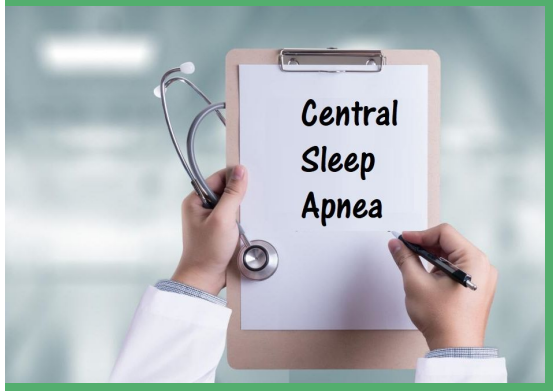
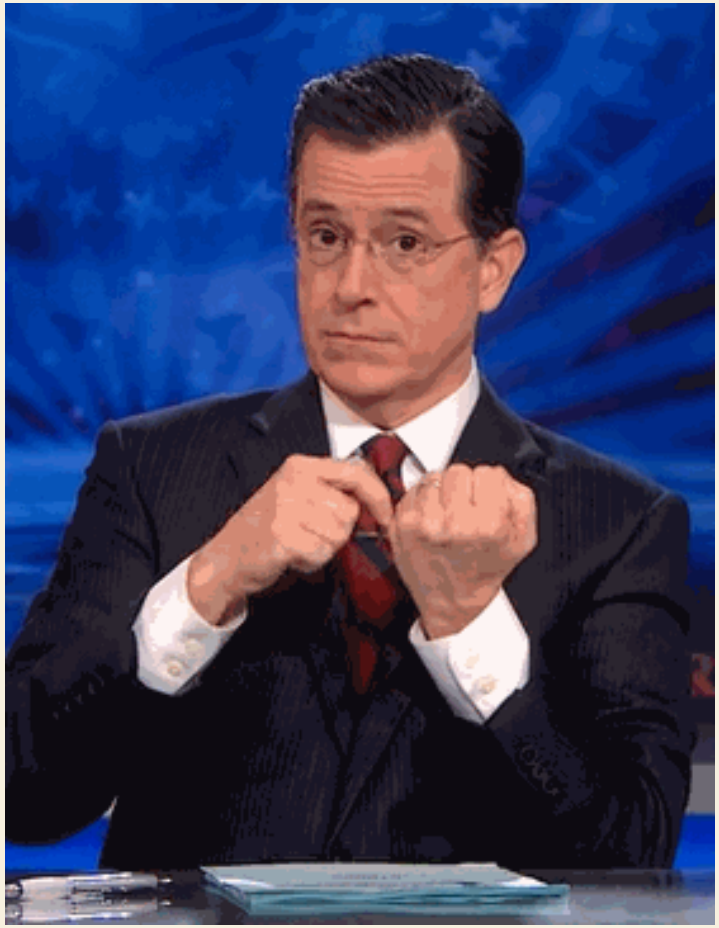
بسم الله الرحمن الرحيم

CENTRAL SLEEP APNEA

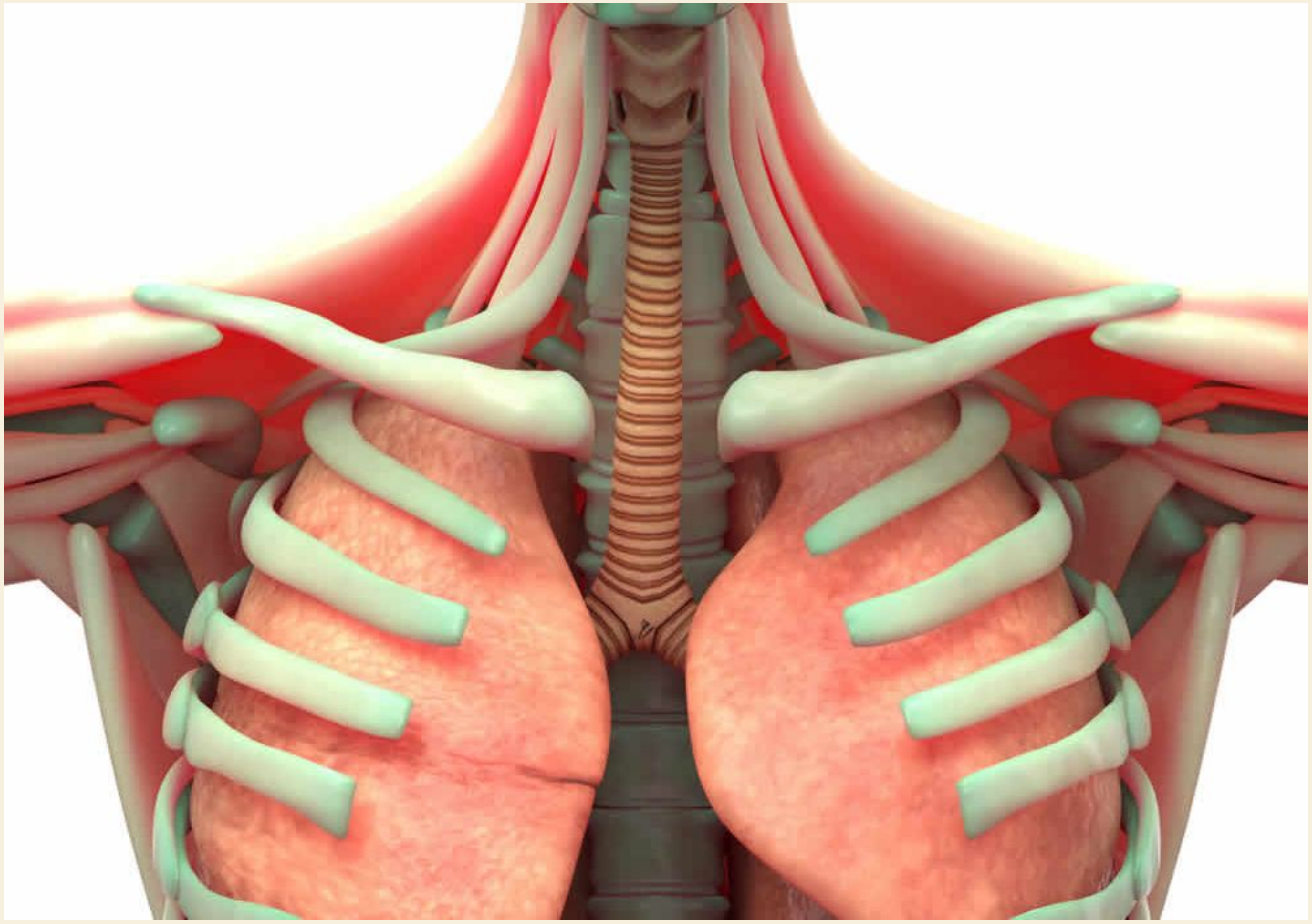


PROF. MOHAMAD SHEHADEH AGHA
MD MRCP(UK)

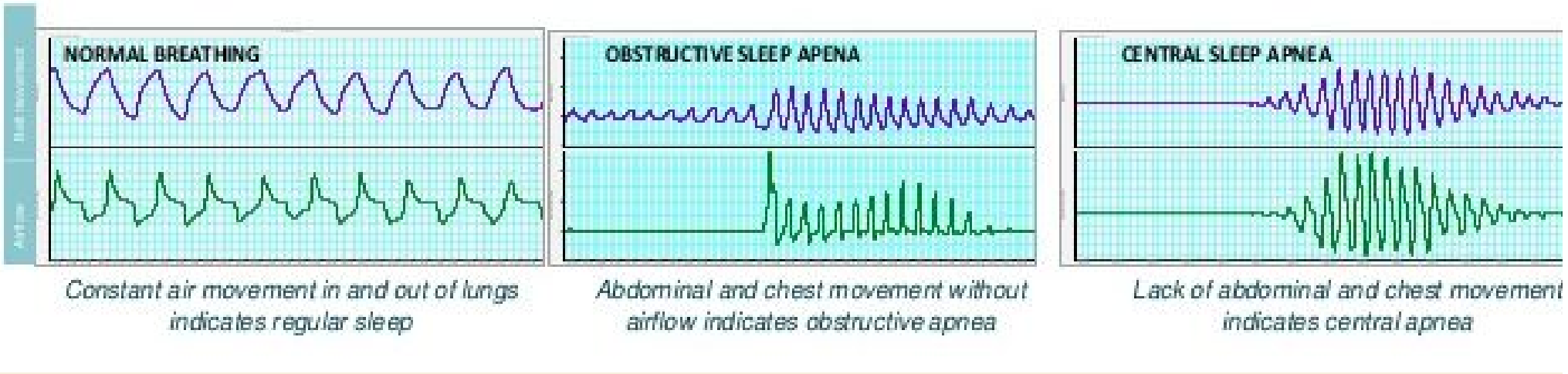
خلل بالمحرك



CSA, defined as the temporary absence of ventilatory effort during sleep, is seen in a variety of forms across the life span.



