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CORSI TEORICO-PRATICI
Sleep Apnea 2020

Apnee ostruttive e apnee centrali: meccanismi patogenetici e fattori predittivi

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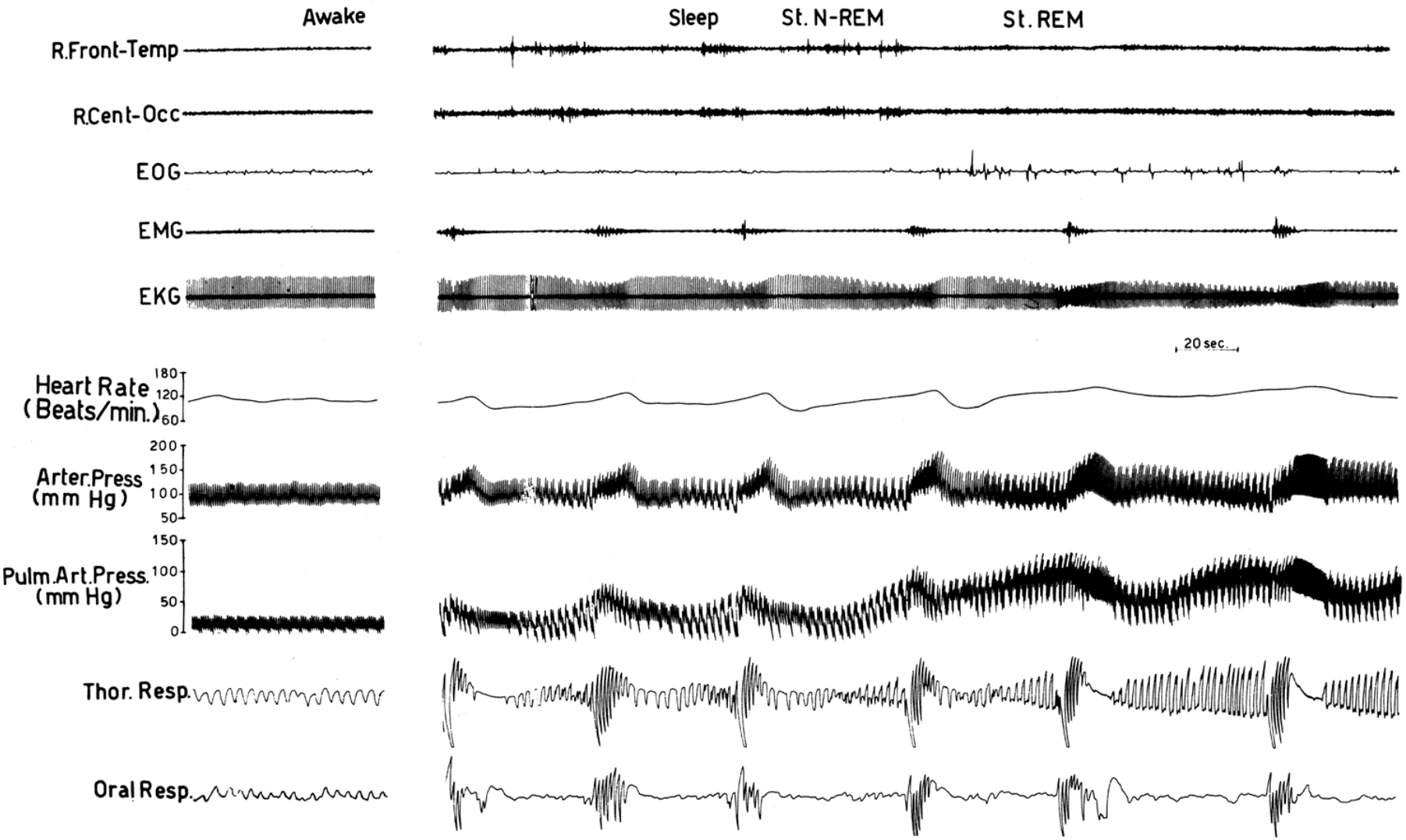
SNORING

