Sleep apnea and importance of multiple levels of sleep assessment for diagnosis of sleep disordered breathing

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- **What is sleep apnea?**
- **What are the types of sleep apnea?**
- **Epidemiology of OSA**
- **Pathophysiology of OSA**
- **Assessment of sleep apnea-**
  - **Various tools**

What is sleep apnea?

- **Sleep Apnea in an adult is defined as the absence of nasal and oral airflow (breathing) for at least 10 seconds in duration during sleep**

Sleep-related breathing disorders are divided into four sections:

- Obstructive sleep apnea
- central sleep apnea (CSA) syndromes
- sleep-related hypoventilation disorders
- sleep related hypoxemia disorder

Epidemiology of sleep apnea

- **In Wisconsin Sleep Cohort, the prevalence of OSA was 24% in men and 9% in women aged 30-60 years based on AHI**
- **OSA with associated EDS prevalence is approximately 3% to 7% in adult men and 2% to 5% in adult women**
- **When data from the Wisconsin sleep cohort study were re-examined with adjustment for current levels of overweight and obesity, a marked increase in the prevalence of OSA was observed**
- **Based on these data, 34% of men and 17.4% of women between the ages of 30-70 would be expected to have an AHI ≥5, which would be associated with excessive daytime sleepiness in 14% of men and 5% of women**

- **Emerging data from Europe suggest that the societal prevalence of the disorder may be even greater when modern diagnostic techniques are used**

- **a community-based Swiss study of over 2,000 subjects diagnosed moderate-severe OSA (i.e., an AHI ≥15) in 23.4% and 49% of female and male subjects, respectively**

J Thorac Dis. 2015 May; 7(5): 920–929

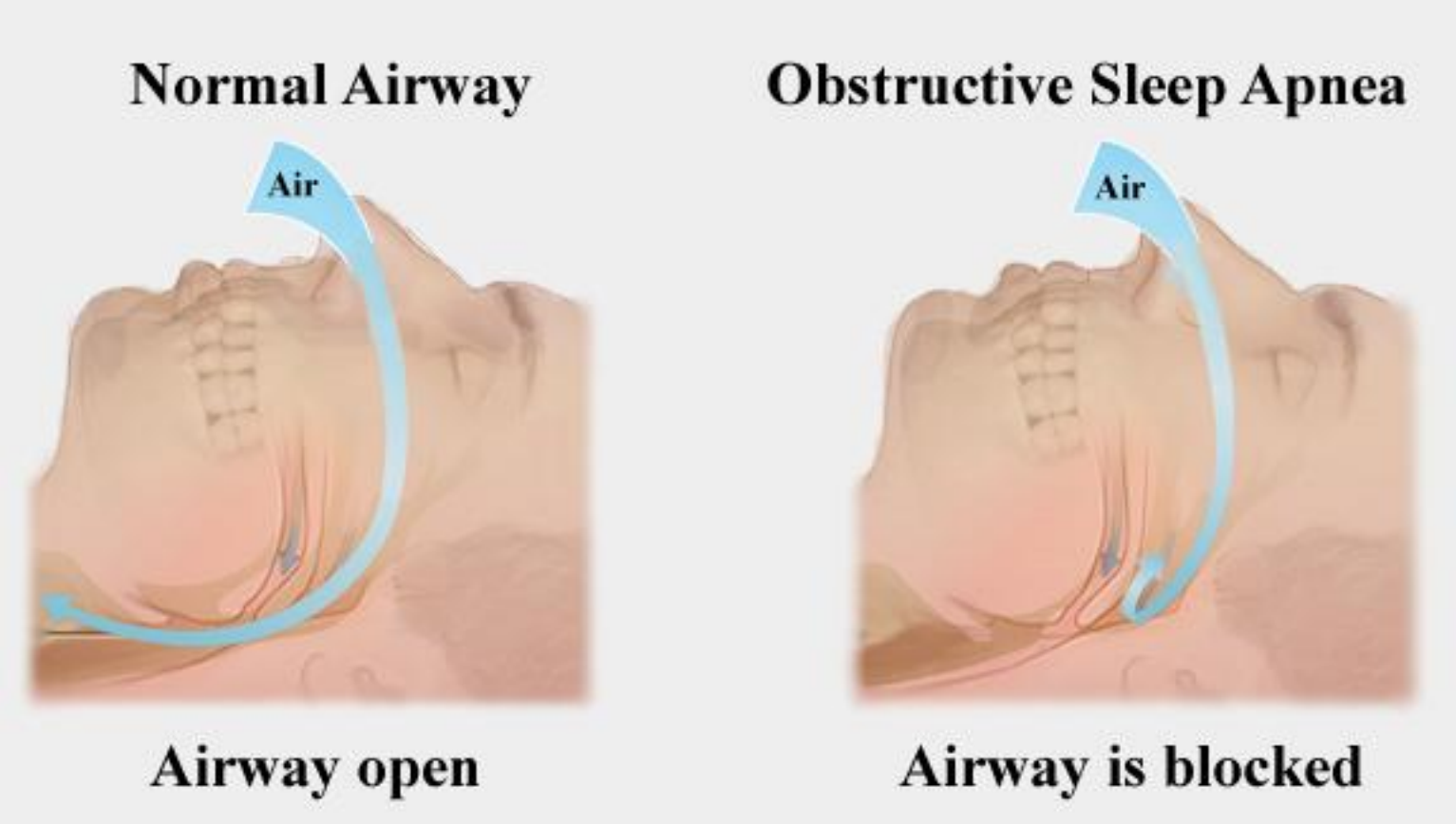
Lancet Respir Med. 2015 April ; 3(4): 310–318. doi:10.1016/S2213-2600(15)00043-0.