CSA VS OSA

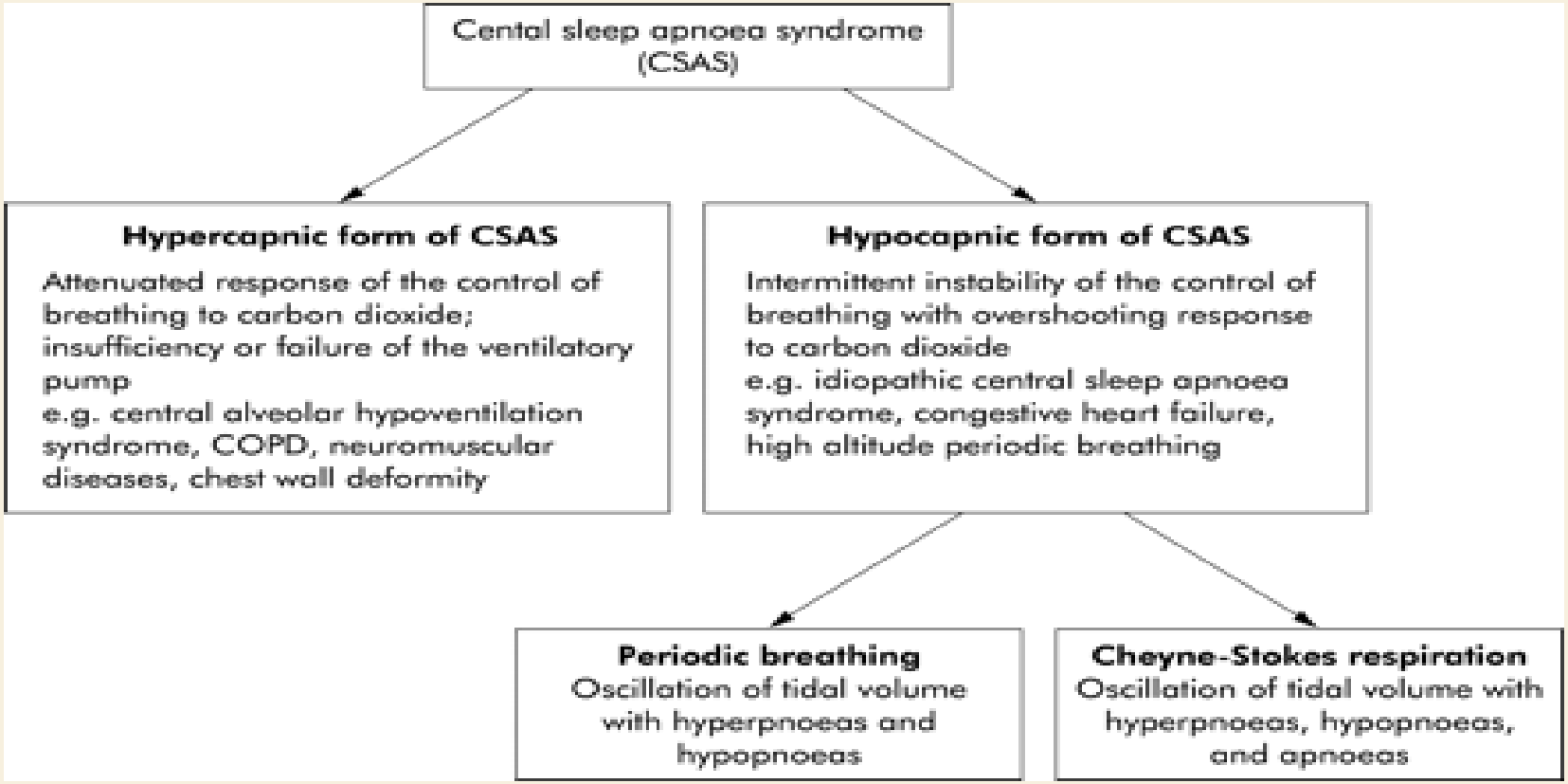


Constant air movement in and out of lungs indicates regular sleep

Abdominal and chest movement without airflow indicates obstructive apnea

Lack of abdominal and chest movement indicates central apnea

CSA

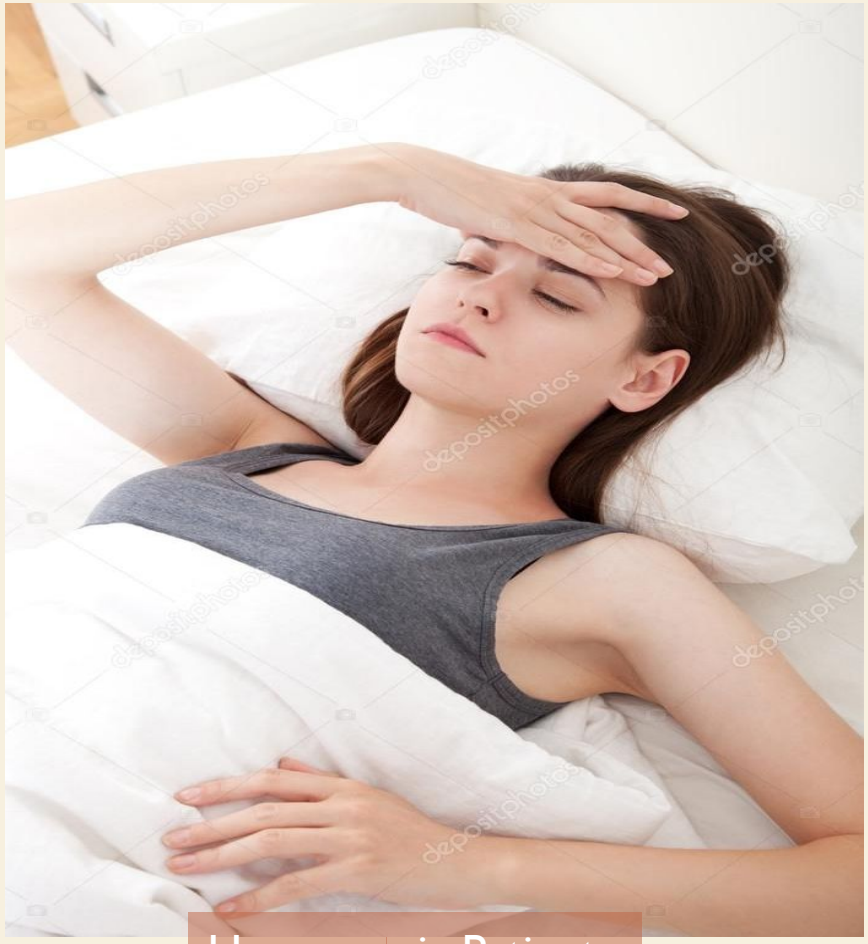

Central sleep apnoea syndrome (CSAS)
Hypercapnic form of CSAS
Attenuated response of the control of breathing to carbon dioxide; insufficiency or failure of the ventilatory pump
e.g. central alveolar hypoventilation syndrome, COPD, neuromuscular diseases, chest wall deformity
Hypocapnic form of CSAS
Intermittent instability of the control of breathing with overshooting response to carbon dioxide
e.g. idiopathic central sleep apnoea syndrome, congestive heart failure, high altitude periodic breathing
Periodic breathing
Oscillation of tidal volume with hyperpnoeas and hypopnoeas
Cheyne-Stokes respiration
Oscillation of tidal volume with hyperpnoeas, hypopnoeas, and apnoeas