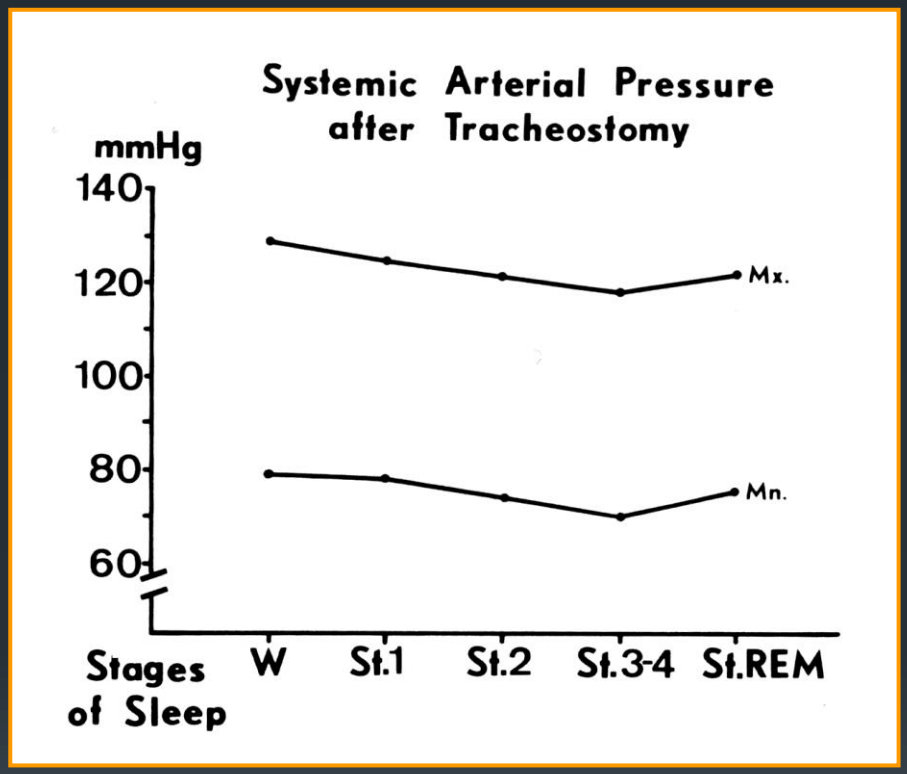
E. LUGARESI, G. COCCAGNA, P. FARNETI, M. MANTOVANI, AND F. CIRIGNOTTA

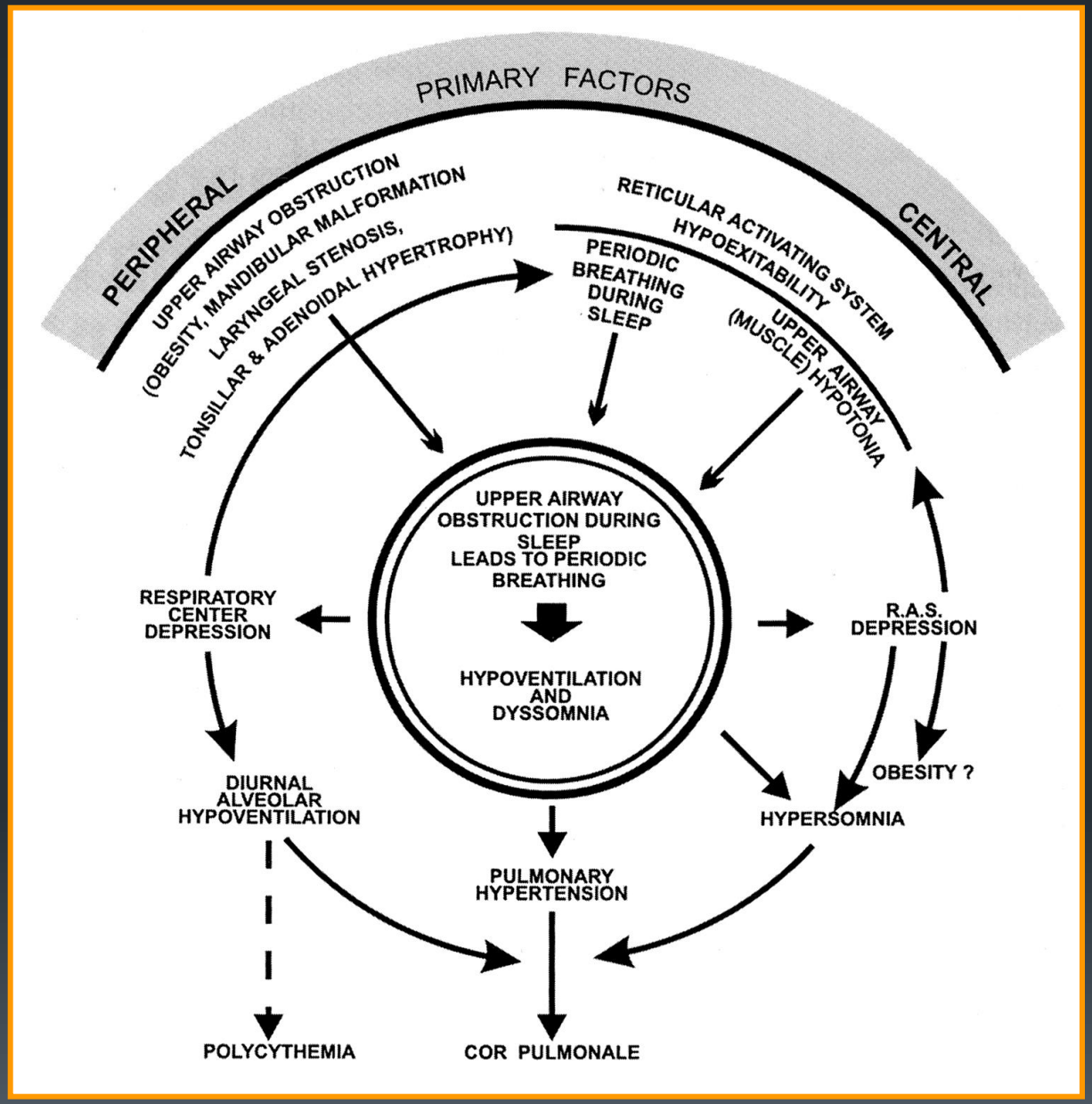
Clinica delle Malattie Nervose e Mentali dell' Universita' di Bologna, 40123 Bologna (Italy)

