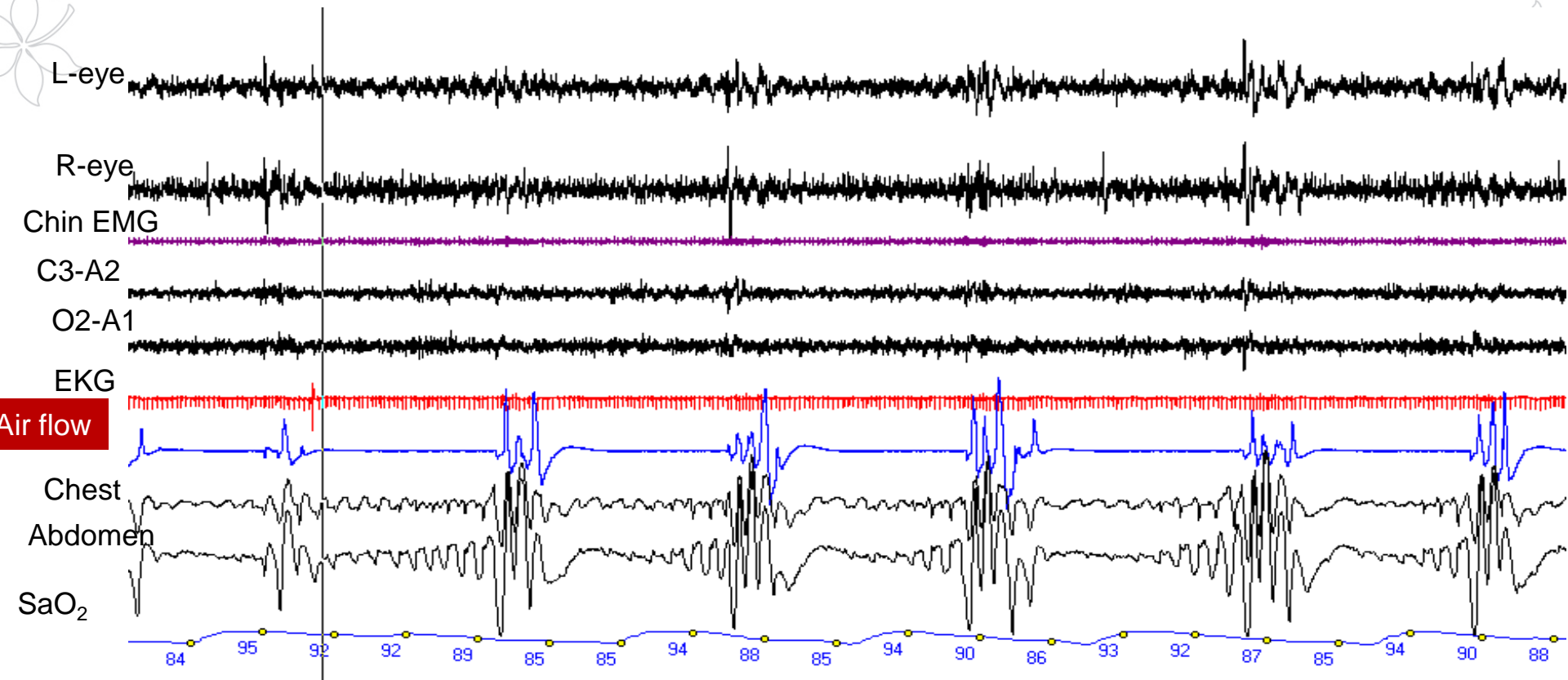
“Mixed SDB”: CPAP induced  
CSA  
Mixed CSA-OSA (heart failure)