SYMPTOMS

EXCESSIVE DAYTIME SLEEPINESS

Hypercapnic Patients

MORNING HEADACHE

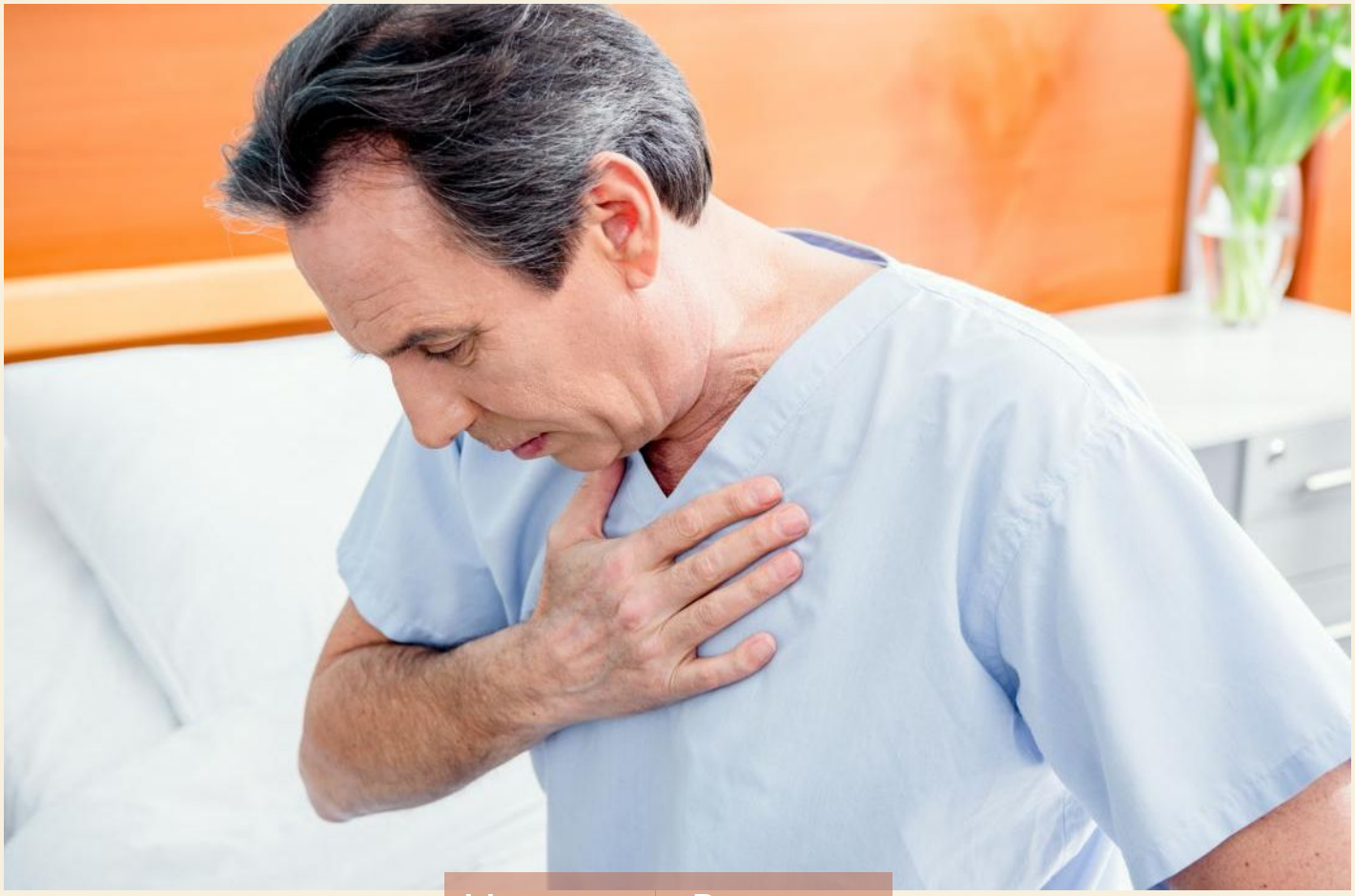


Hypercapnic Patients

INSOMNIA

Hypocapnic Patients

MAN IN HOSPITAL GOWN SITTING ON BED WAKING UP GASPING FOR AIR

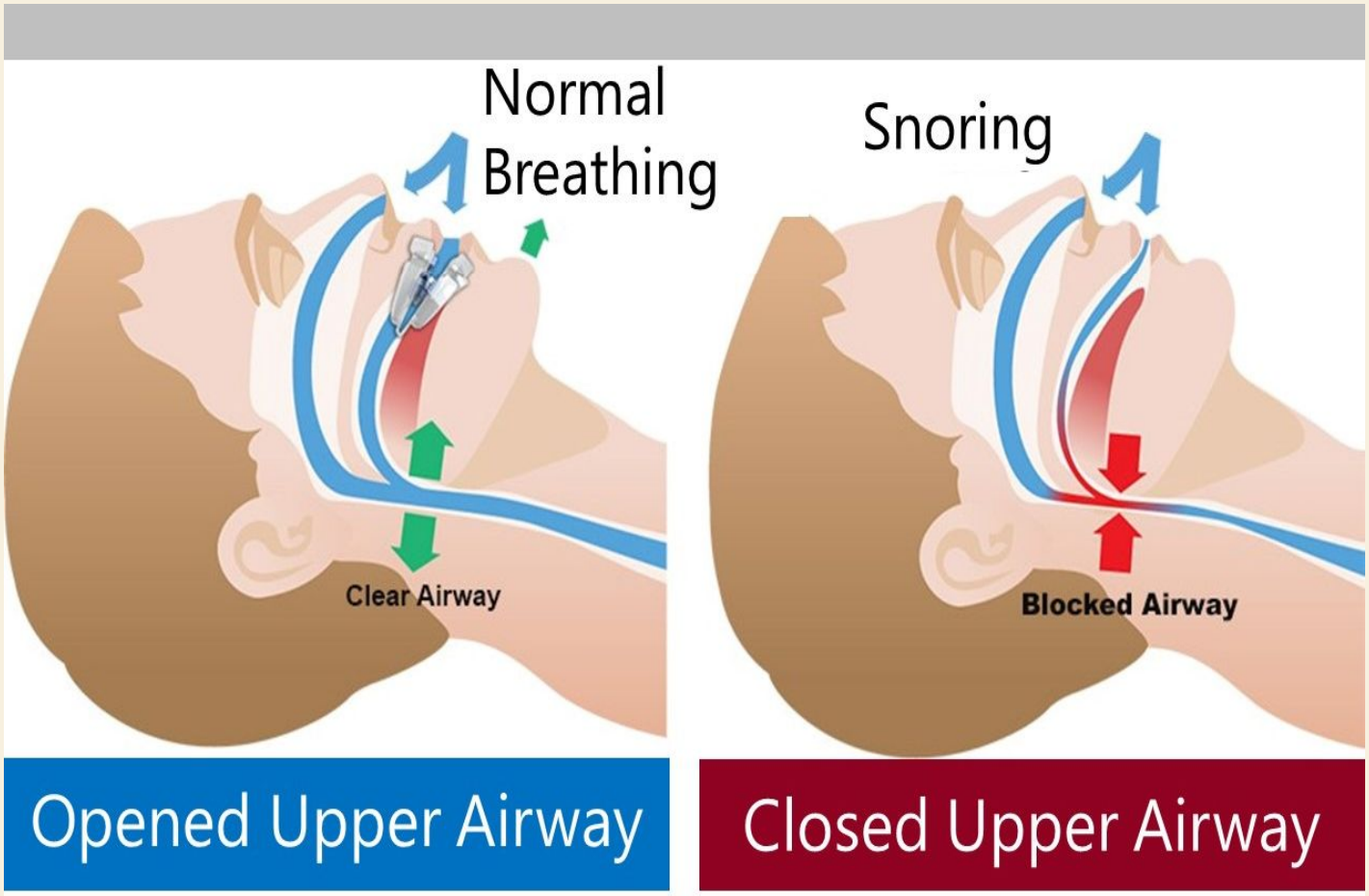


Hypocapnic Patients

CHEST PAIN AT NIGHT

SNORING

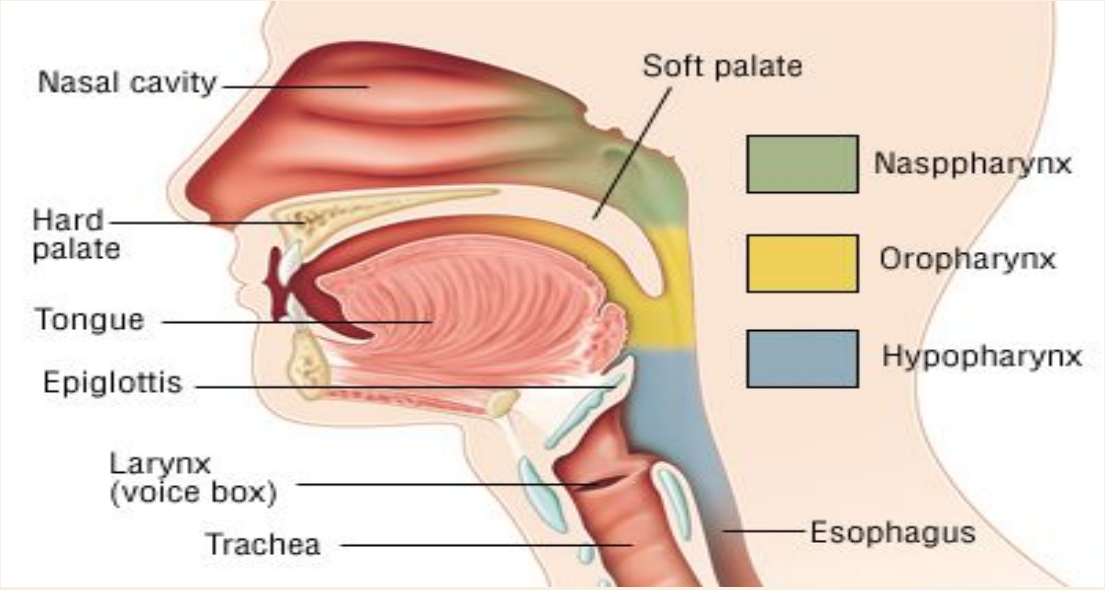
SNORING


Normal
Breathing
Clear Airway
Snoring
Blocked Airway
Opened Upper Airway
Closed Upper Airway

TYPE OF SNORING SOUND

There are three sounds associated with snoring when the power of the sound is examined. The duration of each sound depends on the vibrating tissue:

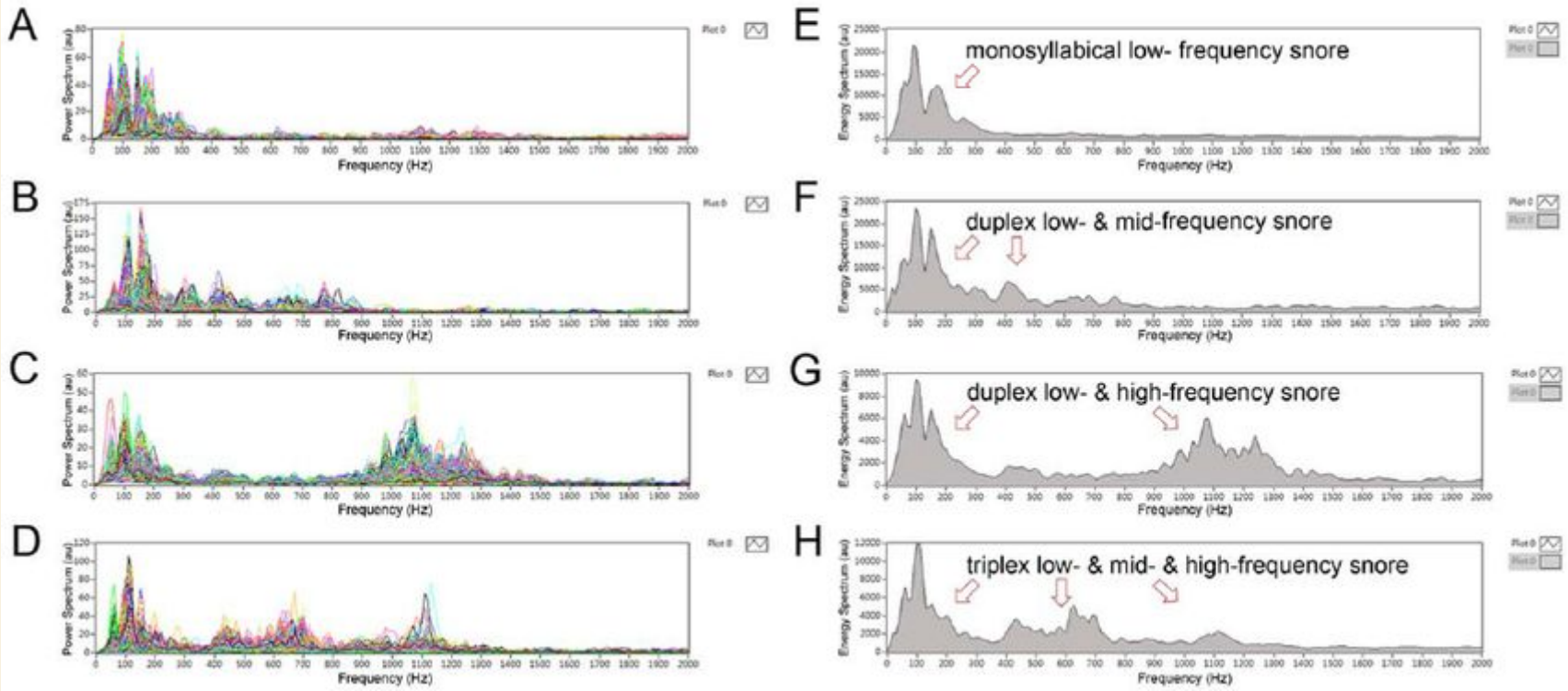
- Thus vibration of the soft palate produces the longest sound
- Followed in length by the epiglottal snore
- The base of the tongue



TYPE OF SNORING SOUND

There are four types of energy sounds in a possible snore. They are mapped as a snore map:

- They consist of a low-frequency single syllable (type 1)
- Duplex sounds with low and middle frequencies (type 2)
- Duplex sounds with low and high frequencies (type 3)
- Triplex sounds with all three types of frequencies (type 4)

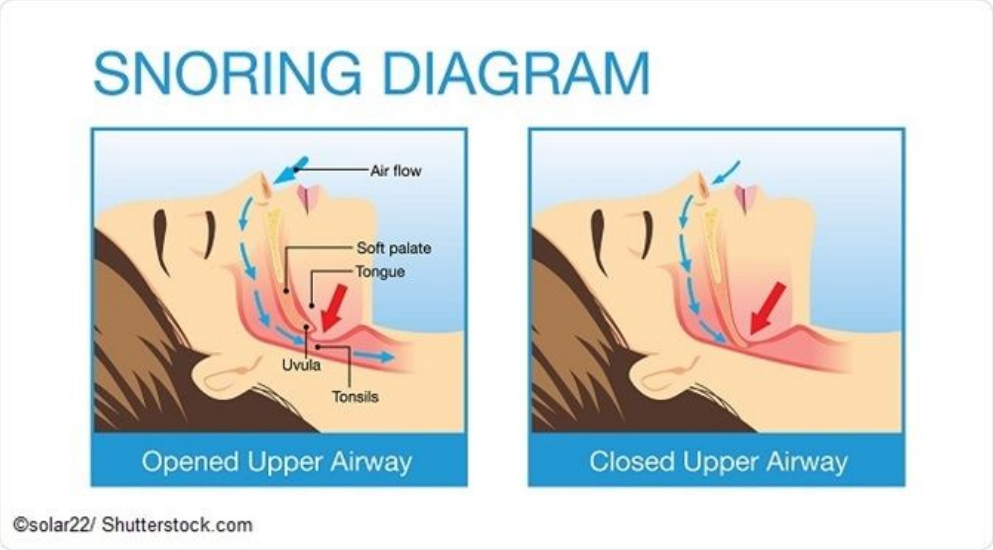


TYPE OF SNORING SOUND

These sounds create two different snore patterns, namely:

- simple waveform snores
- complex waveform snores.

- Momentary closure of the airway produces complex waveform snores
- While the vibration of an open airway leads to simple waveform snores

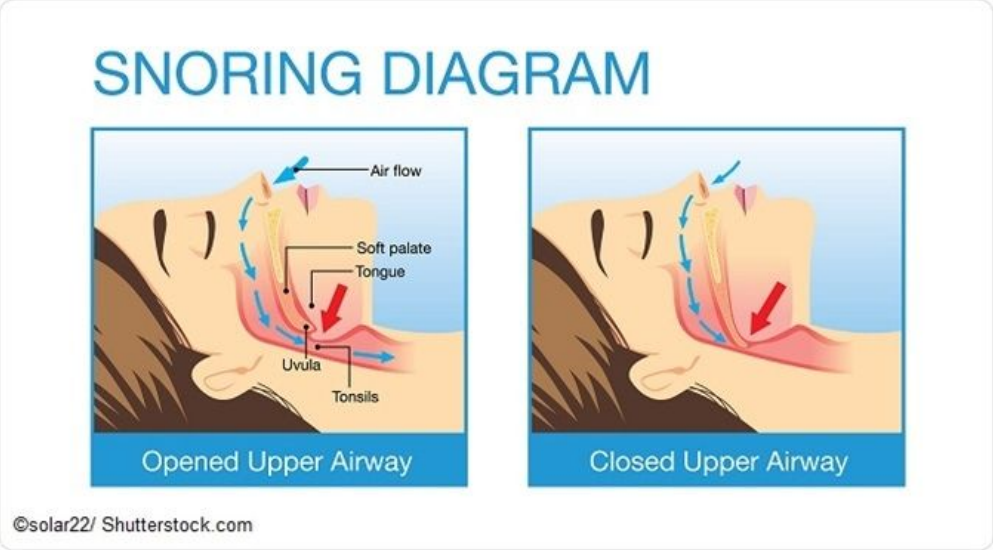


TYPE OF SNORING SOUND

Snoring occurs at peak intensity during stage 4 sleep, or deep sleep, which usually occurs 90 minutes after the onset of sleep.

The position of the sleeper also influences snoring, with the loudest sounds occurring when the individual i lying in the supine position.