Electroencephalography and Clinical Neurophysiology , 1975, 39 : 59-64



E. Lugaresi et al. *Bull. Physiop. Resp. 1972*


Systemic Arterial Pressure
after Tracheostomy
mmHg
140
120
100
80
60
Mx.
Mn.
Stages
of Sleep
W
St.1
St.2
St.3-4
St.REM



E. Lugaresi et al. ***Bull. Physiop. Resp. 1972***

Anatomy

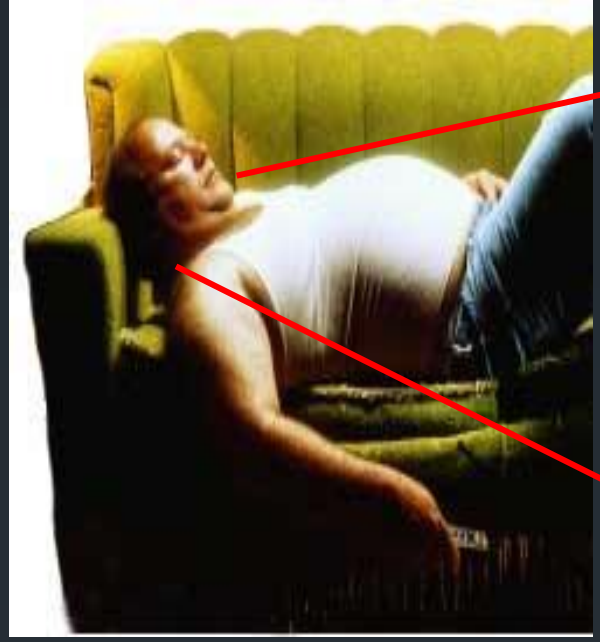
OSA is associated with anatomic risk factors that narrow the UA.
The most widely recognized factor is central obesity, with a direct relationship observed between BMI and apnea severity.

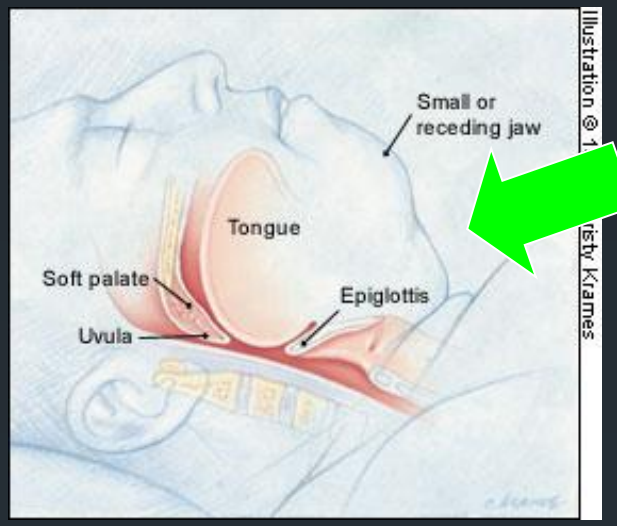
OSA is attributable to obesity in up to 58% of subjects.

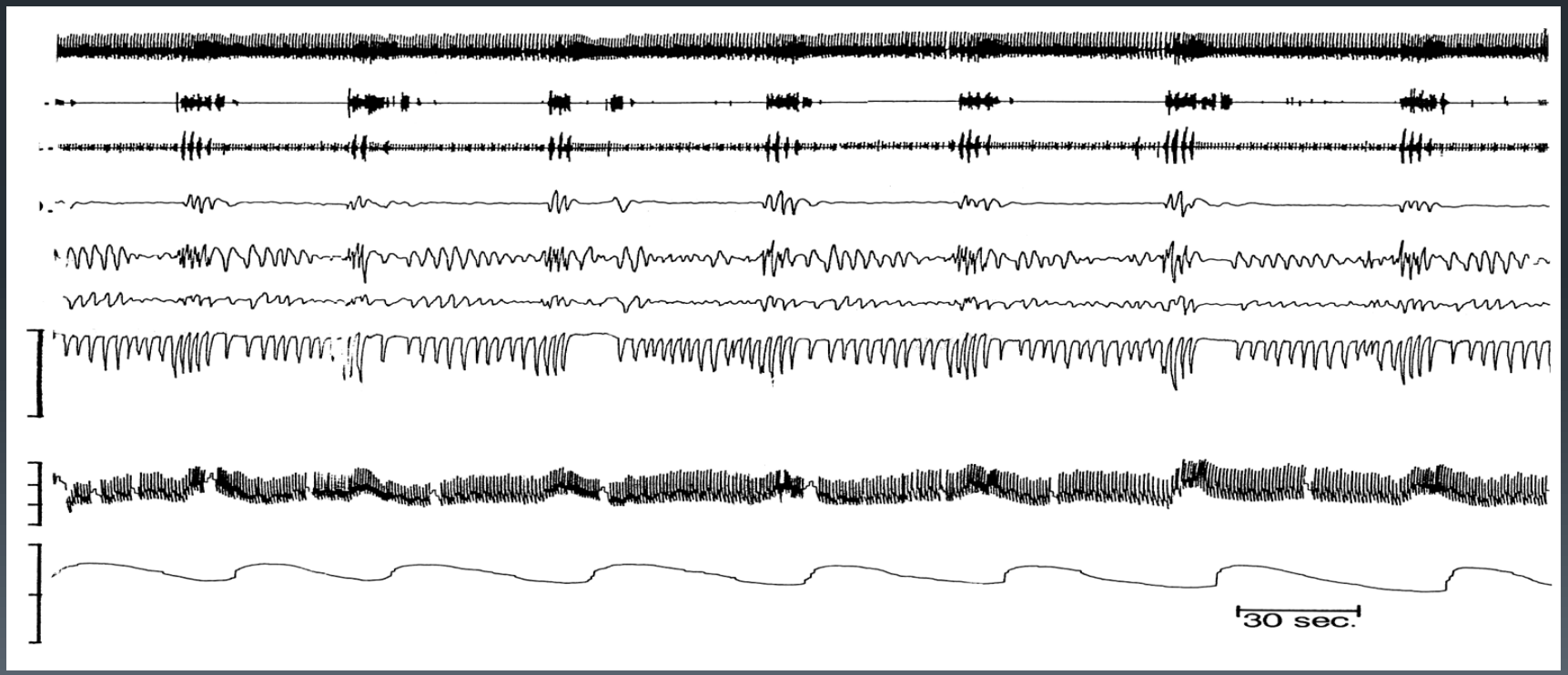
Weight loss typically results in improvement in OSA.
Linear regression modeling from the Wisconsin Sleep Cohort showed that in individuals with OSA, after adjustment for sex, age, and cigarette smoking, an approximate 1% increase or decrease in body weight was associated with a corresponding 3% increase or decrease in the AHI.