Idiopathic Central Sleep  
Apnea Syndrome

Cheyne-Stokes  
Respiration/ HF



# Obstructive Sleep Apnea on Sleep Study



# Central Sleep Apnea

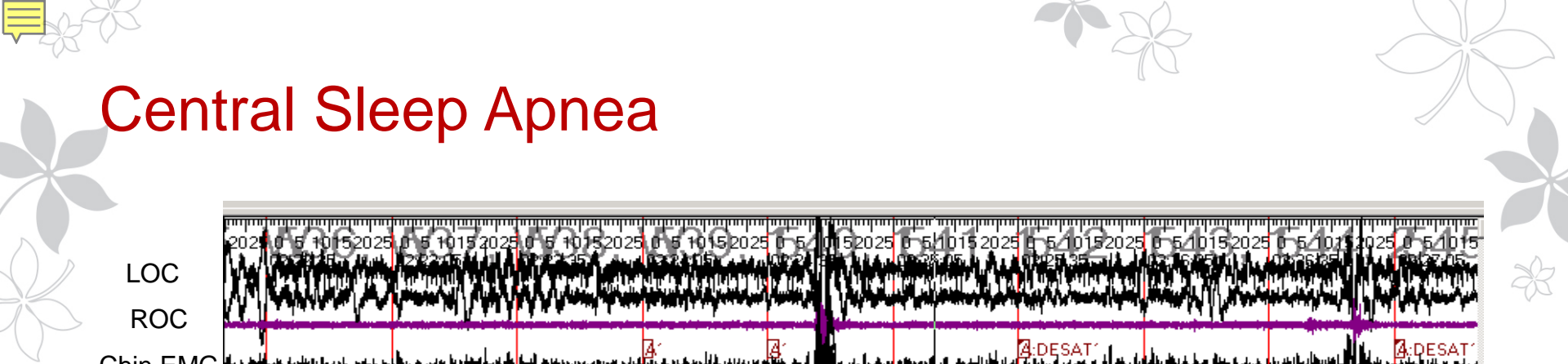
LOC

ROC

Chin EMC

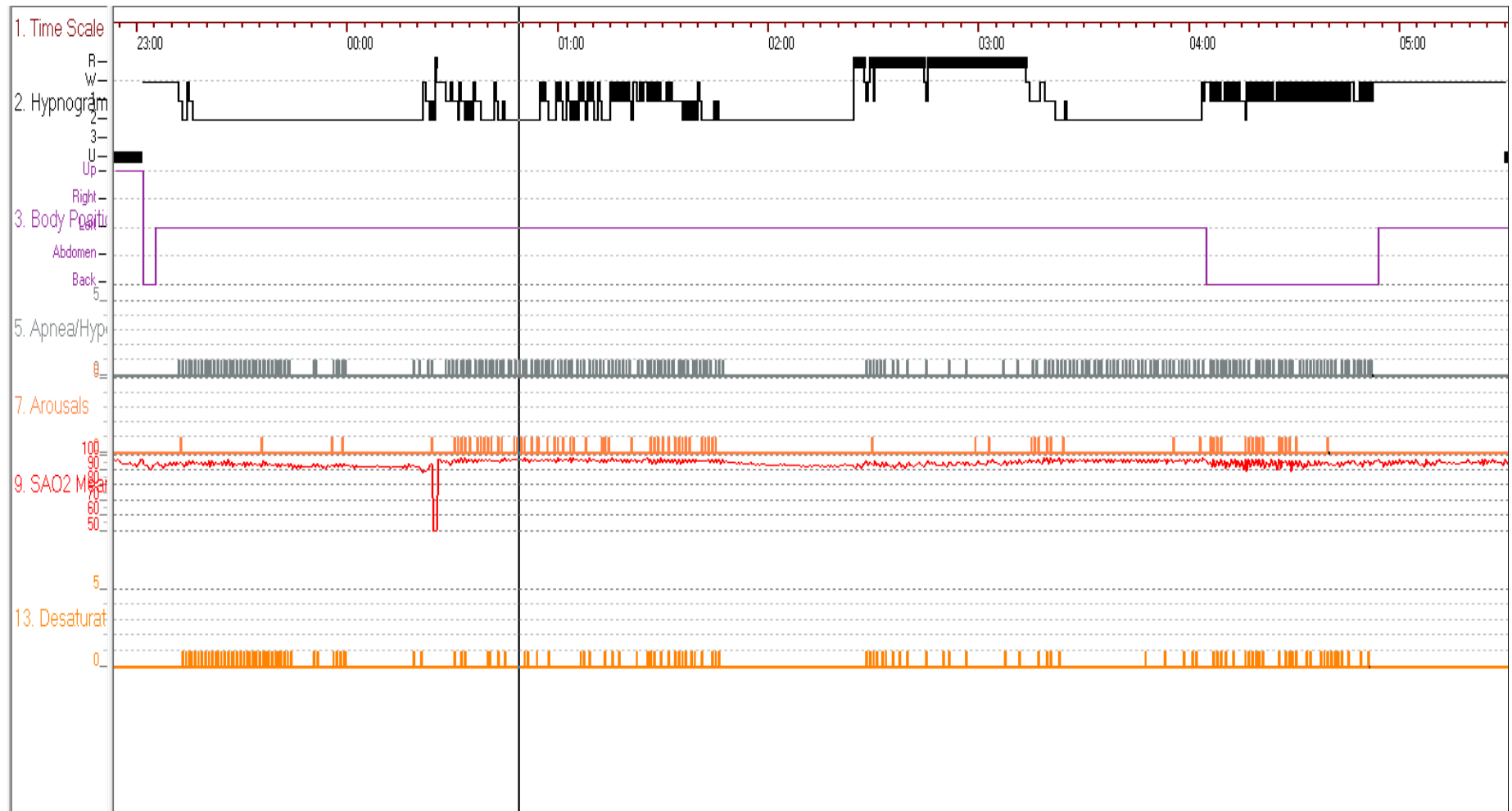
A

A-DESAT

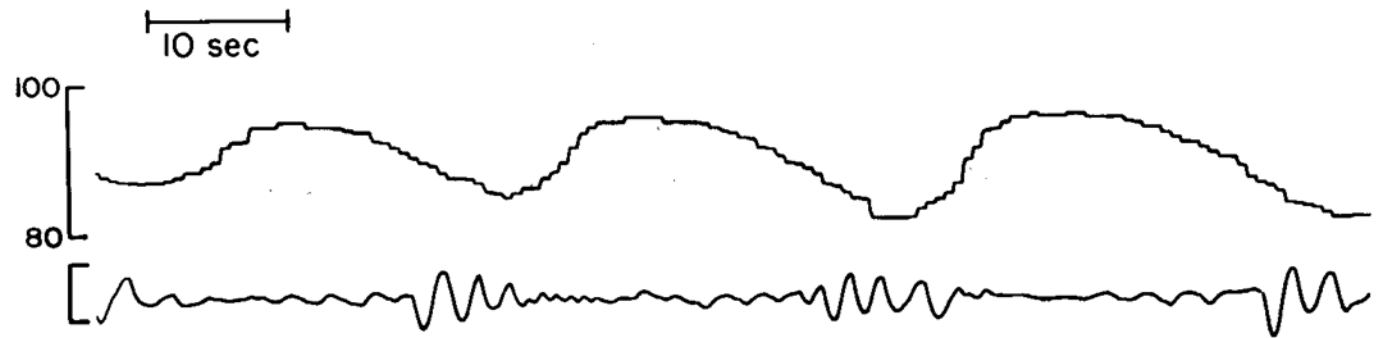




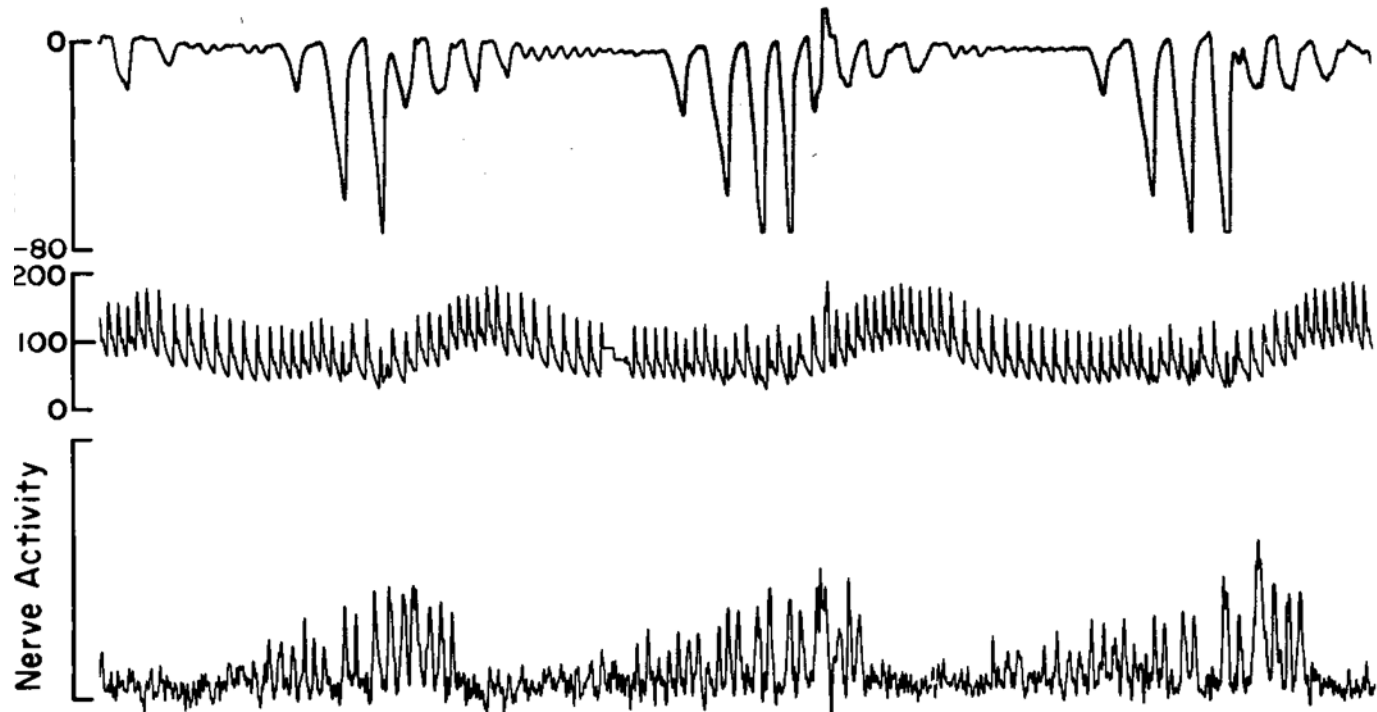
# Disruption of Sleep Architecture in OSA