Prevalence of sleep-disordered breathing in the general population: the HypnoLaus study

- **population-based study**
- **invited a cohort of 3043 consecutive participants**
- **The prevalence of moderate-to-severe SDB (≥15/h) was 23·4% (95% CI 20·9–26·0) in women and 49·7% (46·6–52·8) in men**

Interpretation—The high prevalence of sleep-disordered breathing recorded in our population-based sample might be attributable to the increased sensitivity of current recording techniques and scoring criteria. These results suggest that sleep-disordered breathing is highly prevalent, with important public health outcomes, and that the definition of the disorder should be revised.

Pathogenesis



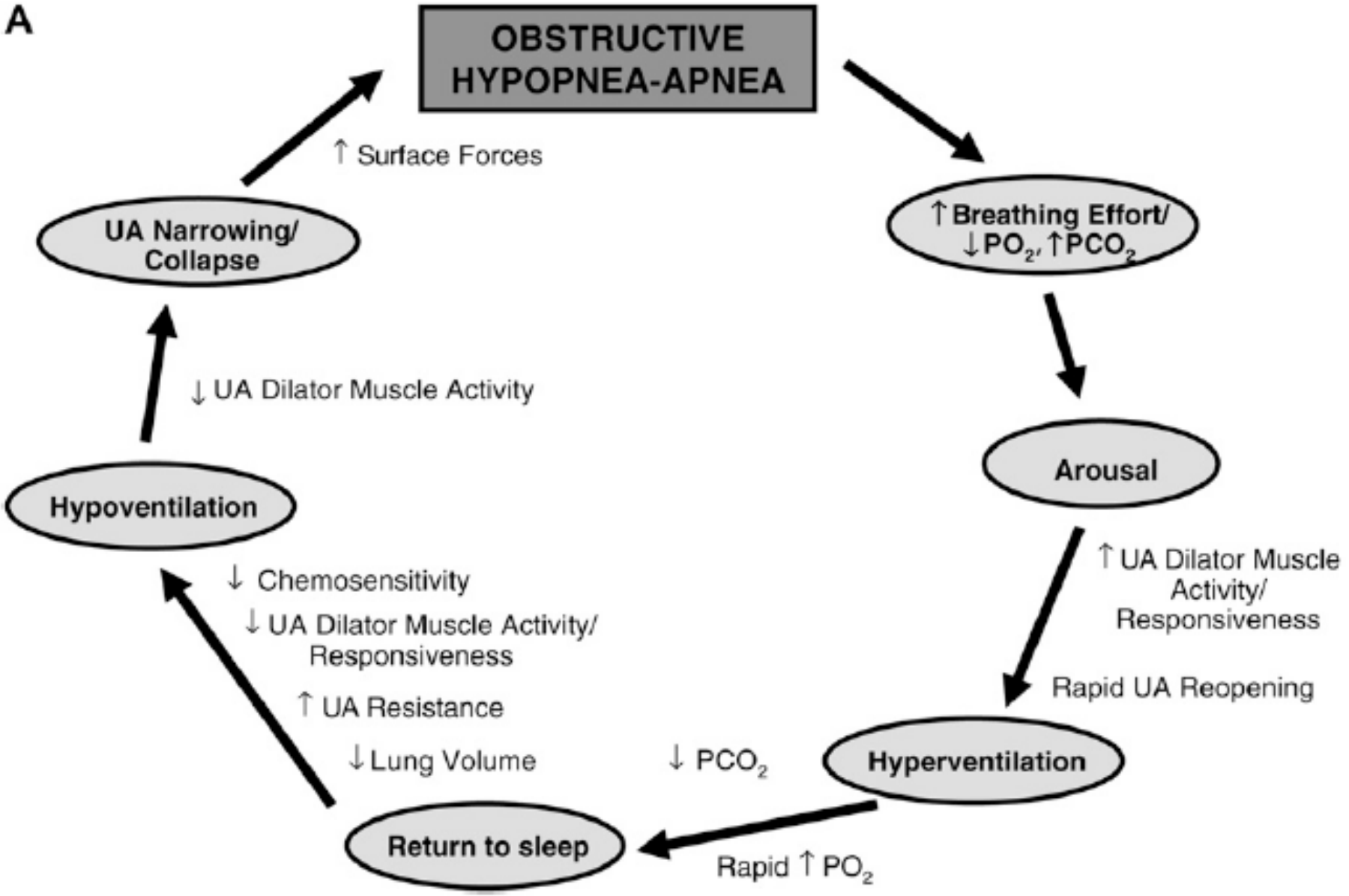
Pathogenesis

- **Alterations in upper airway anatomy (skeletal, soft tissue, nasal obst, craniofacial disproportion, tonsillar hypertrophy, macroglossia and acromegaly)**

- **mechanical and tissue characteristics (resistance)**
- **Motor control**

- **Ventilatory control instability**
- **Low sleeping lung volume**

- **Arousal threshold**


A
OBSTRUCTIVE HYPOPNEA-APNEA
↑ Surface Forces
UA Narrowing/ Collapse
↓ UA Dilator Muscle Activity
Hypoventilation
↓ Chemosensitivity
↓ UA Dilator Muscle Activity/ Responsiveness
↑ UA Resistance
↓ Lung Volume
Return to sleep
Rapid ↑ PO2
↓ PCO2
Hyperventilation