Obesity can contribute to airway narrowing by depositing adipose tissue around collapsible segments of the UA, increasing the size of the parapharyngeal fat pads and increasing fat content and volume of the base of the tongue.

Obesity may also indirectly contribute to UA collapsibility by reducing lung volume. Lower lung volume is associated with reduced tracheal caudal traction on the UA, which decreases stiffness of the lateral pharyngeal walls and promotes airway collapse.



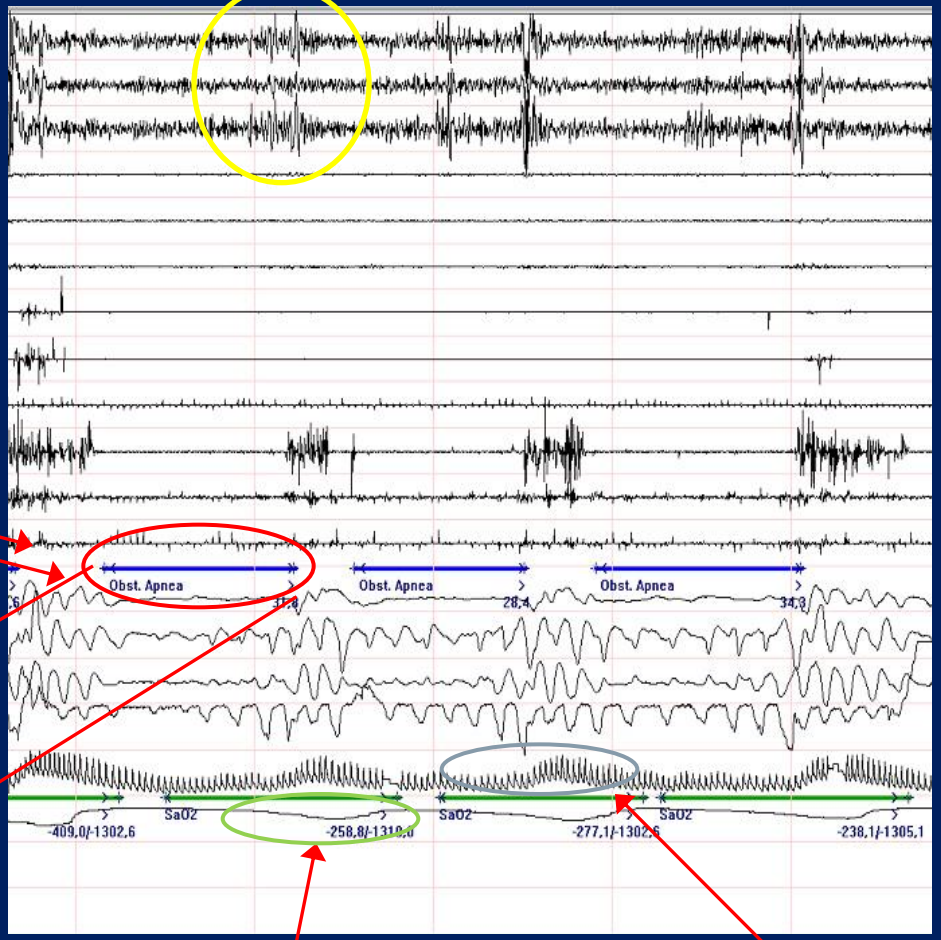

Small or
receding jaw
Tongue
Soft palate
Epiglottis
Uvula


Micr.
RON
RTA
PE
PA
SaO2
30 sec.