# Vascular Response to Apnea



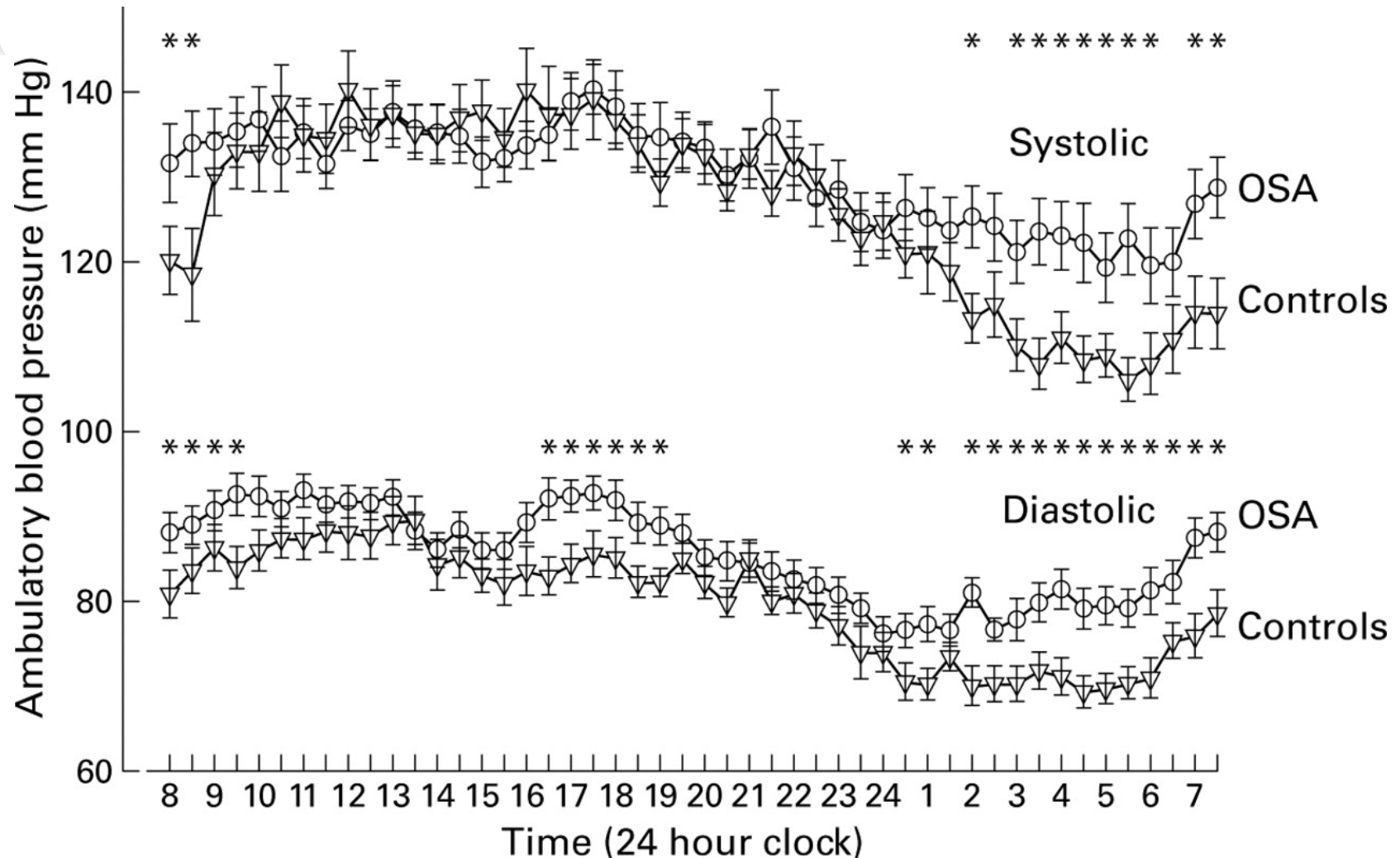
Respiratory  
Effort



Blood  
Pressure

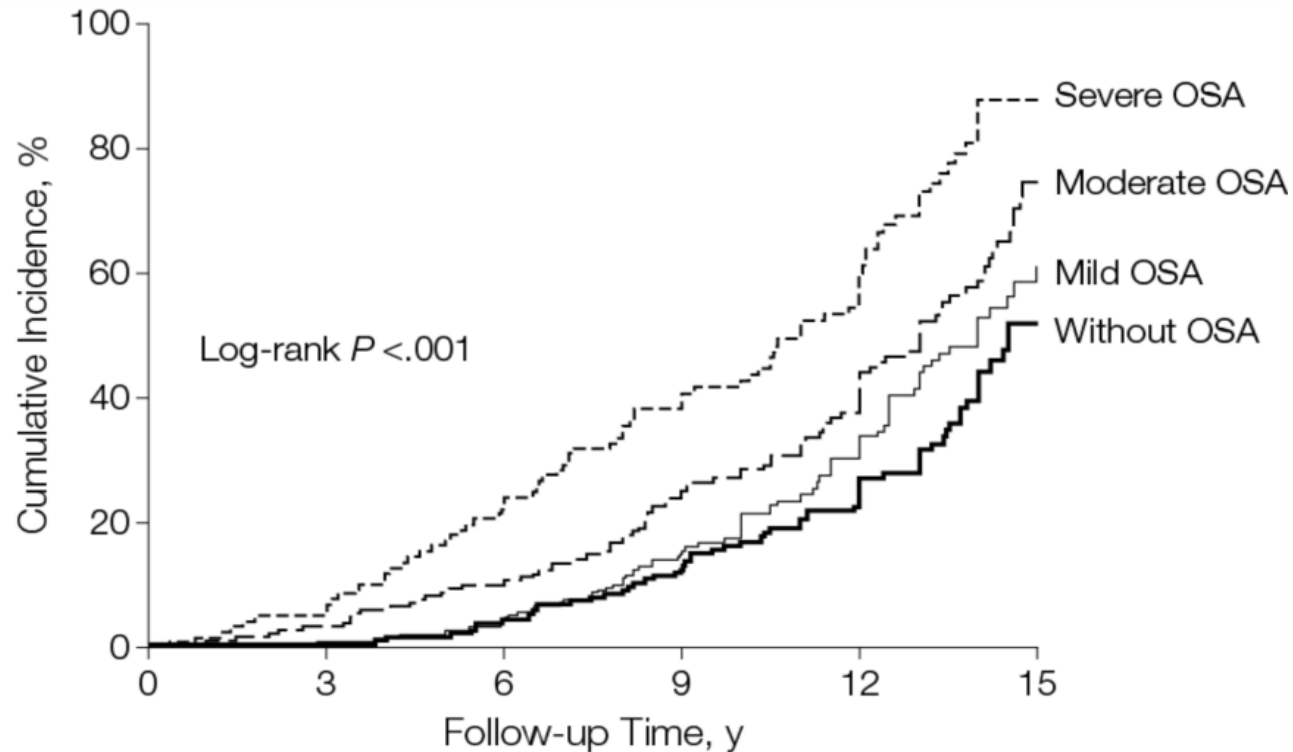
Sympathetic  
Nerve Activity

# Nocturnal Blood Pressure Response to Sleep Apnea



# Association Between Treated and Untreated Obstructive Sleep Apnea and Risk of Hypertension

JAMA. 2012;307(20):2169-2176. doi:10.1001/jama.2012.3418