The sound occurs during the stage of inspiration.




© KylieJenner/Instagram

CAUSES

- **Cheyne-Stokes breathing.**
- **Drug-induced apnea.**
- **High-altitude periodic breathing.**
- **Complex sleep apnea.**
- **Medical condition-induced central sleep apnea.**
- **Idiopathic (primary) central sleep apnea.**

RISK FACTORS

- **Sex.**
- **Age.**
- **Heart disorders.**
- **Stroke, brain tumor or a structural brainstem lesion.**
- **High altitude.**
- **Opioid use.**
- **CPAP.**

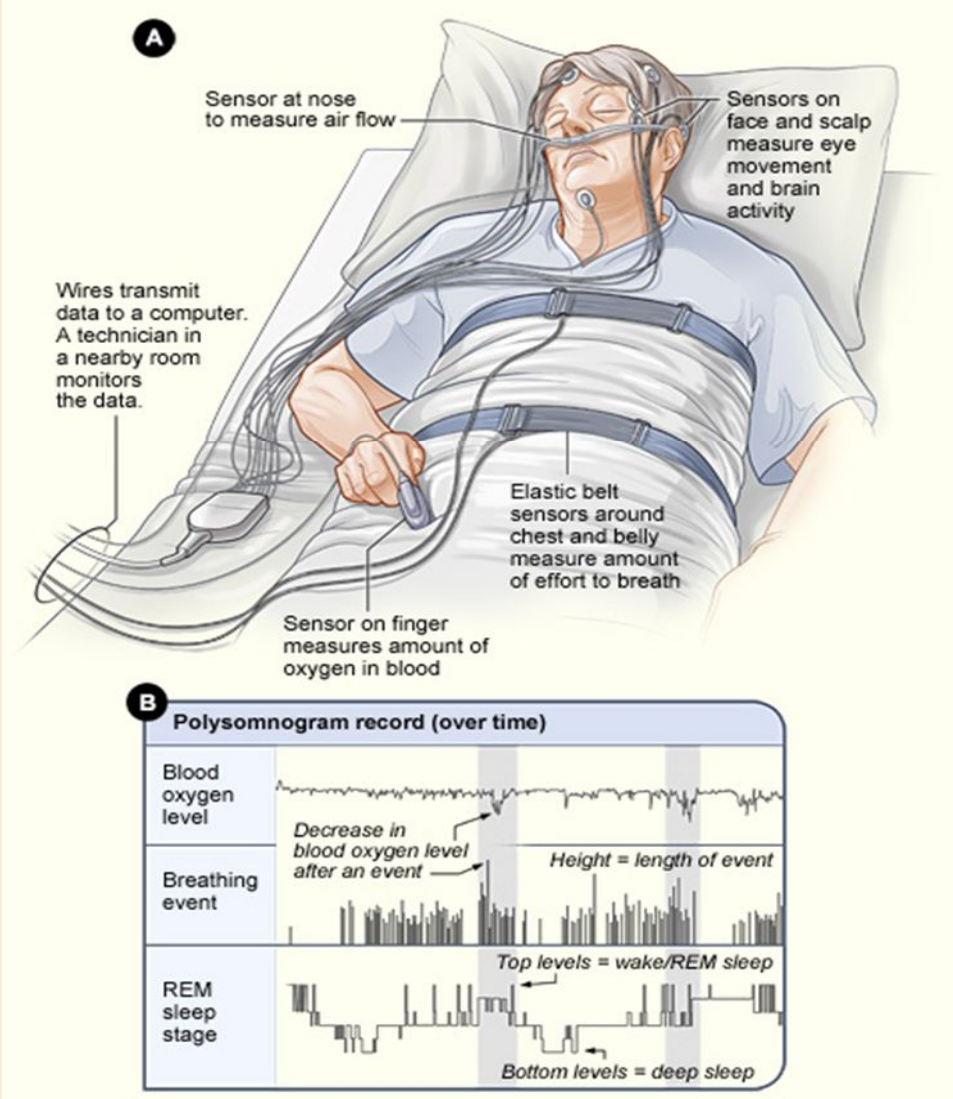
THE INTERNATIONAL CLASSIFICATION OF SLEEP DISORDERS, THIRD EDITION (ICSD-3)

Those that affect adults include:

- Primary central sleep apnea
- Cheyne-Stokes breathing-central sleep apnea (CSB-CSA) pattern
- High-altitude periodic breathing, central sleep apnea due to medical conditions other than Cheyne-Stokes
- Central sleep apnea due to drugs or substances.

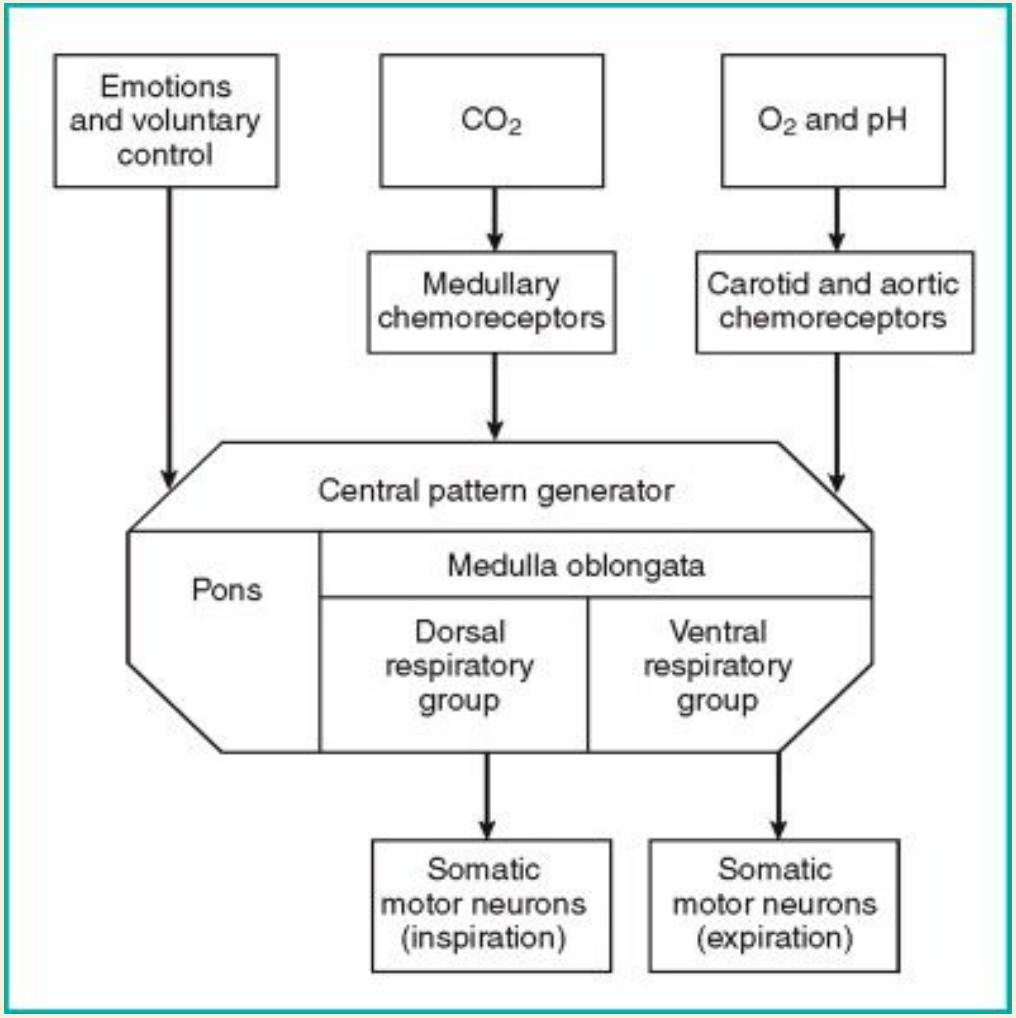
The primary sleep apnea of infancy primarily affects premature newborns and is excluded from this discussion.

INVESTIGATIONS



Polysomnogram

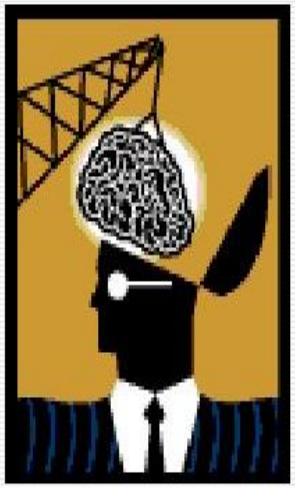
PATHOPHYSIOLOGY



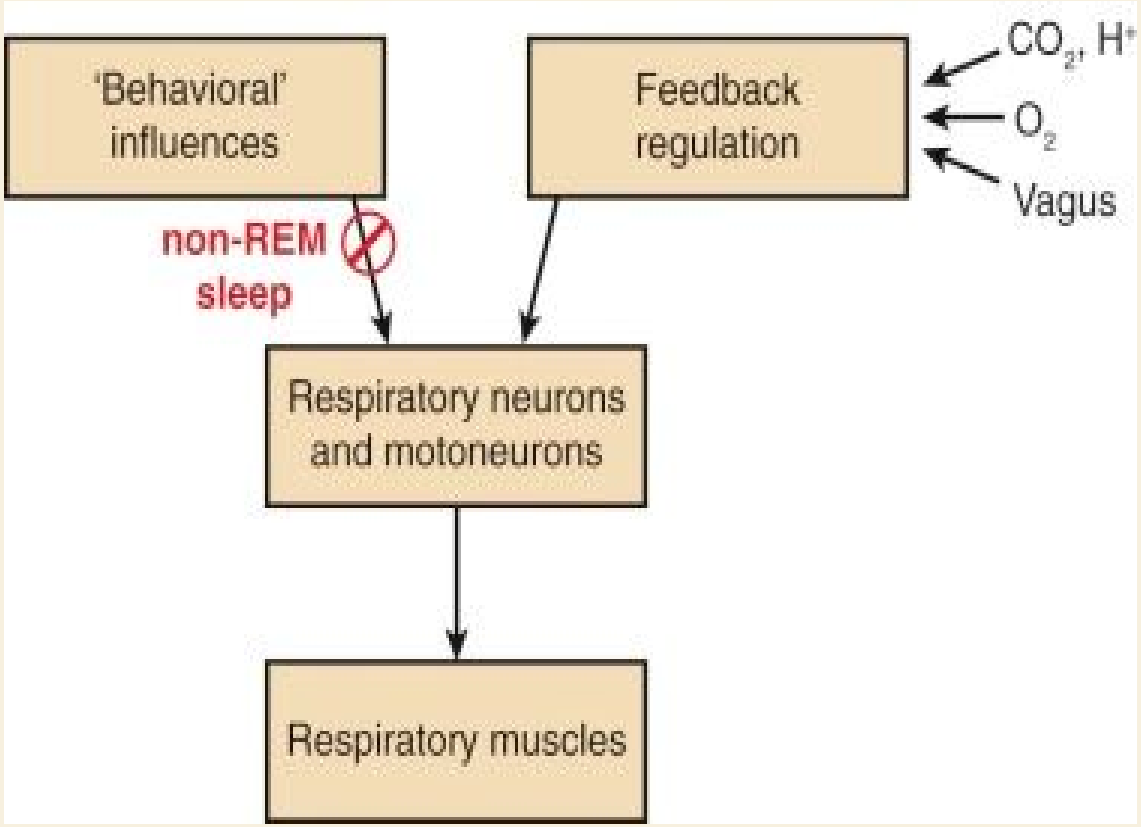
PATHOPHYSIOLOGY

CONTROL OF RESPIRATION

- Metabolic (automatic) control system
- Behavioral control system
- Wakefullness stimulus system



PATHOPHYSIOLOGY



PATHOPHYSIOLOGY

Central sleep apnea is most often seen during non–rapid eye movement (NREM) sleep, when behavioral influence is least, followed by rapid eye movement (REM) sleep, while a fully awake person is least likely to manifest it.