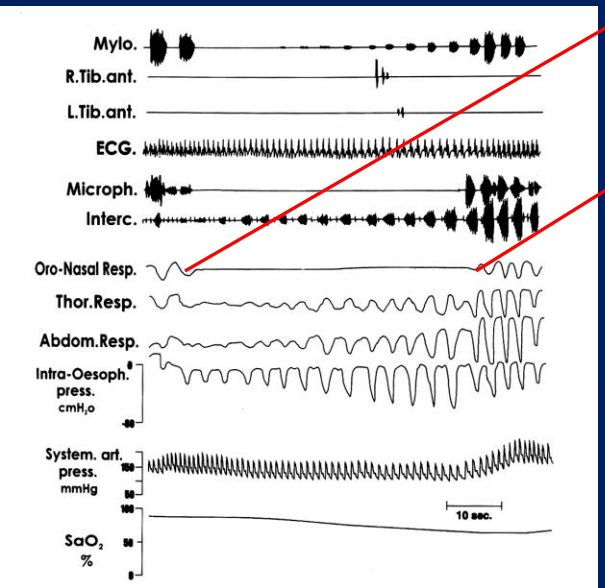
Sleep fragmentation

SWS

arousal

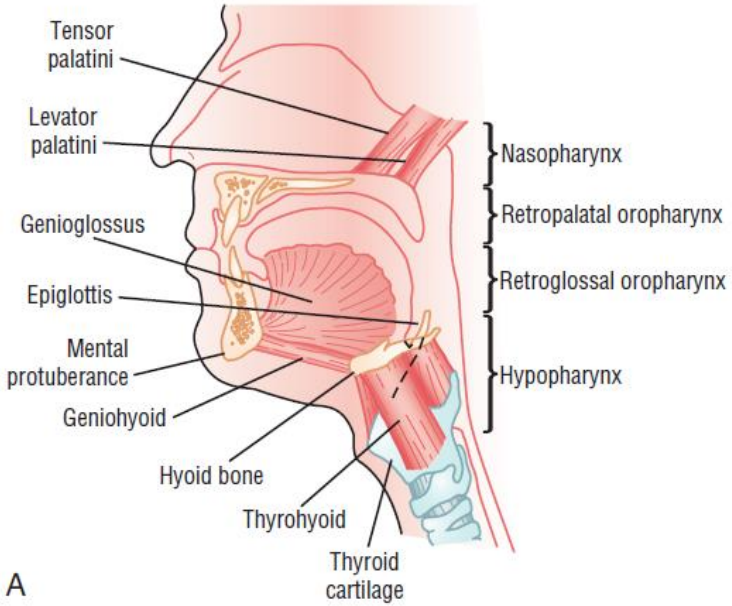


Obstructive apnea



Acute changes O2 and CO2

BP and HR changes



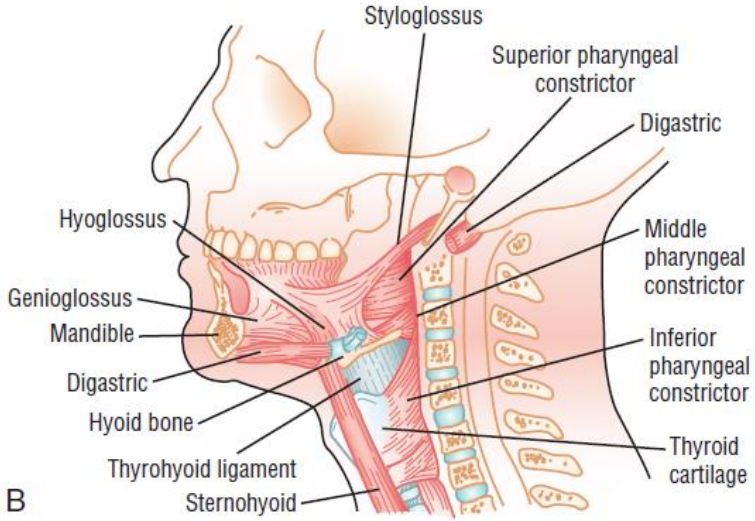


Figure 111-1 **A,** Schematic diagram of upper airway anatomy showing the classic divisions of the pharynx and key upper airway muscles. **B,** Schematic diagram of upper airway muscles and other key landmarks such as the hyoid.

Neuromuscular Function of the Upper Airway

There are at least 10 upper airway muscles that may be classified as pharyngeal “dilators,” innervated by multiple cranial nerves.
Some, such as the **genioglossus**, are classified as dilators by virtue of their phasic inspiratory activity. Others, such as the **tensor palatini**, do not clearly have a dilating effect but demonstrate activity throughout the respiratory cycle (tonic activity) and are presumed to “**stiffen” the upper airway wall** and decrease pharyngeal collapsibility.

It is widely accepted that upper airway dilators play a critical role in preserving pharyngeal patency.

There is evidence from EMG studies that activity of upper airway dilators begins about 200 milliseconds before onset of thoracic pump activity in normal subjects.