Rapid UA Reopening
↑ UA Dilator Muscle Activity/ Responsiveness
Arousal
↑ Breathing Effort/ ↓PO2, ↑PCO2

Consequences (OSA)

- Hypertension, DM
- Ischemic Heart Disease
- Cerebrovascular Disease
- Mood, Neurocognitive & Behavioral Effects
- Motor Vehicle Accidents (3-fold increase)
- Mortality: older people with AHI > 20/ hour have shorter survival than those with milder OSA

Evaluation of EDS/sleep apnea

- **One fifth of adult suffer from excessive daytime sleepiness**

- **EDS may be due to several medical conditions and sleep apnea is one of the common cause**

History…. History… history ……

- **The evaluation of sleep apnea involves taking a thorough history and performing a good physical examination.**
- **A detail history is the key to diagnosis/ DDs and guide to appropriate investigations**
- **Family history is also important for sleep disorders**

RISK FACTORS

- Obesity
- Snoring
- DNS / nasal obstruction
- Adenoids / tonsillar hypertrophy
- Alcoholism
- COPD
- Hypothyroidism, DM
- Post-menopausal state
- Chinese race
- Indian
- African Americans
- arrythmia
- Refractory hypertension

CLINICAL PRESENTATION

Common nocturnal symptoms

- **Snoring**
- **Witnessed apneas**
- **Nocturnal choking**
- **Restlessness**
- **Dyspnea**
- **Diaphoresis**
- **Nocturia**
- **Dry mouth**
- **Drooling**
- **Gastroesophageal reflux**