PATHOPHYSIOLOGY

Two types of pathophysiologic phenomena can cause central sleep apnea syndromes:

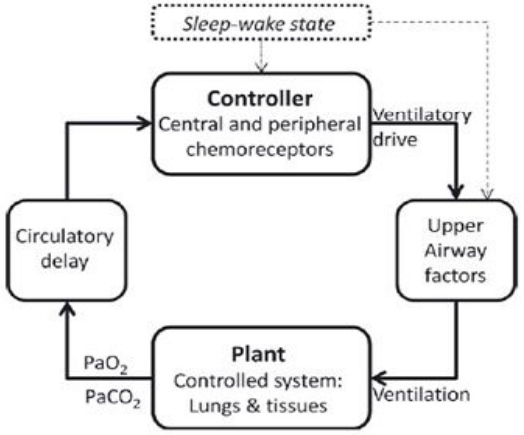
1) Ventilatory instability
2) Depression of the brainstem respiratory centers or chemoreceptors.

MECHANISM: LOOP-GAIN

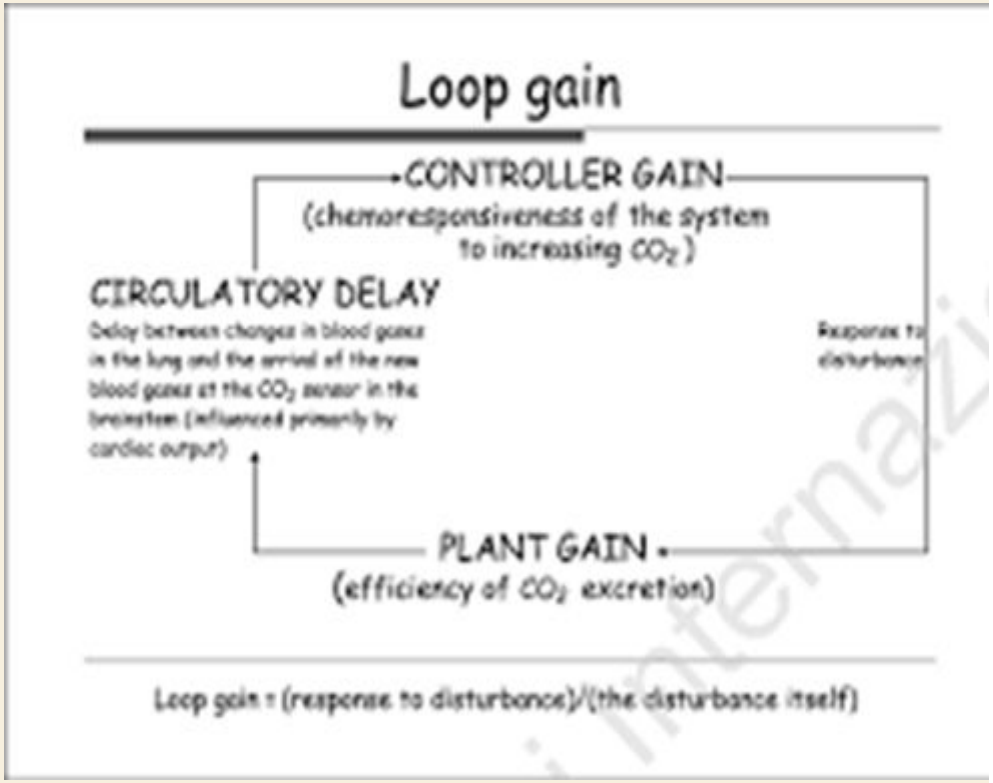
Op-CSA: Mechanism

Loop-gain theory:

$$\text{Loop gain} = \frac{\text{Response to disturbance}}{\text{Disturbance}}$$

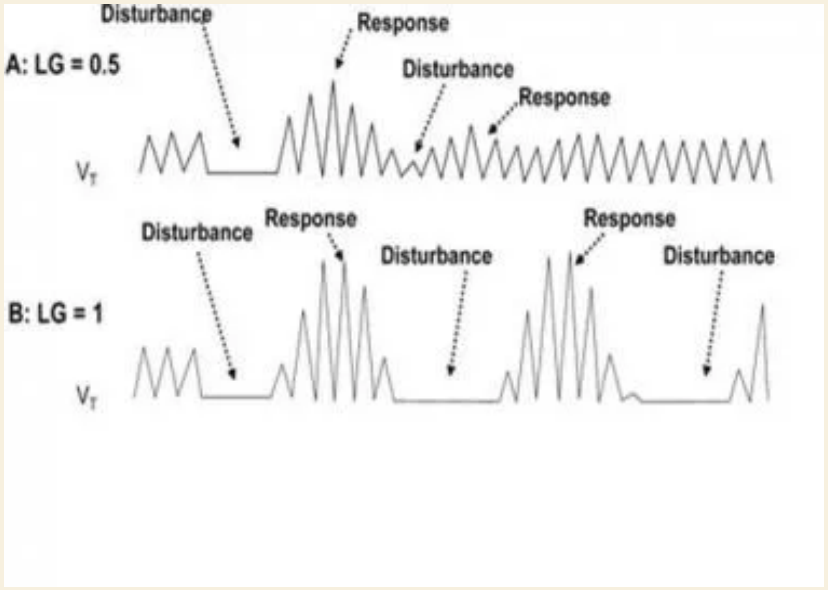


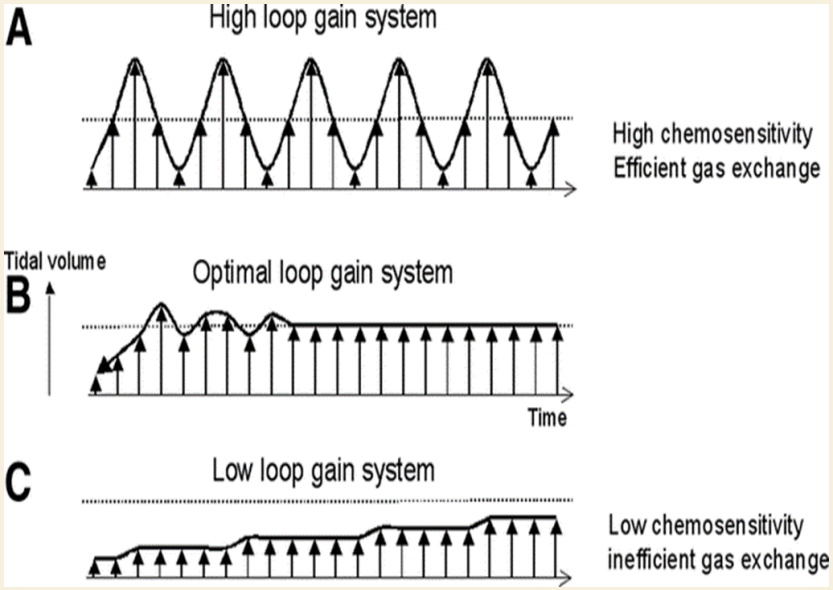
Burgess KR. J Physiol. 2012;590:1781-1782.



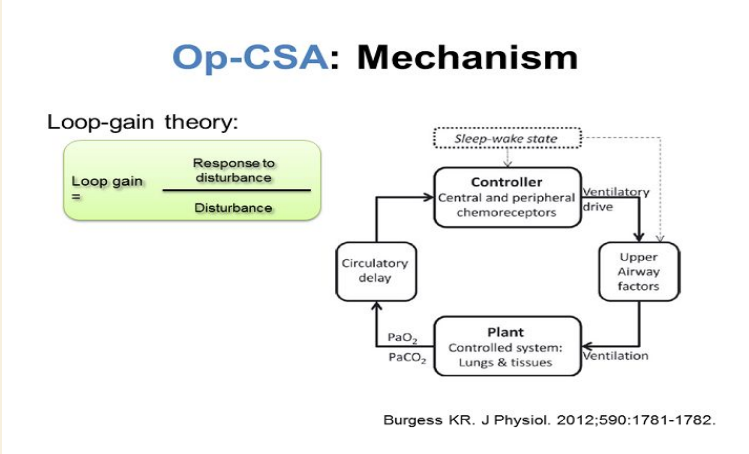
MECHANISM: LOOP-GAIN

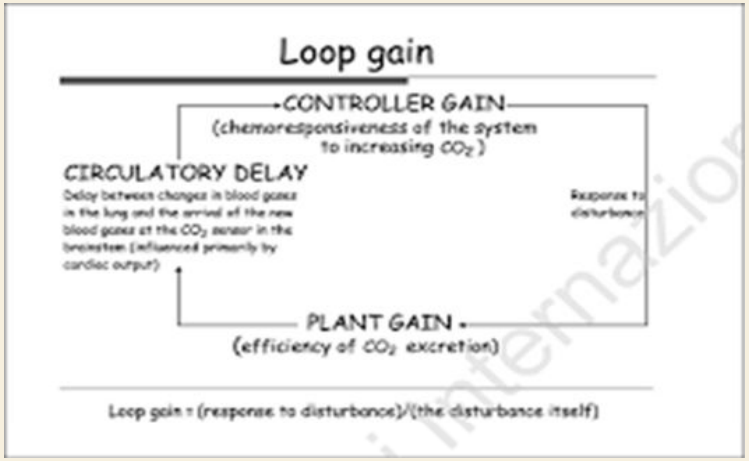
It is generally described by the equation that calculates the ratio of the response to a given disturbance to the disturbance itself. So a high loop gain, or a high-gain, system responds quickly and vigorously to any disturbance, whereas a low-gain system responds more slowly and weakly.





MECHANISM: LOOP-GAIN





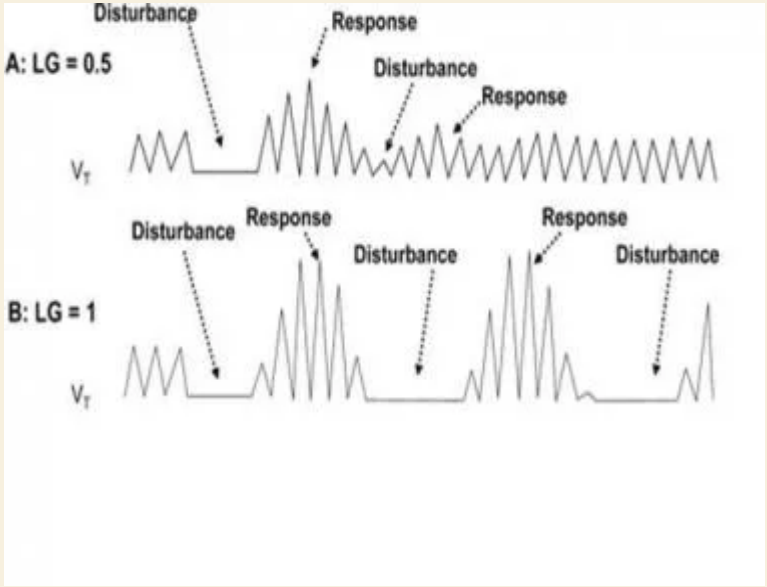
The two primary factors influencing loop gain are the controller gain and the plant gain, and both are important in ventilatory stability.

For example, chemoresponsiveness to hypoxemia and hypercapnia is part of the controller gain. When a person has a high controller gain, it means that their hypercapnia responsiveness is brisk and tends to overshoot.