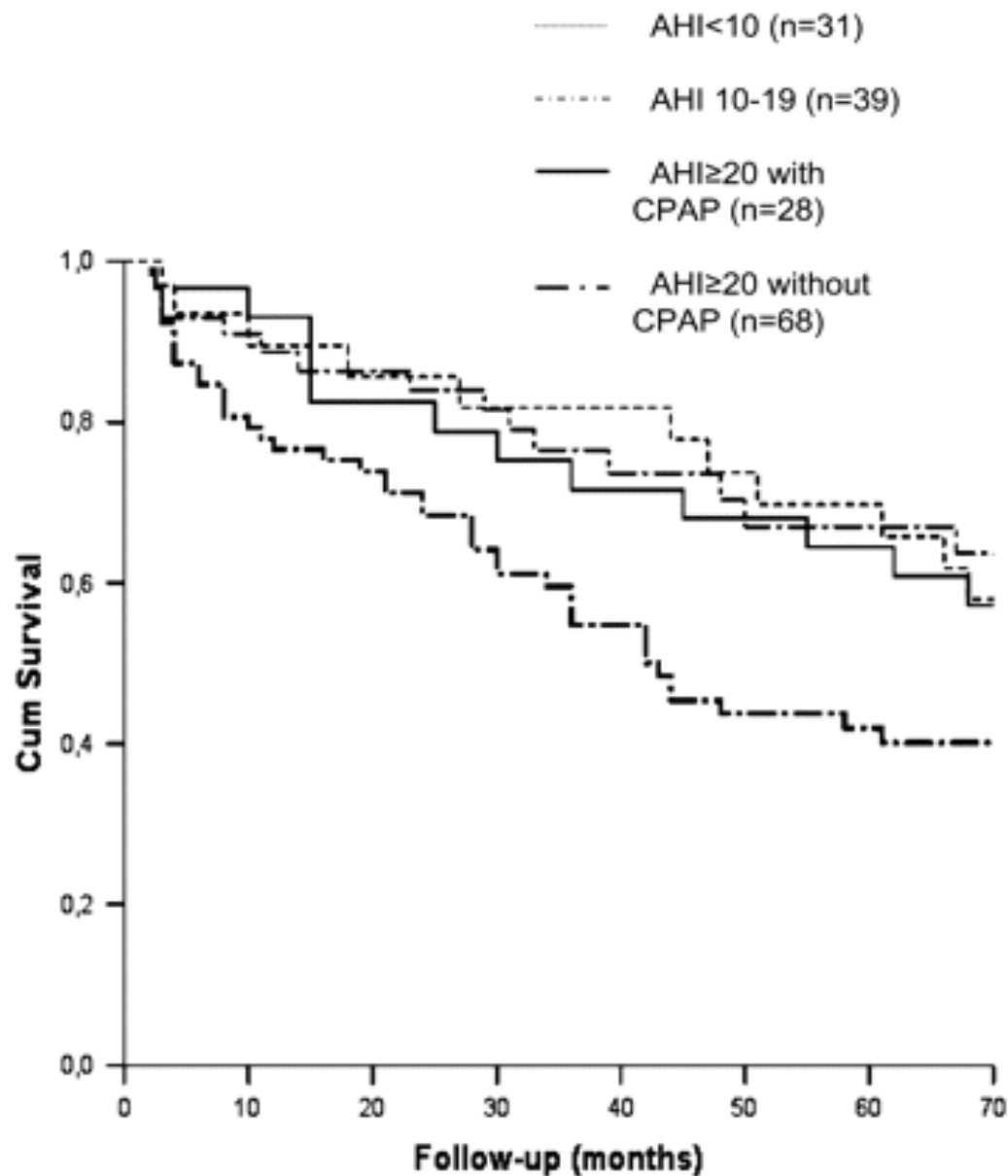


No. at risk

Severe OSA	199	184	141	119	62	37
Moderate OSA	258	222	202	162	114	67
Mild OSA	298	289	260	194	127	59
Without OSA	310	306	269	211	152	72

Mild OSA (AHI, 5.0-14.9), moderate OSA (AHI, 15.0-29.9), and severe OSA (AHI,  $\geq 30.0$ ). P value reflects an overall log-rank test, providing an overall survival difference among the 4 study groups.