Common daytime symptoms

- Excessive Daytime sleepiness/fatigue
- Morning headaches
- Impaired memory and concentration
- Poor school performance
- Personality Changes
  - Irritability
  - Aggressiveness
  - Depression
  - Anxiety
  - Decreased libido
  - Impotence

MANY A TIME REMAIN ASYMPTOMIC

DD of EDS

Insufficient sleep

- Sleep deprivation
- Environmental intrusions

Sleep disorders

- Obstructive sleep apnea
- Central sleep apnea
- Sleep-related hypoventilation or hypoxemia
- Central disorders of hypersomnolence
  - Narcolepsy type 1 or 2
  - Kleine-Levin syndrome
  - Idiopathic hypersomnia
- Circadian rhythm sleep-wake disorders
  - Delayed sleep phase disorder
  - Advanced sleep phase disorder
  - Jet lag
  - Shift work
- Restless legs syndrome
- Periodic limb movement disorder

Other neurologic disorders

- Neurodegenerative disease
  - Parkinson disease
  - Dementia with Lewy bodies
  - Alzheimer disease
  - Multiple system atrophy
- Myotonic dystrophy
- Multiple sclerosis
- Amyotrophic lateral sclerosis (via sleep-related breathing disorders)
- Structural lesions affecting thalamus, hypothalamus, or brainstem
- Traumatic brain injury
- Encephalitis lethargica
- Cerebral trypanosomiasis

Medical and genetic disorders

- Hypothyroidism
- Obesity
- End-stage renal disease
- Adrenal insufficiency
- Hepatic encephalopathy
- Niemann-Pick type C
- Prader-Willi syndrome

Psychiatric disorders

- Depression
- Anxiety
- Substance abuse
  - Alcohol
  - Narcotics
  - Prescription opioid abuse
  - Stimulant withdrawal
- Psychogenic sleepiness

Medications

Physical examination

Clinical features

- **Sleep apnea**
  - ***Overall Inspection***
    - **Obesity, hypothyroidism & acromegaly**
  - **Craniofacial Factors**
  - **Nasal Factors**
  - **Neck Circumference (16” & 17”)**
  - ***Examination of the Pharynx, Tonsils***
  - ***Neurologic Examination***
  - ***Cardio-pulmonary Examination***

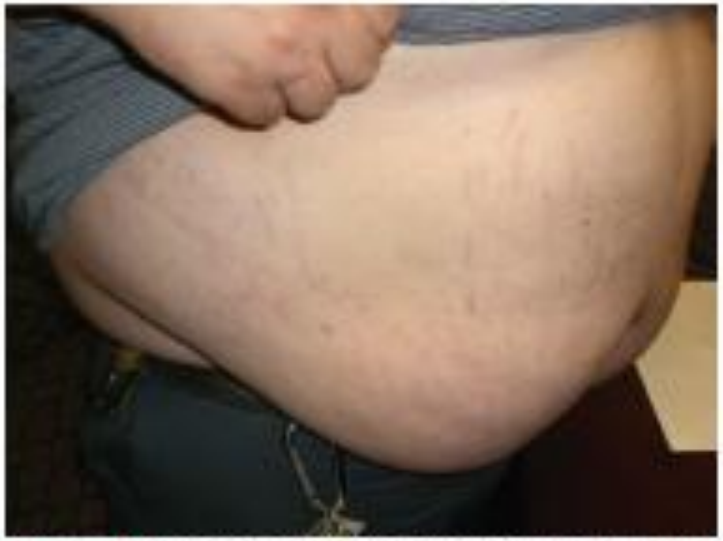


Figure 58-1 Central obesity in OSA. (From Kryger MH. Atlas of clinical sleep medicine. Philadelphia: Elsevier; 2010.)