Plant gain reflects the effectiveness of any given change in ventilation to eliminate CO_2 and increase stores of O_2. So a high plant gain would occur, for example, if a small change in ventilation produced large changes in PCO_2, and a condition that would be described as a high plant gain would be, e.g., having low dead space.

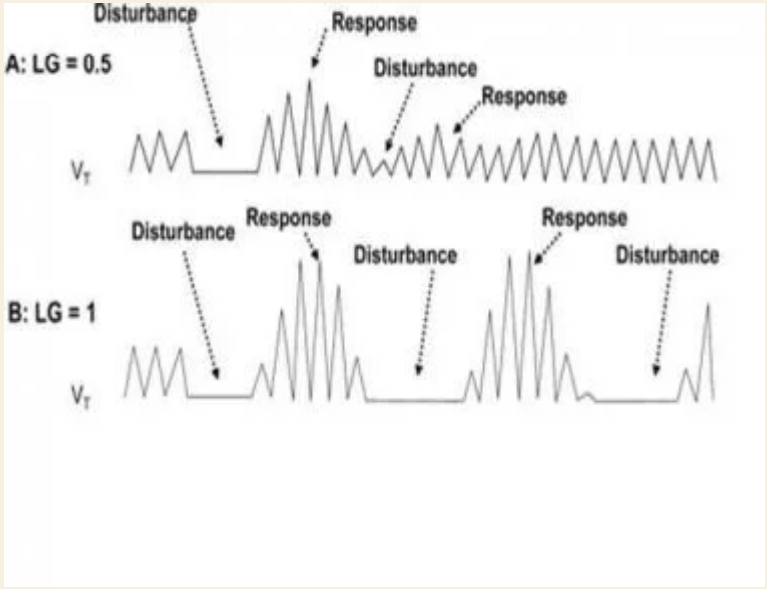
PATHOPHYSIOLOGY

- If loop gain is less than 1, responses to apneas or hypopneas are more gradual and smaller, allowing ventilation to return to a steady pattern. If loop gain is greater than 1, the large responses to apneas and hypopneas result in swings of hyperventilation and apnea/hypoventilation, causing a state of instability termed periodic breathing.



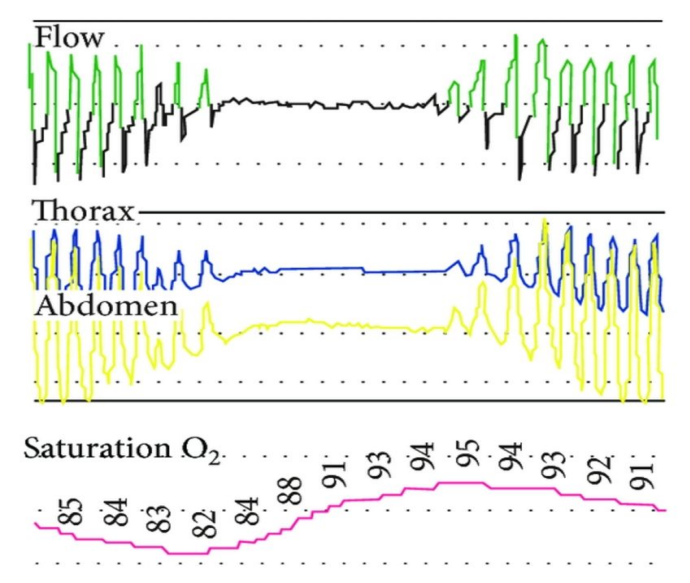
PATHOPHYSIOLOGY

During waking, behavioral control may override periodic breathing patterns, so that the effect of high loop gain on the ventilatory system is most evident during sleep.



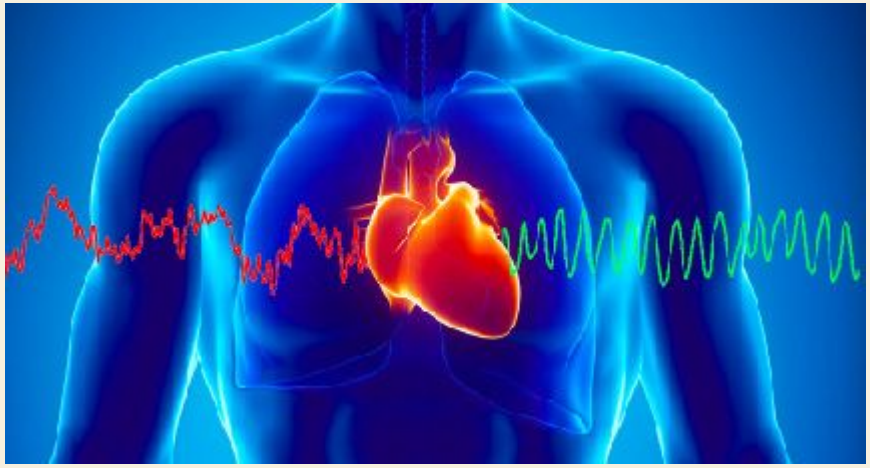
PATHOPHYSIOLOGY

Ventilatory instability is the mechanism behind CSB-CSA, high-altitude periodic breathing, and probably primary central sleep apnea.



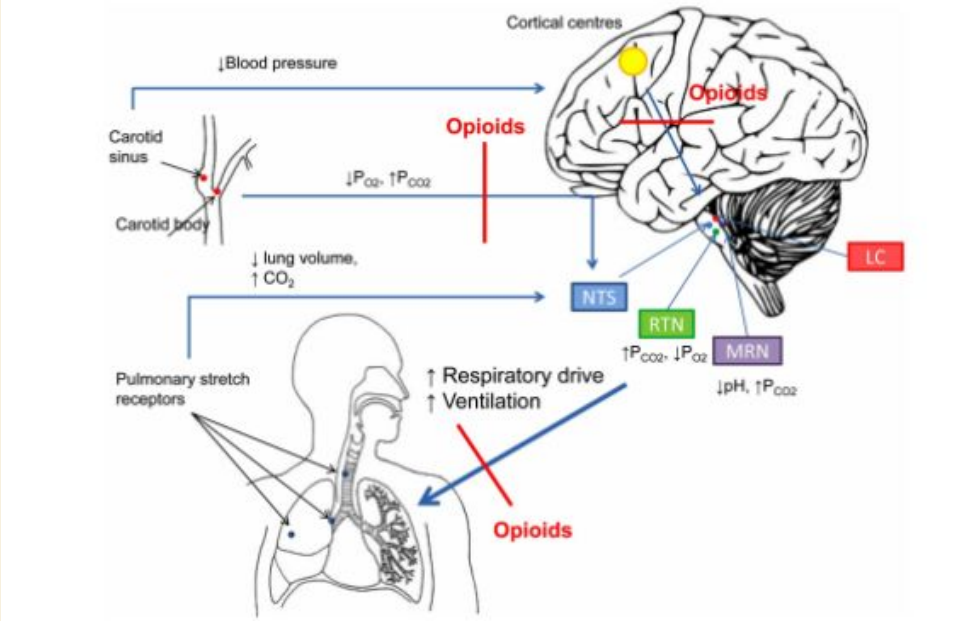
PATHOPHYSIOLOGY

- Patients with heart failure and central sleep apnea have been shown to have an augmented ventilatory response to change in $PaCO_2$ compared with patients with heart failure and obstructive sleep apnea.



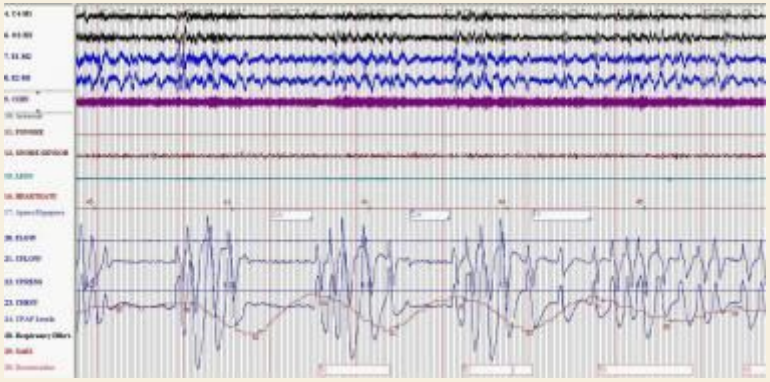
PATHOPHYSIOLOGY

- Central sleep apnea-hypoventilation syndromes such as those associated with narcotic use or brainstem lesions are due to disturbances of the central respiratory pattern center or peripheral chemoreceptors or both that may become more evident during sleep because of the suppression of wakefulness or behavior drive.



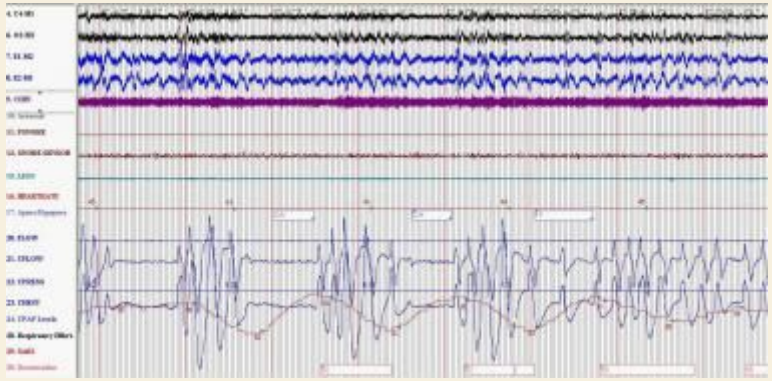
PATHOPHYSIOLOGY

- Primary disorders of the central nervous system such as meningitis or hemorrhage and tumor or strokes that involve the brainstem can result in an ataxic breathing pattern, referred to as Biot respiration. The Biot pattern may be irregular without any type of periodicity or it can consist of runs of similar-sized breaths alternating with central apneas, as demonstrated in the image below.



PATHOPHYSIOLOGY

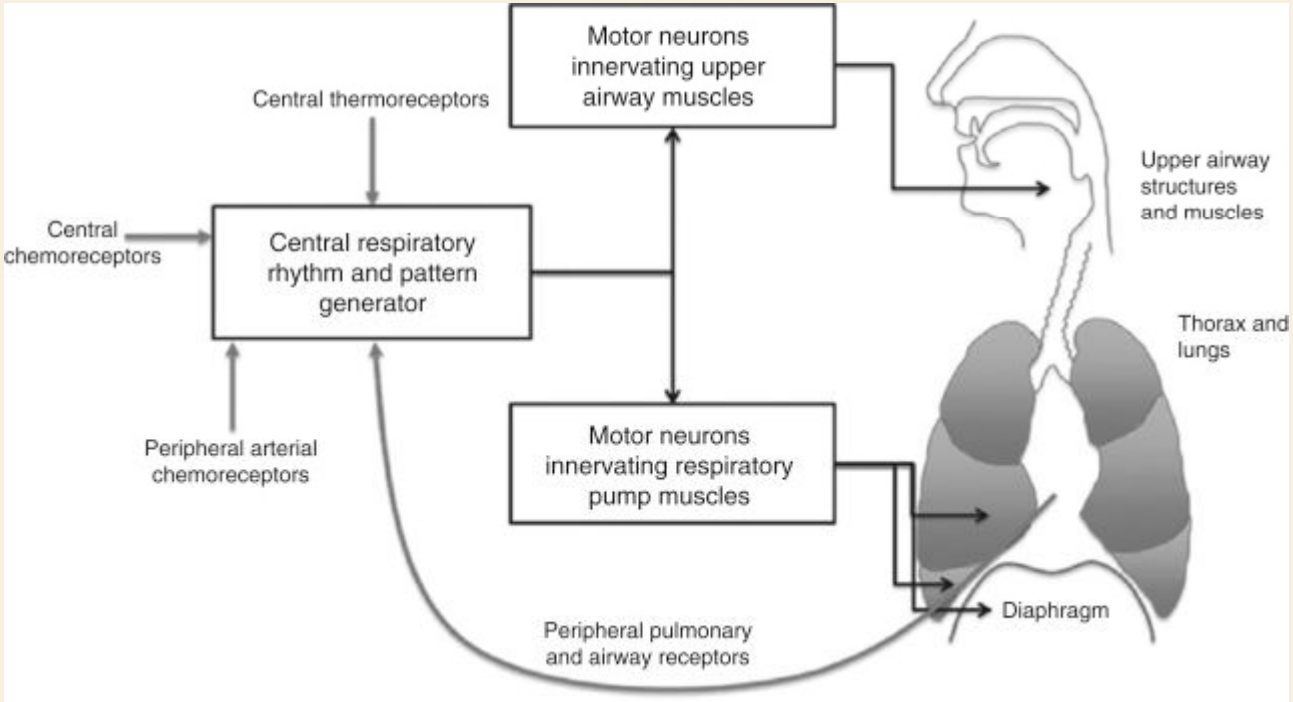
- This polysomnogram demonstrates central sleep apnea and Biot respiration in a patient receiving long-term morphine for chronic pain. The Biot pattern may be irregular without any type of periodicity, or it can consist of runs of similar-sized breaths alternating with central apneas.