# CPAP treatment reduces mortality in patients with ischemic stroke and obstructive sleep apnea: a 5-year follow-up study





# OSA and Atrial Fibrillation

- Increased prevalence of OSA in patients with AF
- Increased rate of recurrence of AF in patients with untreated OSA
- Increased rate of failure of anti-arrhythmic medication in AF patients who have untreated OSA
- Increased likelihood of failure of first and second ablation procedure if OSA is untreated

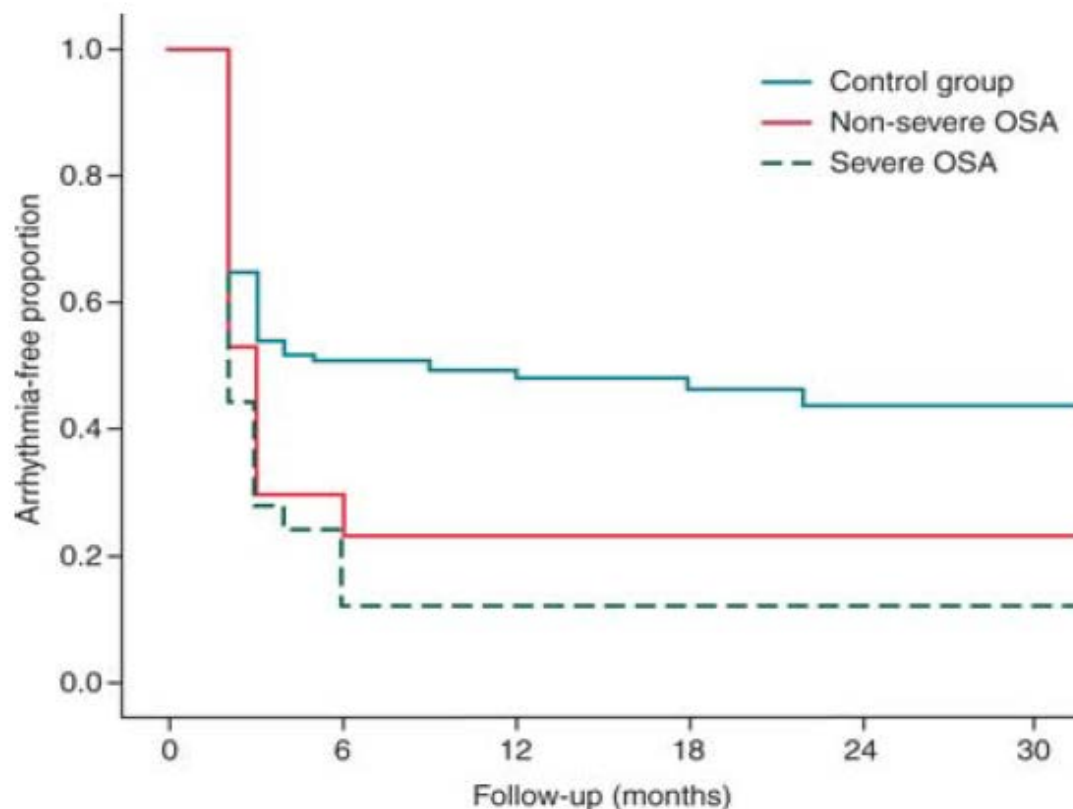
Gami, et al. *JACC* 2007;49:565-71

Fein et al. *J Am Coll Cardiol* 2013;62:300–5



# Low Efficacy of Atrial fibrillation Ablation in severe OSA Patients

Matiello et al Europace (2010))



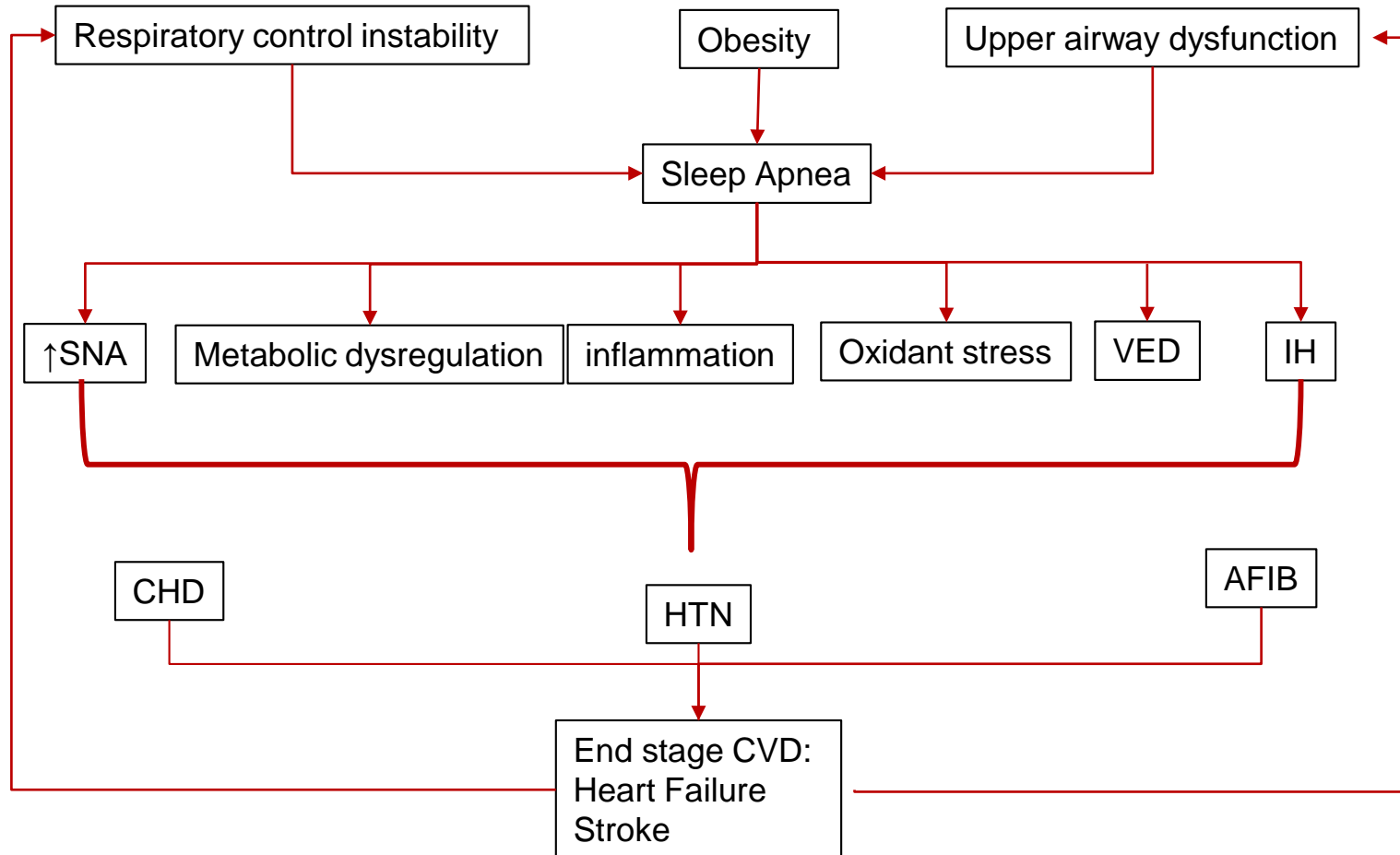
Patients at risk	0	6	12	18	24
Low risk OSA	132	56	32	23	15
Non-severe OSA	17	11	8	5	3
Severe OSA	25	5	1	1	1

## Freedom from arrhythmia recurrences after a single ablation procedure.

(a) Patients classified as low risk for OSA according to low BQ score or AHI<10 in the sleep study (control group), (b) Non-severe OSA group, (patients with high BQ score and 10 , AHI , 30). (c) Severe OSA group (patients with high BQ score and AHI ≥ 30). P ¼ 0.052 for (a) vs. (b) and P , 0.001 for (a) vs. (c) (log-rank test).