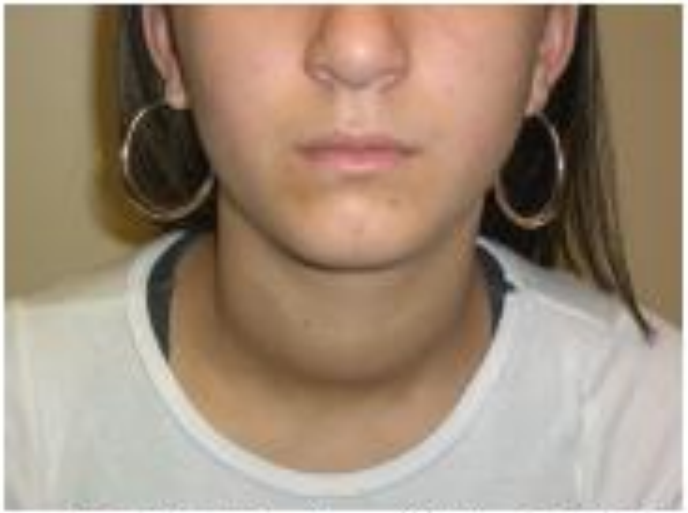


Figure 58-2 Goiter. (From Kryger MH. Atlas of clinical sleep medicine. Philadelphia: Elsevier; 2010.)

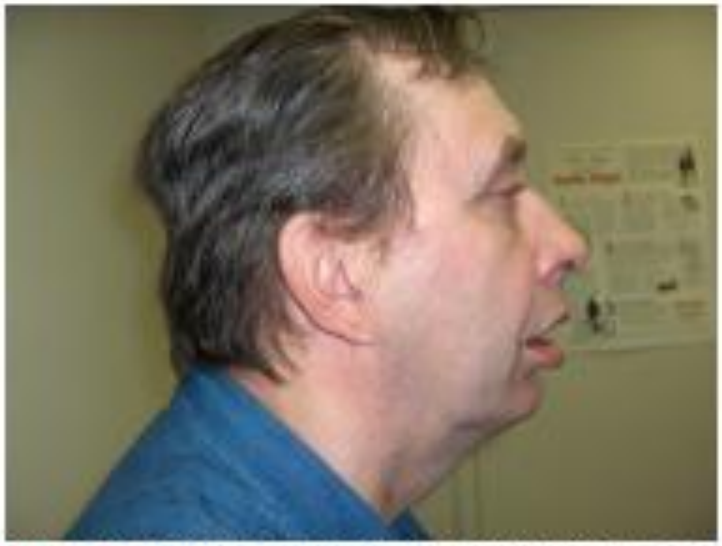


Figure 58-3 Mandibular retrognathia contributing to OSA. (From Kryger MH. Atlas of clinical sleep medicine. Philadelphia: Elsevier; 2010.)

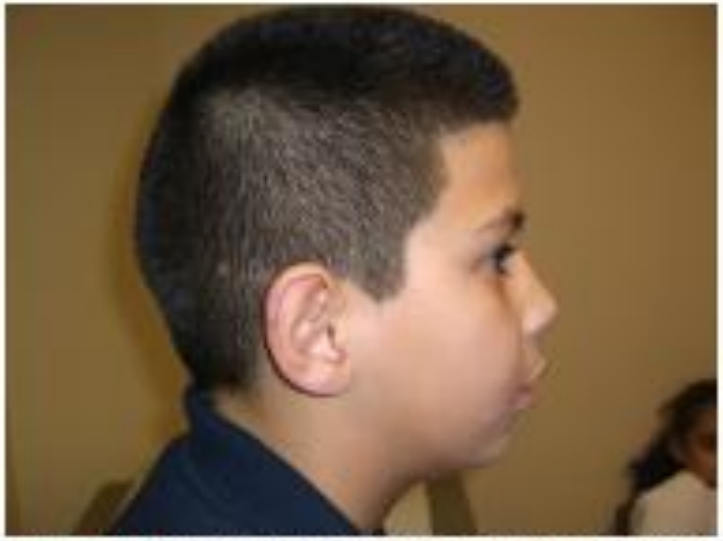


Figure 58-4 Mandibular micrognathia contributing to OSA. (From Kryger MH. Atlas of clinical sleep medicine. Philadelphia: Elsevier; 2010.)