PATHOPHYSIOLOGY

During normal inspiration, a neuronal discharge occurs to the diaphragm and to the upper airway muscles that stiffens and dilates the pharynx to keep it open.

If, despite a lack of activation of the pharyngeal muscles, the upper airway remains open, the event will be a central apnea.

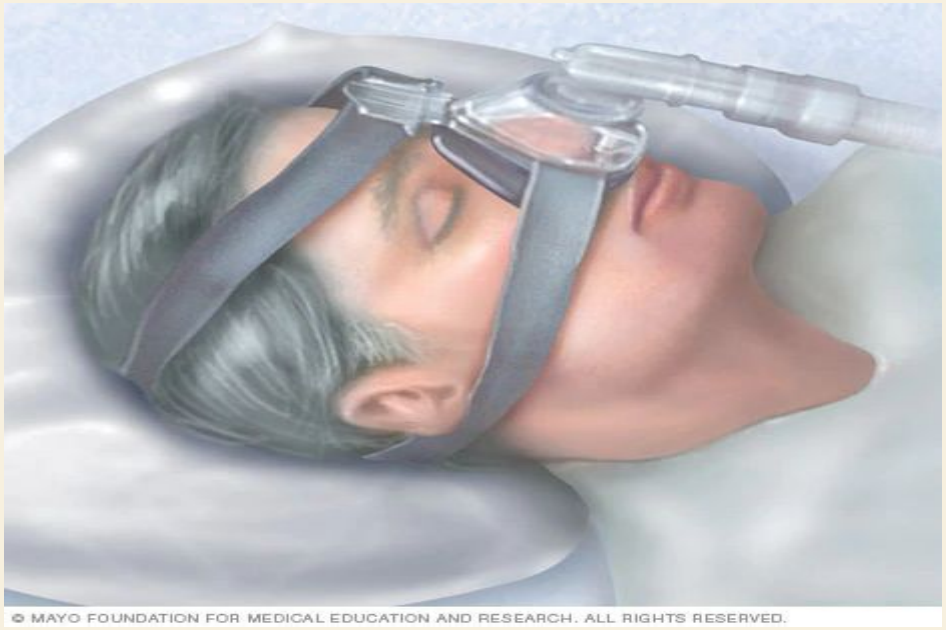


If a decrease in activity occurs in both the diaphragm and upper airway dilators, the result could be a central or obstructive apnea.

If the upper airway closed during centr apnea and diaphragmatic activ resumes before pharyngeal dilator muscle tone is rest a mixed apnea resu

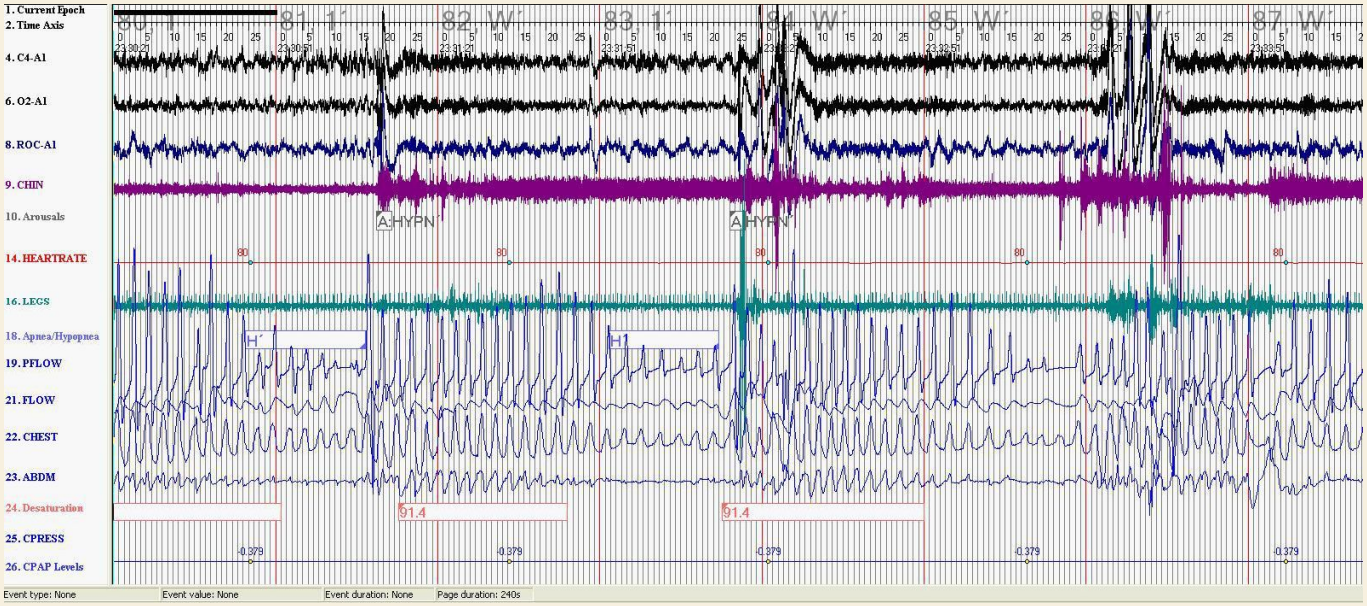
PATHOPHYSIOLOGY

- Thus, the susceptibility to upper airway collapse may determine whether central or obstructiv apneas occur with cycling due to ventilatory instability. The conversion of obstructive apneas t a Cheyne-Stokes breathing pattern with the introduction of continuous positive airway pressure (CPAP) is an example of this phenomenon.



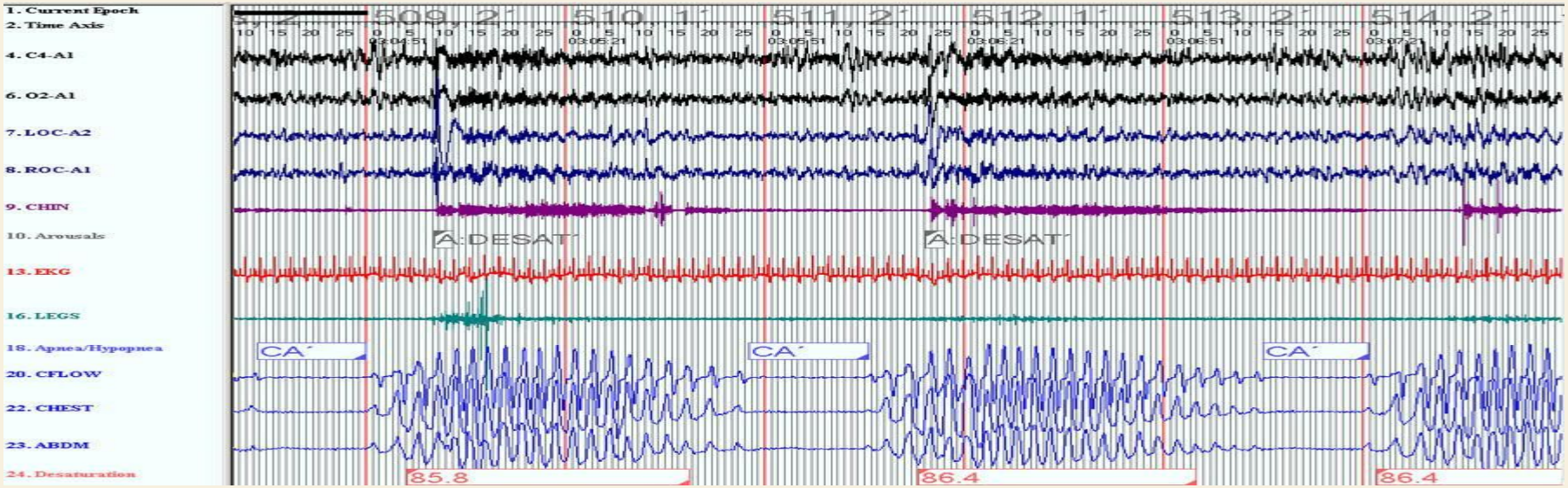
PATHOPHYSIOLOGY

- Obstructive sleep apnea (OSA): This polysomnogram demonstrates typical hypopneas occurring in OSA prior to continuous positive airway pressure titration. In OSA, airflow is absent or reduced, but ventilatory effort persists.



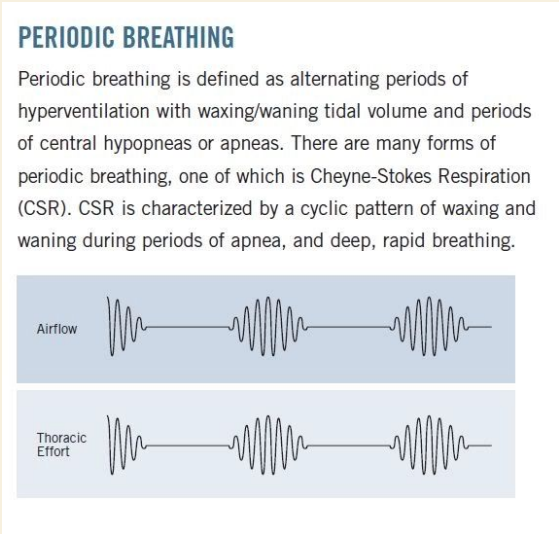
PATHOPHYSIOLOGY

- Cheyne Stokes: This polysomnogram represents Cheyne Stokes breathing and occurred subsequent to continuous positive airway pressure titration for OSA in the same patient in the previous media file. Cheyne Stokes breathing has a classic crescendo-decrescendo breathing pattern.