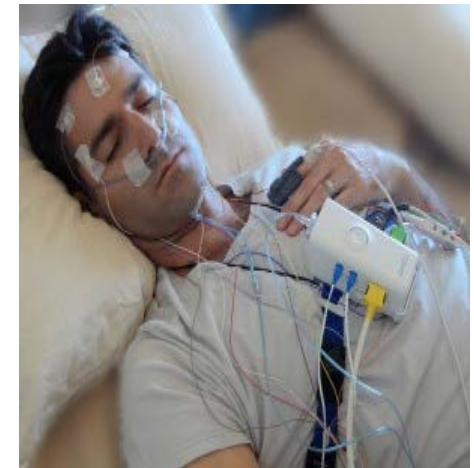


# Pathways of Cardiovascular Disease in Sleep Apnea



# Polysomnography

- Evaluate for
  - Sleep disordered breathing
  - Periodic Limb movements of sleep



# Home sleep test

- Limited recording of respiratory parameters
- Sufficient for the diagnosis of OSA in most cases
- Limited to no information on sleep quality, heart rhythm, and severity in mild to moderate cases



# Severity of Sleep Apnea

- Sleep apnea is measured by the number of events per hour of sleep

- Apnea Hypopnea Index (AHI)

Number of apneas+hyopneas

Hour of sleep

- Respiratory disturbance index (RDI)

Apneas+hypopneas+ RERA

Hour of Sleep





# Severity of Sleep Apnea

- Normal-  $AHI < 5$
- Mild OSA-  $AHI$  of 5 to  $< 15$
- Moderate is  $AHI$  of 15 to 29
- Severe is  $AHI \geq 30$
- OSA-  $> 50\%$  of events are obstructive
- CSA-  $> 50\%$  of the events are central



# Factors that contribute to increased OSA severity

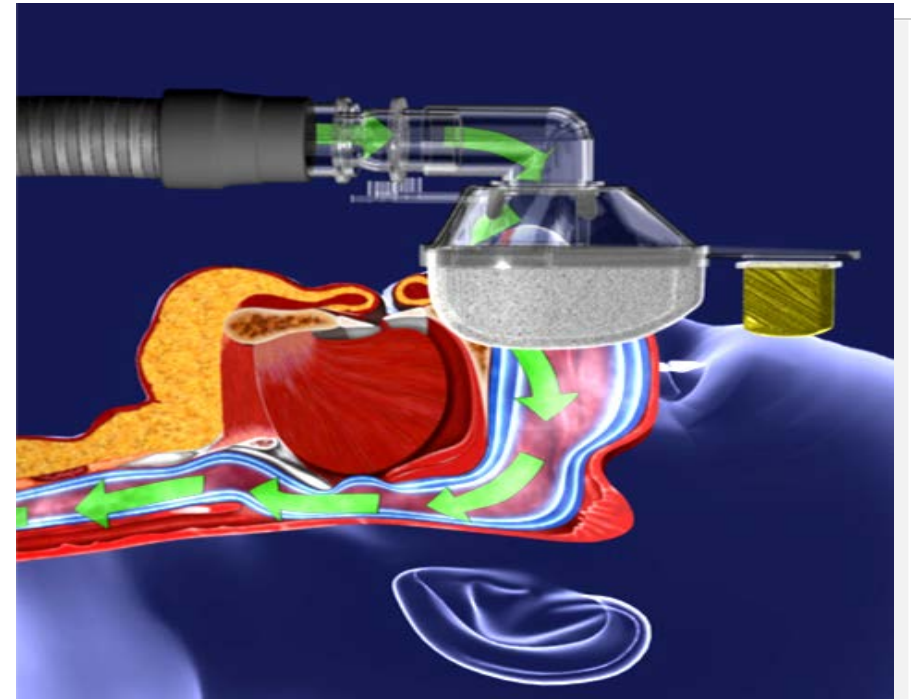
- Weight gain
  - 10% increase in body weight associated with 6 times increased risk of OSA
- Alcohol
- Sedatives
- Smoking
- Nasal congestion
- Supine sleeping position



# Treatment of OSA in Patients with Cardiovascular Disease

- CPAP remains the mainstay of treatment
- CPAP has the most available data on safety and efficacy
- Improvement in blood pressure, atrial fibrillation control and endothelial dysfunction are reported only with CPAP
- Tolerance of CPAP is likely increased with improved technology of device and interface





# *What mask should I use?*





## Is it the mask?



While it's not the mask; it can be the mask selection; the mask fitting; the process; the clinician and the company