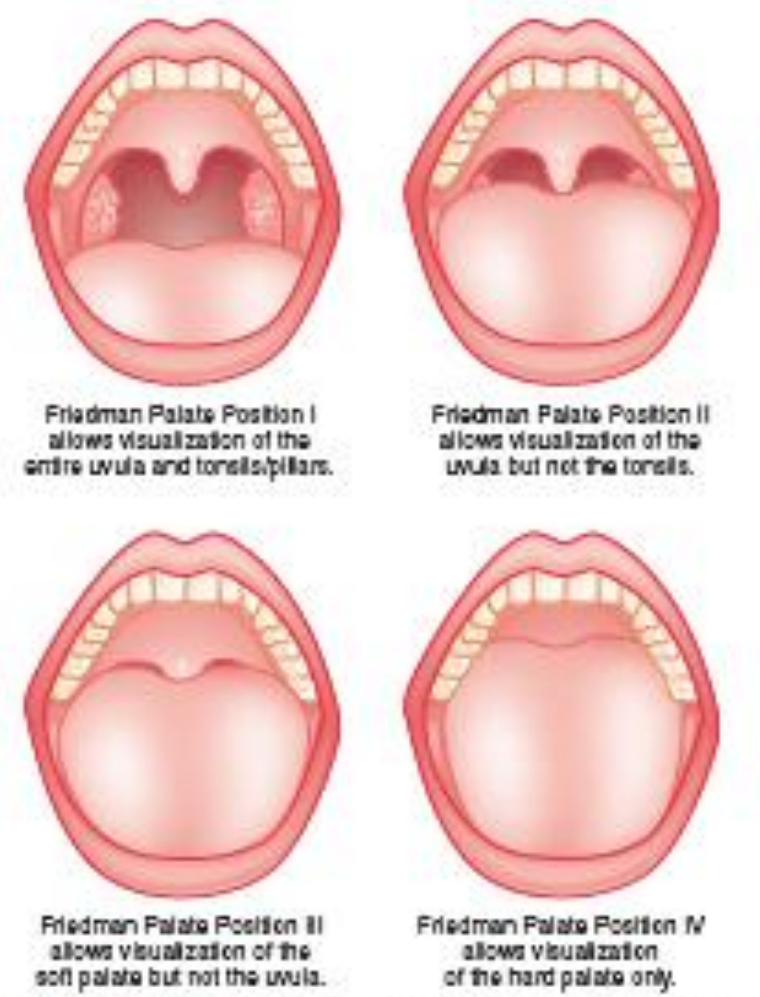


Figure 58-13 Friedman classification. (From Friedman M, Ibrahim H, Bass L. Clinical staging for sleep-disordered breathing. Otolaryngol Head Neck Surg 2002;127:13-21.)

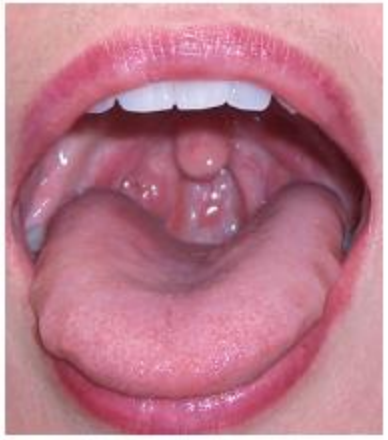


Figure 58-9 Mallampati class I. (From Kryger MH. Atlas of clinical sleep medicine. Philadelphia: Elsevier; 2010.)

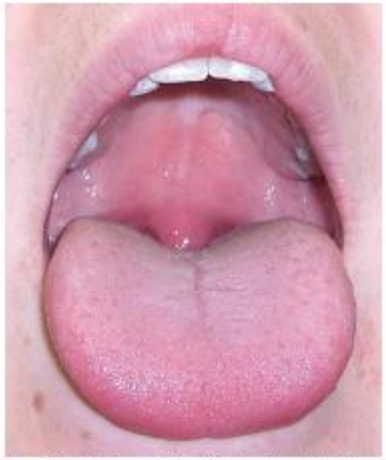


Figure 58-11 Mallampati class III. (From Kryger MH. Atlas of

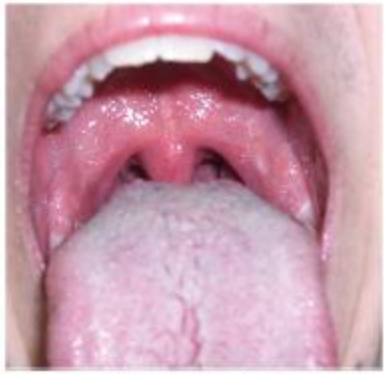


Figure 58-10 Mallampati class II. (From Kryger MH. Atlas of clinical sleep medicine. Philadelphia: Elsevier; 2010.)