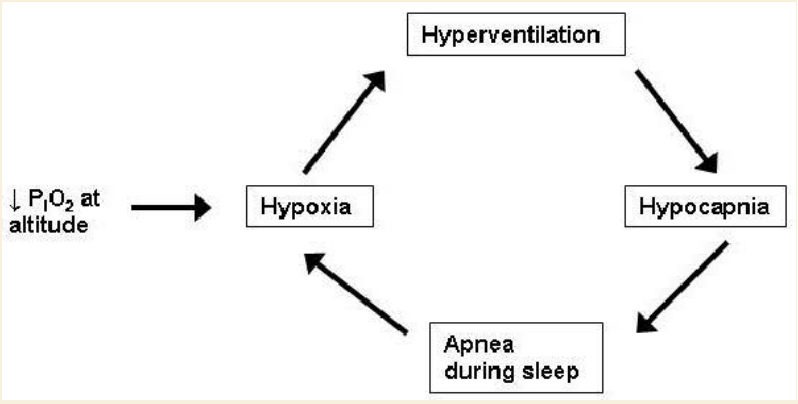
CHEYNE STOKES BREATHING-CENTRAL SLEEP APNEA

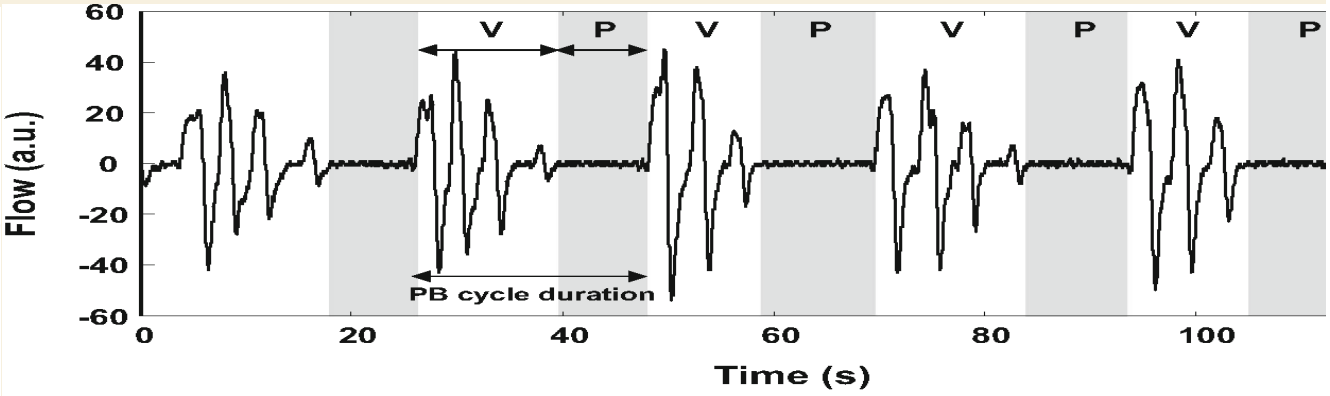
- CSB-CSA is characterized by classic a crescendo-decrescendo pattern that typically occurs with a periodicity of 45 second or greater cycles (see image below). The *ICSD-3* specifies that at least 10 central apneas and hypopneas per hour of sleep should occur, accompanied by arousals and derangement of sleep structure. The arousals occur at the peak of the hyperpnea phase. Patients usually have predisposing factors such as heart failure, stroke, or renal failure, as well as a lower resting $PaCO_2$ than normal.
  - Heart failure
  - Stroke
  - Renal failure



HIGH-ALTITUDE PERIODIC BREATHING

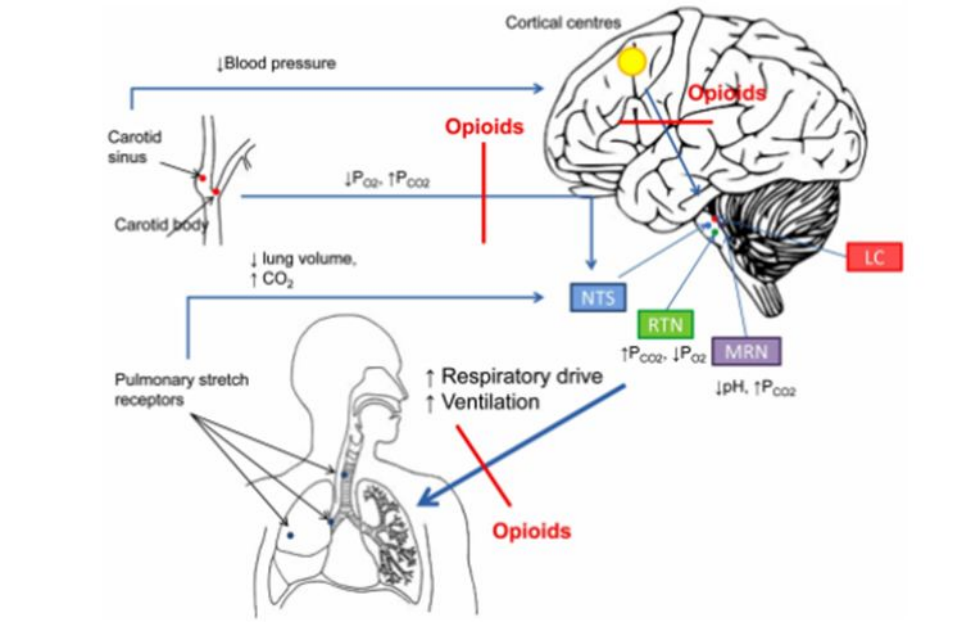
- The single most important feature is that high-altitude periodic breathing occurs only with recent ascent to high altitudes. Many patients develop this at an altitude of 5000 meters or greater, while almost everyone develops it at an elevation of 7600 meters. The cycle length is shorter than in CSB-CSA, 12-34 seconds.





USE OF OPIATES AND OTHER CNS DEPRESSANTS

- This is most easily recognized by a history of opiate use. Thirty percent of participants in a stable methadone maintenance program had a central apnea index (CAI) of greater than 5 and 20% had a CAI of greater than 10. Methadone blood concentration was significantly associated with the severity of central sleep apnea.



PRIMARY CENTRAL SLEEP APNEA

- This is an uncommon condition in which 5 or more central apneas, lasting 10 seconds or more occur per hour of sleep. Patients have a low-normal $PaCO_2$. The central apneas terminate abruptly with a large breath and without associated hypoxemia. They do not have a crescendo-decrescendo pattern of breathing.

COMPLEX SLEEP APNEA

- Central sleep apnea may emerge during titration of CPAP in patients previously diagnosed with obstructive sleep apnea. This syndrome, termed complex sleep apnea, has become a controversial topic in the sleep literature and has been raised as a possible type of difficult-to-treat obstructive sleep apnea. As many as 6.5% of patients with obstructive sleep apnea may develop emergent or persistent central sleep apnea with CPAP treatment. CPAP emergent central sleep apnea is generally transitory and is eliminated after eight weeks of CPAP therapy. Persistent CPAP-related central sleep apnea has been observed in approximately 1.5% of treated patients. Similarly, complex sleep apnea can occur following a tracheostomy for obstructive sleep apnea. Central apneas have been found initially after a tracheostomy, but after an extended period, central sleep apnea decreased on repeat PSG.

PHYSIOLOGICALLY NORMAL APNEIC EVENTS

- *Central sleep apnea during sleep-wake transition*

Up to 40% of healthy individuals may exhibit central apneas during sleep-wake transition. The central apneas occur during the period that chemoreceptors are resetting and instability of ventilation control occurs. They are usually brief and not associated with significant oxygen desaturation. The clinical significance of this entity is unknown. Once stable sleep is reached, normal individuals should not have more than 5 central apneas per hour of sleep.

- *Postarousal central apnea or postsigh central apnea*

During a PSG review, central apneas are commonly seen following an arousal or after a sigh and are usually inconsequential. They are thought to be a result of Herring-Breuer reflex or hypocapnia induced by hyperventilation caused by a sigh or arousal.

FORMS OF CENTRAL SLEEP APNEA

Type of Central Apnea	Mechanism	Treatment
Sleep transition apnea	Ventilatory response to arousal drives P_{CO_2} below apnea threshold	Reassurance Sleep hygiene Hypnotic therapy Oxygen
Narcotic-induced central apnea	Unclear, suppressed output from respiratory pattern generator	Reduce narcotic dose Consider advanced PAP device
Cheyne-Stokes breathing	High loop gain from extravascular lung water and robust chemoresponsiveness	Optimize medical therapy Consider PAP
Complex sleep apnea	CPAP reduces upper-airway resistance, improving the efficiency of CO_2 excretion	Reassurance Expectant management
Idiopathic central apnea	Unknown	Acetazolamide Consider bi-level PAP

PAP = positive airway pressure
CPAP = continuous positive airway pressure

TREATMENT OPTIONS

Non-Positive-Airway-Pressure Treatment options:

- In patients with heart failure and CSA, medical management of heart failure seems to be overall helpful in treating CSA.
  - Diuresis with a reduction in cardiac filling pressure has been shown to reduce the severity of CSA
  - Angiotensin-Converting Enzyme inhibition can lower the AHI and reduce the nocturnal desaturation of patients with mild to moderate heart failure
  - β-adrenergic blockade has been reported to decrease AHI in patients with CSA
- Supplemental Nocturnal Oxygen alone has been shown to eliminate apnea-related hypoxia and CSA. Yet to date it has not been shown to improve symptoms or improve long-term cardiovascular outcomes when given for CSA alone.
- Novel therapies such as atrial overdrive pacing, are as of yet considered investigational.

TREATMENT OPTIONS

Positive-Airway-Pressure (PAP) Treatment Options: There are actually several PAP solutions for patients with OSA and CSA.

- **Continuous positive airway pressure therapy (CPAP)** is prescribed to maintain airway patency in obstructive events. CPAP is generally a "fixed" pressure that does not differ during inhalation or exhalation phases (see figure), but several advancements to traditional CPAP have made CPAP more comfortable and thereby effective:
  - Addition of Expiratory Pressure Relief (EPR or C-Flex), allowing an adjustable pressure drop upon sensing exhalation to facilitate comfort with exhalation.
  - Bilevel Therapies (BiPAP) may be used in certain instances to improve ventilation with a different inspiratory and expiratory pressure.
  - Heated humidification, either through the device or nowadays sometimes through the tubing itself to minimize condensation. li>
  - Automated CPAP and BiPAP devices that sense obstructions and respiratory effort, therefore auto-adjust the pressures within a prescribed therapeutic range.
  - Newer masks, newer materials, and quieter machines
- **Adaptive servo-ventilation (ASV)** is an advanced BiPAP device that has an exquisite automated algorithm that not only detects central apneas, but also adjusts the rate delivery of the backup breath depending on the respiratory needs. There are theoretical benefits to this mode of delivery in patients with Cheyne-stokes respiration and some smaller studies demonstrating a reduction in overall respiratory events.

PROGNOSIS

- The mortality and morbidity associated with primary central apnea remains unknown; however, these individuals are unlikely to develop significant hypercarbia or hypoxia to the detriment of pulmonary circulation or cor pulmonale. Patients with heart failure and CSB-CSA have a higher mortality rate than those without it. I one study, the 2-year survival rate for patients in heart failure with concomitant CSB-CSA higher than in those without CSB-CSA. A more recent study demonstrated a higher mortality rate in congestive heart failure patients with central sleep apnea than those with no sleep apnea. However, the observed difference was no longer significant after adjusting for age and New York Heart Association functional class.
- A study of sleep-disordered breathing and nocturnal cardiac arrhythmias in older men documented that the likelihood of atrial fibrillation or complex ventricular ectopy increased along with the severity of sleep-disordered breathing, which included obstructive sleep apnea and CSB-CSA. Different forms of sleep-disordered breathing were associated with different types of arrhythmias, and central sleep apnea was strongly associated with atrial fibrillation/flutter. The odds of atrial fibrillation ($P = .01$) and of complex ventricular ectop ($P < .001$) increased with increasing quartiles of the respiratory disturbance index (a major index including all apneas and hypopneas).