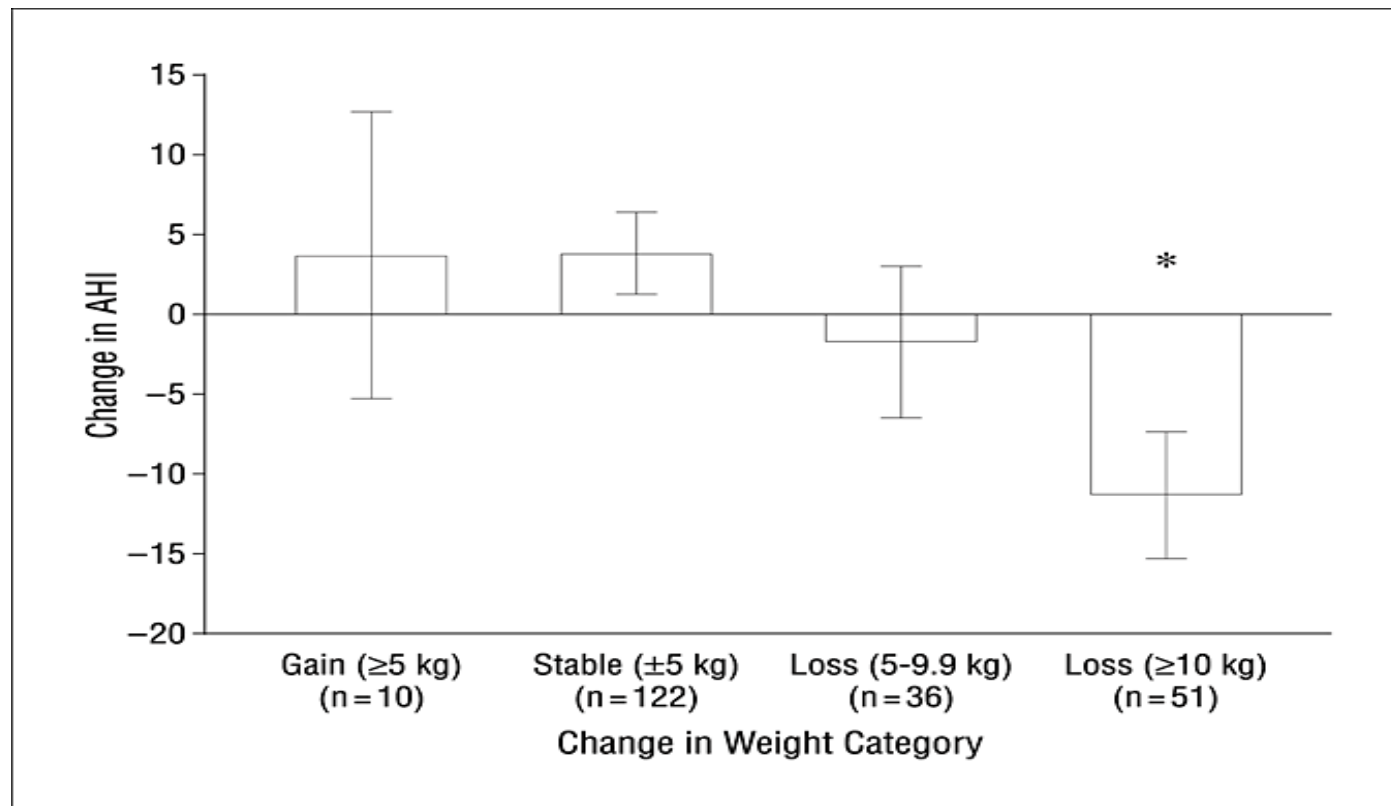
# Treatment options

- Mandibular advancement devices
- Surgery
  - UPPP
  - Jaw advancement surgeries
  - Bariatric procedures
  - Tracheostomy
- Neurostimulation: Inspire®
- Positional therapy
- Weight loss





# Weight loss and sleep apnea



Changes in apnea-hypopnea index (AHI) by category of weight change over 1 year







# Effects of Sleep and the Supine position on Upper Airway Muscle Tone

- Airway volume reduced
- Muscle tone decreased
- Decreased lung volumes

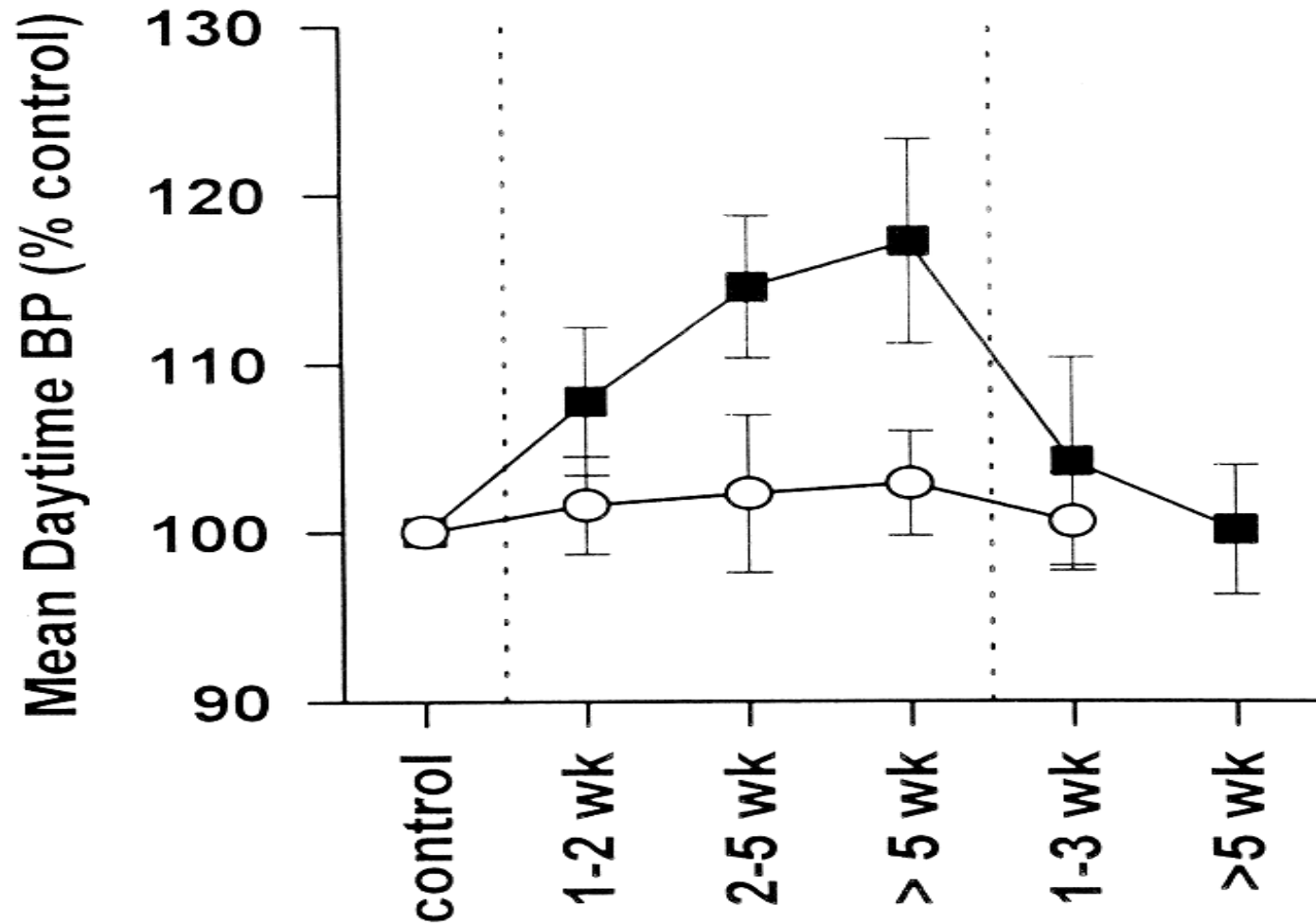


# Daytime Sympathetic Activity and Blood Pressure elevation in OSA

- Sympathetic activity is elevated during the night and remains elevated during the morning in OSA patients
- Blood pressure elevation is noted also in the early morning in individuals exposed to hypoxia (OSA patients)
- Treatment of OSA decreases daytime blood pressure and sympathetic activation
  - Somers et al JCI; 1993
  - Arabi et al J Appl Physiol 1999