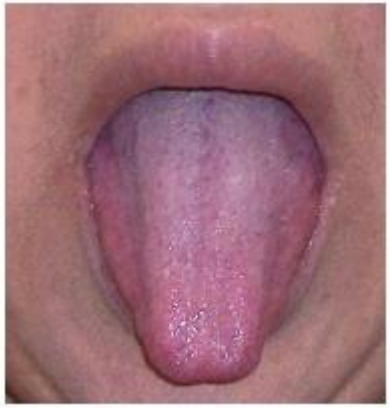


Figure 58-12 Mallampati class IV. (From Kryger MH. Atlas of clinical sleep medicine. Philadelphia: Elsevier; 2010.)

Class I Soft palate, fauces, uvula, and posterior and anterior pillars are visible

Class II Soft palate, fauces, and uvula are visible

Class III Soft palate, fauces, and only base of uvula are visible

Class IV Soft palate is not visible

Sleep endoscopy

- **Measures collapsibility of upper airway during induced sleep by endoscopy**
- **Useful when surgery is planned**

MRI

- **MRI during artificially induced sleep can give better idea for anatomical abnormality of OSA patient**

- **Useful for surgery and dental appliances**

Tools for Evaluating Sleepiness-

- Measure EDS
- Measure risk of OSA

Screening .....

- **Epworth Sleepiness Scale (ESS) ≥10**
- **Stanford Sleepiness Scale**
- **Visual Analog Scale**
- **STOP bang**
  - **Snoring**
  - **Tired/EDS**
  - **Observed apnea**
  - **BP**
  - **BMI, AGE >50, NECK CIR , MALE GENDER**
  - **0-2, 3-4, 5-8**
- **BERLIN QUESTIONNAIRE**