The effect of non–rapid eye movement (NREM) sleep on upper airway muscle function is complex and difficult to study.

NREM sleep is associated with a **reduction in tonic or phasic EMG activity** in numerous upper airway muscles, including the levator palatini, tensor palatini, palatoglossus, and geniohyoid.

The effect of REM sleep on upper airway muscle activity is more clearly documented.
Activity of phasic upper airway dilating muscles, such as the genioglossus, is **greatly attenuated during REM sleep**, particularly during periods of phasic rapid eye movements.

In summary, the sleep state is associated with decreased upper airway muscle activity.

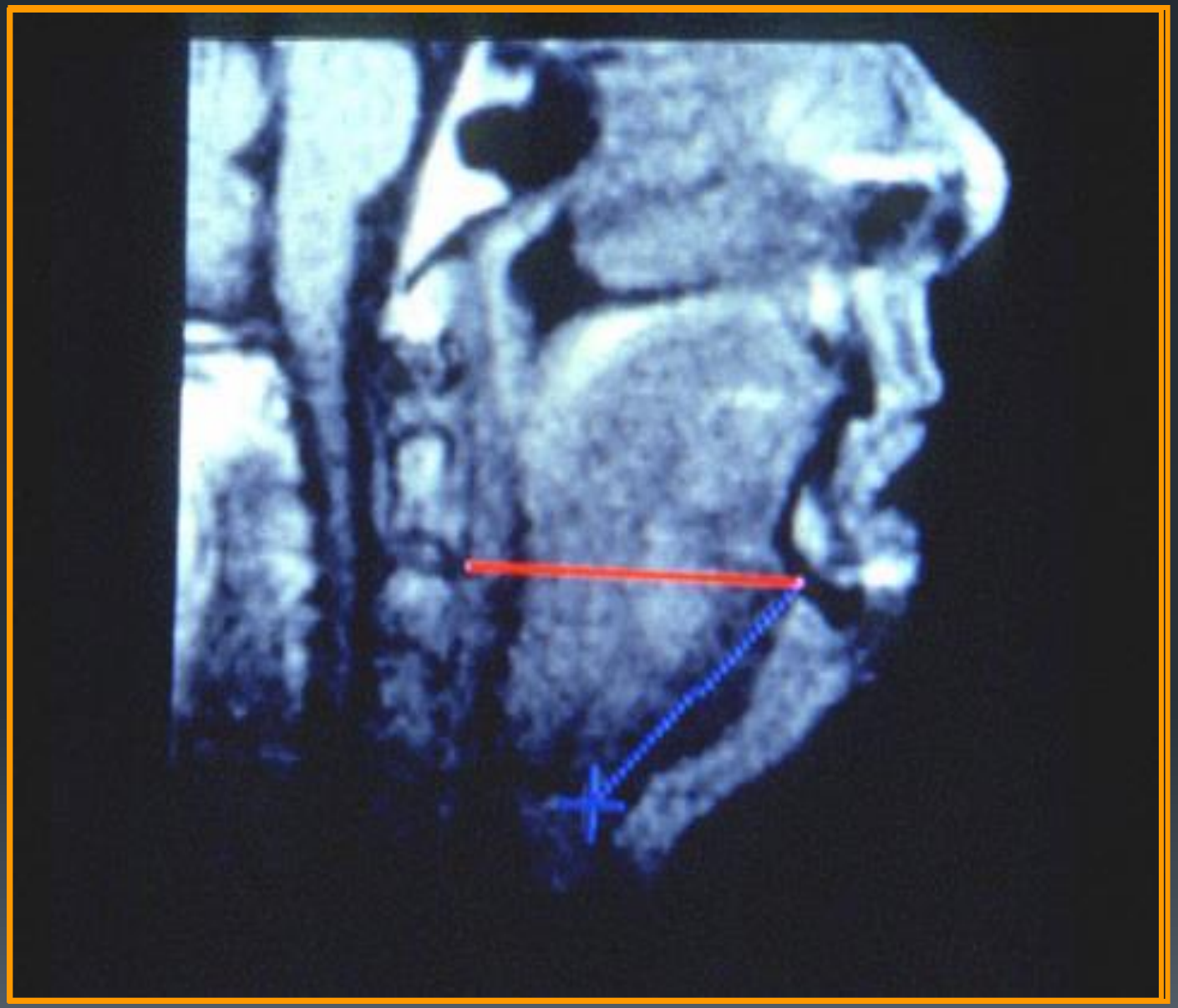
Craniofacial Structure

Craniofacial structure is an important determinant of upper airway patency.