# OSA- Induced Hypertension- Dog Model of Airway Occlusion



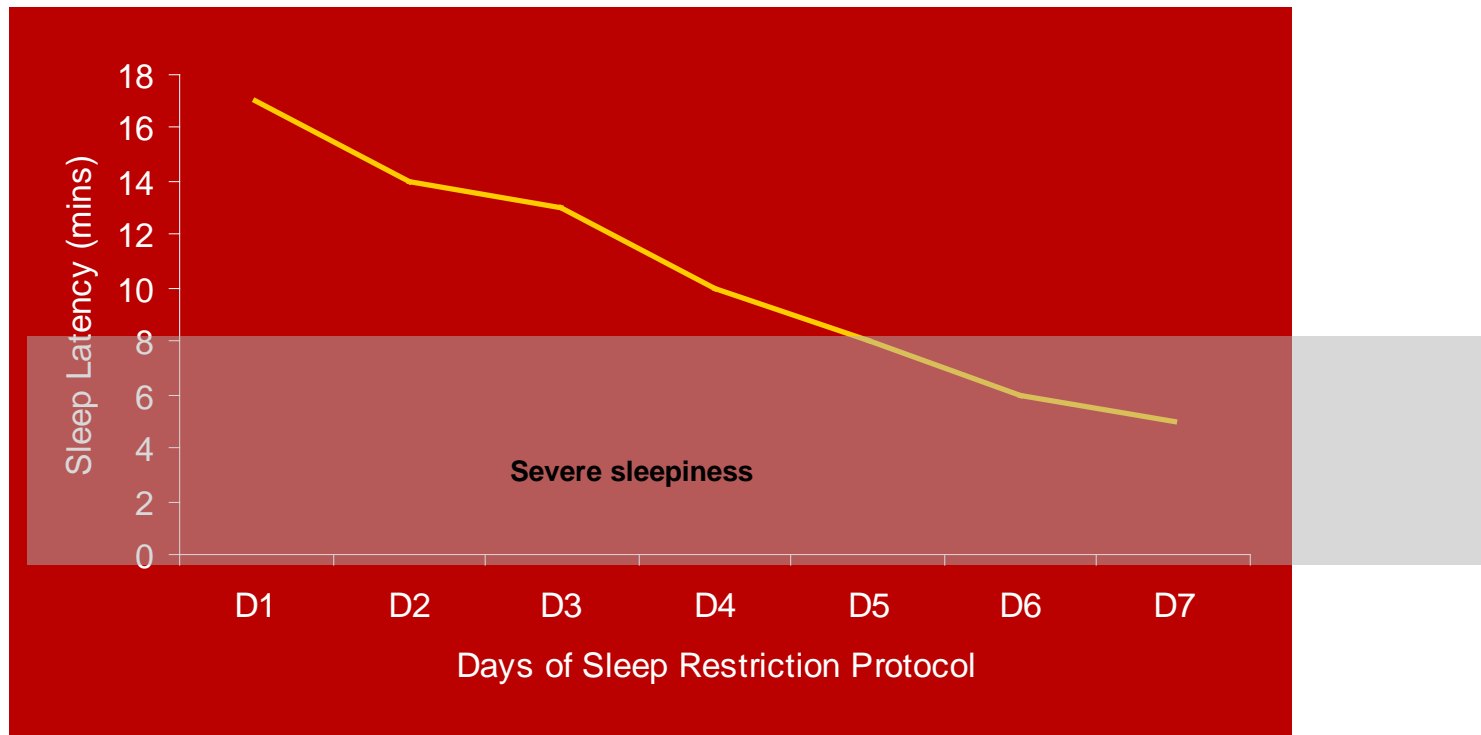
Brooks, et al. J Clin Invest 99:106, 1997

# Evaluation for OSA

- Patients at high risk for OSA should be evaluated for OSA symptoms
  - Obesity (BMI > 35)
  - Congestive heart failure
  - Atrial fibrillation
  - Refractory hypertension
  - Type II diabetes
  - Nocturnal dysrhythmias
  - Stroke
  - Pulmonary hypertension
  - High risk driving populations
  - Preoperative evaluation



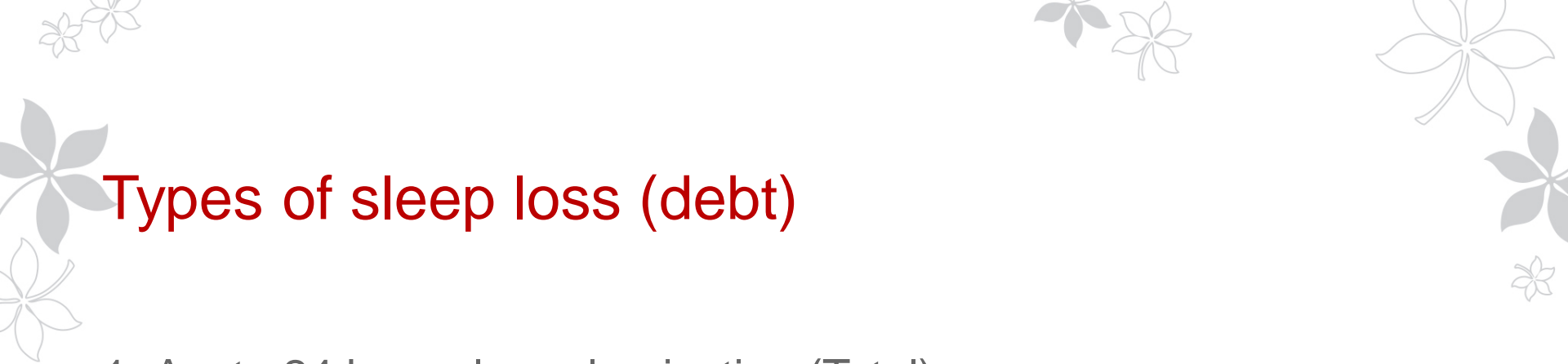
# Sleep Restriction and Sleep Drive



Daily sleep restriction by two hours (non-progressive):

adapted from Carskadon and Dement, 2000 in *Principle and Practice of Sleep Medicine*





## Types of sleep loss (debt)

- 1- Acute 24 hour sleep deprivation (Total)
- 2- Sub-acute: several days with significant sleep loss or restriction
- 3- Chronic: Sleep period reduction by 10-20% for months or years
- Sleep restriction
- Sleep “disruption” or “none-restorative” sleep due to sleep disorder



# Sleep Debt and recovery

- Adult daily sleep need is an average of 7-9 h and is required to perform at optimal levels
- Sleeping less than the average required sleep contributes to “sleep debt”
- Recovery “make-up” sleep is likely only partially helpful in reversing the negative effects of sleep debt





# Manifestations of Short term sleep loss

- Fatigue or daytime sleepiness
- impaired concentration, memory, attention
- Poor academic and job performance
- Mood disturbance or irritability



# Obstructive sleep apnea syndrome

- A condition characterized by repeated episodes of upper airway obstruction during sleep associated with daytime symptoms.
- Episodes of airway obstructions are associated with increases in BP and sympathetic tone, hypoxemia, hypercapnea, and EEG arousals.