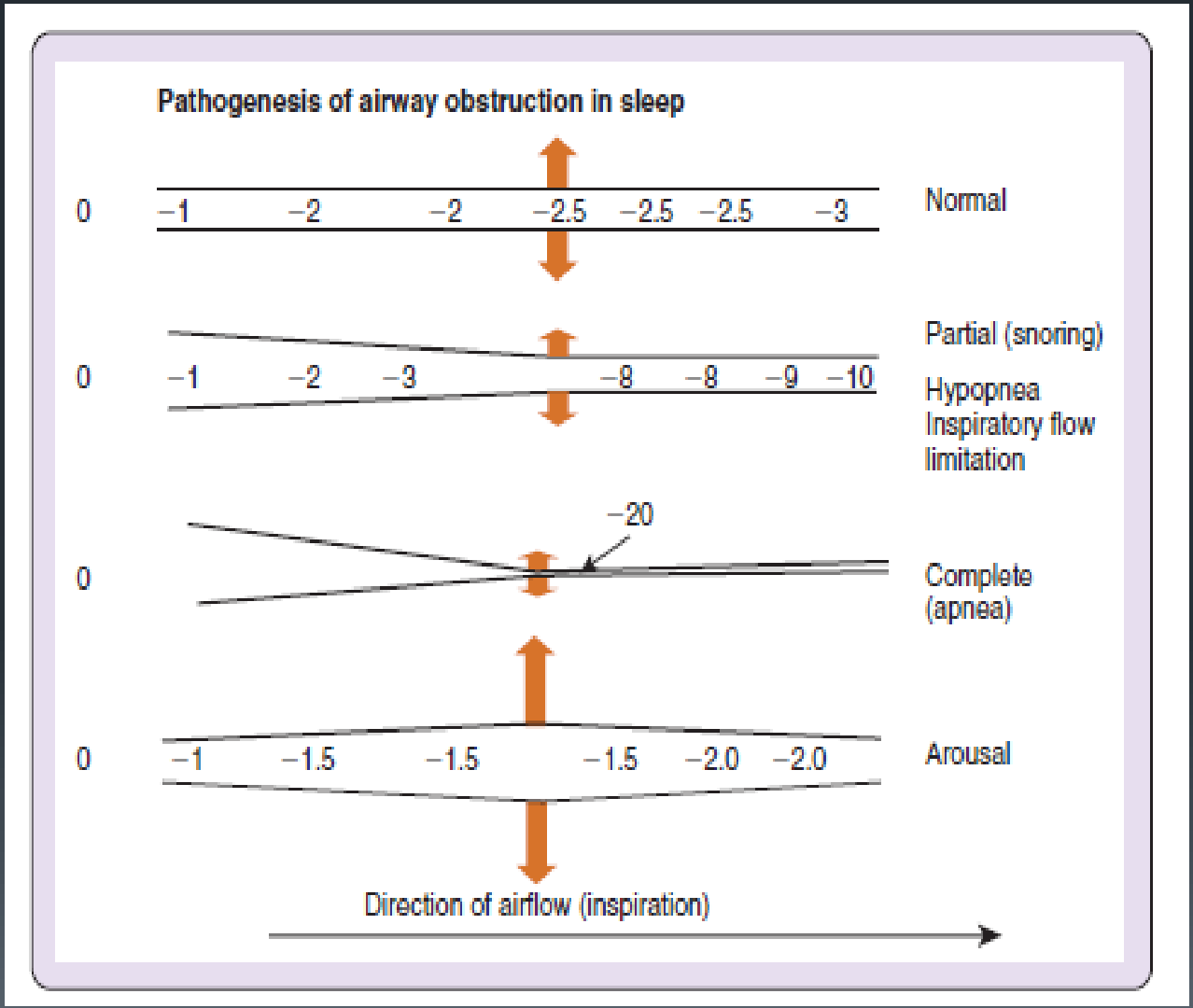
Common craniofacial abnormalities that have been associated with increased severity of sleep apnea include

- smaller airway dimensions, particularly those involving the maxilla and mandible
- mandibular retrognathia
- decreased posterior airspace
- an inferiorly placed hyoid bone
- increased soft palate dimensions and length.

These abnormalities decrease the dimensions of the nasopharynx and oropharynx, likely increasing the risk for upper airway obstruction.



Relationship of Upper Airway Anatomic Factors to Development of Inspiratory Flow Limitation and Obstruction

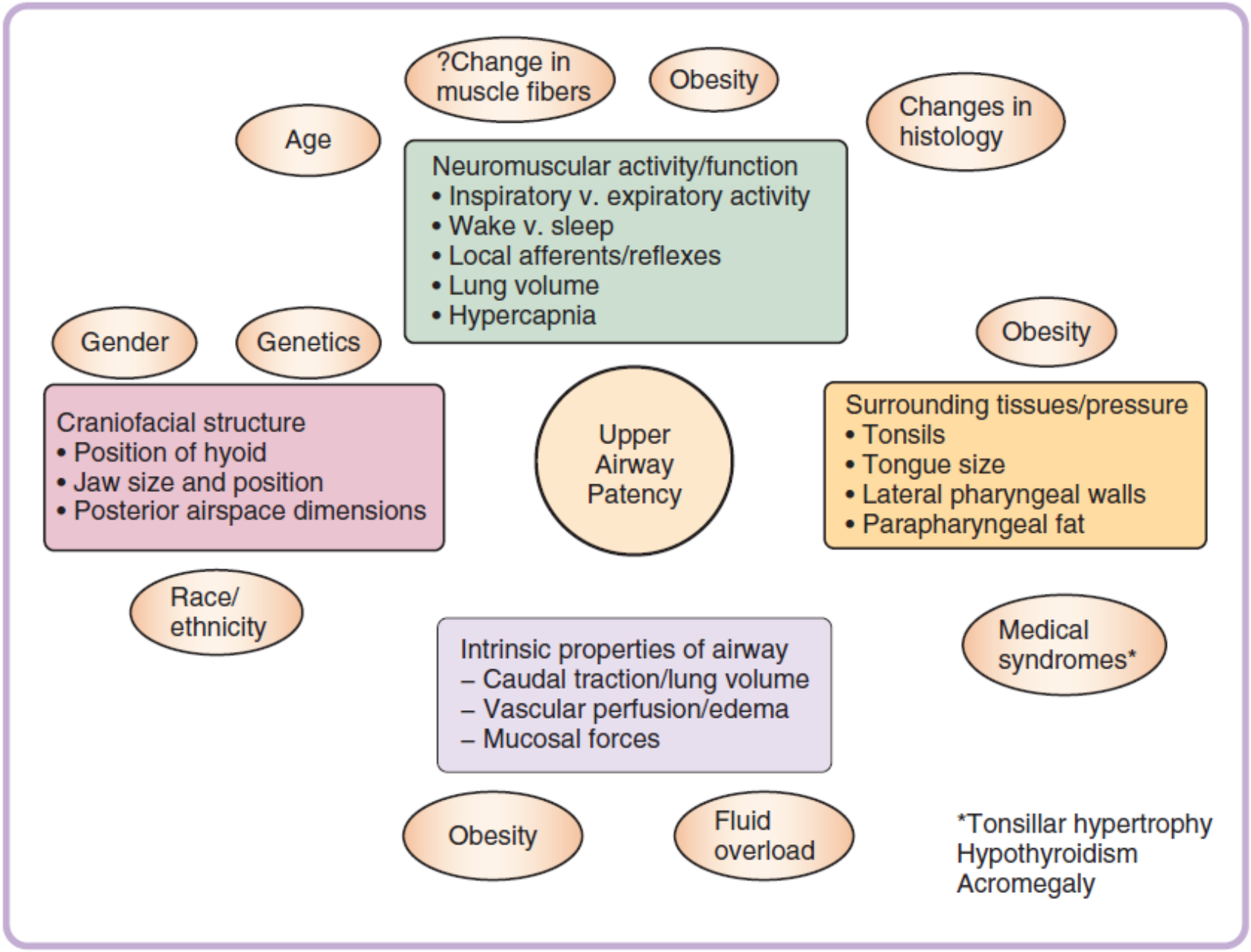


Ventilatory Control

Abnormalities of ventilatory control may predispose to OSA or central sleep apnea by affecting ventilation, ventilatory drive, and upper airway patency.

These ventilatory control abnormalities may include neuromuscular responses to the influences of state (sleep-wake), chemical drive (e.g., ventilatory response to hypoxia and hypercapnia) and arousal threshold.

In the presence of a lesser degree of anatomic compromise, OSA occurs when there are coexistent abnormalities in arousal threshold, loop gain (sensitivity of the ventilatory control system to feedback loops, such as due to changes in CO2), or muscle responses.


?Change in muscle fibers
Obesity
Age
Changes in histology
Neuromuscular activity/function
• Inspiratory v. expiratory activity
• Wake v. sleep
• Local afferents/reflexes
• Lung volume
• Hypercapnia
Gender
Genetics
Obesity
Craniofacial structure
• Position of hyoid
• Jaw size and position
• Posterior airspace dimensions
Upper Airway Patency
Surrounding tissues/pressure
• Tonsils
• Tongue size
• Lateral pharyngeal walls
• Parapharyngeal fat
Race/ ethnicity
Intrinsic properties of airway
– Caudal traction/lung volume
– Vascular perfusion/edema
– Mucosal forces
Medical syndromes*
Obesity
Fluid overload
*Tonsillar hypertrophy
Hypothyroidism
Acromegaly

In central sleep apnea (CSA) syndromes,
apnea events generally result from temporary cessation of pontomedullary pacemaker activity.

Considering the mechanism(s) and the resulting tension of carbon dioxide in blood ($PaCO_2$), CSA may be grouped into:

- non-hypercapnic CSA (the most prevalent category)
- alveolar hypoventilation syndromes

In non-hypercapnic CSA, apneic events are most often the result of over-response or under-response of the respiratory control system to minimal changes in nocturnal $PaCO_2$ (high “loop gain”).

Loop gain is an engineering term that describes the degree of response of the respiratory control system, after a ventilatory disturbance.

The higher the loop gain, the higher the overventilation or underventilation response, resulting in respiratory instability.

Disorders such as idiopathic CSA, Cheyne–Stokes respiration (CSR), and high-altitude CSA are considered to be the result of high “loop gain” of the respiratory control system.

Because of the dependency on a $PaCO_2$ -driven ventilatory response, these breathing disorders are generally exclusive to NREM sleep, where the ventilatory pattern is particularly influenced by chemical drive.
In REM sleep, ventilator pattern is influenced by a combination of chemical and other nonmetabolic influences, producing lower ventilatory responsiveness to hypercapnia and hypoxia, and less tendency to over- or under-react to transient perturbations in ventilation.