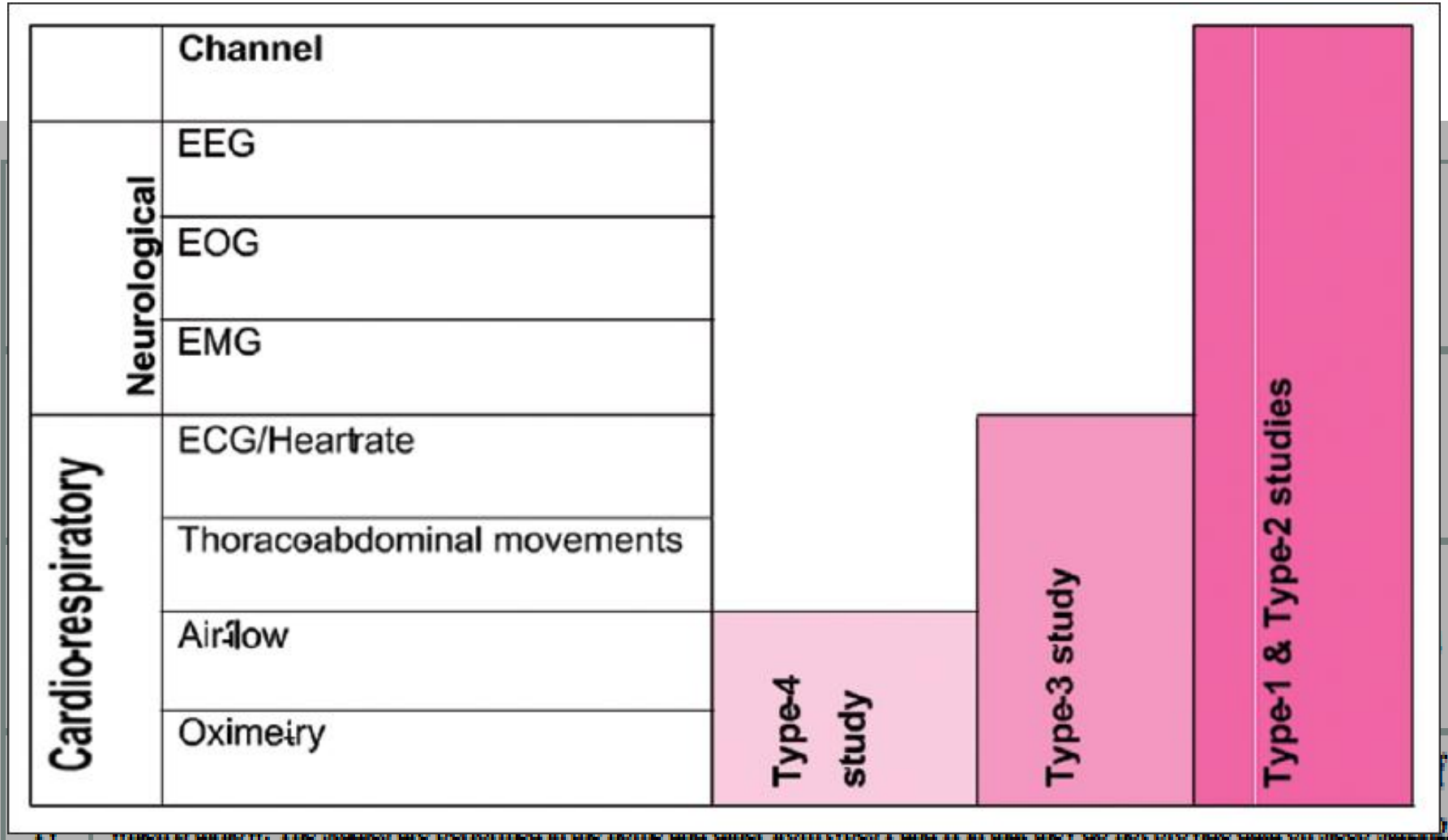
POLYSOMNOGRAPHY

Polysomnography Definition

- **Polysomnography refers to the collective process of monitoring and recording physiologic variables of a patient during sleep.**

- **The term polysomnography was given by Holland, Dement and Raynall in 1974**

TYPES OF PSG


Channel
Neurological
EEG
EOG
EMG
Cardio-respiratory
ECG/Heartrate
Thoracoabdominal movements
Airflow
Oximetry
Type-4 study
Type-3 study
Type-1 & Type-2 studies

Indications of level one PSG (has a contraindication to a home sleep study)

- 1. Observed apneas during sleep; OR
- 2. A combination of at least two (2) of the following (a–e):
- a. Excessive daytime sleepiness evidenced by an Epworth sleepiness scale score greater than ten (10), inappropriate daytime napping (e.g., during driving, conversation, or eating), or sleepiness that interferes with daily activities and is not explained by other conditions
- b. Habitual snoring or gasping/choking episodes associated with awakenings
- c. Treatment-resistant hypertension (persistent hypertension in a patient taking three or more antihypertensive medications)

- **d. Obesity, defined as a body mass index greater than 30 kg/m2 or increased neck circumference defined as greater than 17 inches in men or greater than 16 inches in women**
- **e. Craniofacial or upper airway soft tissue abnormalities, including adenotonsillar hypertrophy, or neuromuscular disease; OR**

- **3. History of stroke, transient ischemic attack, coronary artery disease, or sustained tachycardic or bradycardic arrhythmias**

Suspected Sleep Disorder Other Than OSA
An in-lab supervised sleep study is appropriate when there is suspicion of any of the following

- **1. Central sleep apnea**
- **2. Narcolepsy**
- **3. Nocturnal seizures**
- **4. Parasomnia**
- **5. Idiopathic hypersomnia**
- **6. Periodic limb movement disorder**
- **7. Nocturnal desaturation (due to severe chronic obstructive pulmonary disease [COPD] or certain restrictive thoracic disorders) or unexplained right heart failure, polycythemia, cardiac arrhythmias during sleep or pulmonary hypertension**

HST OR LEVEL 2/3 PSG

Advantages

- **Can often minimize first-night effect.**
- **Reduce costs to the patient.**
- **It allows the testing service provider to reach more patients.**
- **Portable monitoring allows the testing service provider to reach people in remote, rural areas who most likely would not travel to a conventional sleep center.**

Disadvanages

-
- **Unattended portable polysomnography monitoring will undoubtedly include multiple varieties of technical artifact, which may result in an uninterpretable recording.**
- **Effective NCPAP titration cannot be conclusively or objectively documented during an unattended study**
- **In RCTs, PSG in comparison to HSAT has failed to show superior outcomes for the patient population**
- **HSAT is less sensitive than PSG in establishing a diagnosis of OSA**

Indication of HST- AASM 2016

4.2ai We recommend that attended polysomnography or home sleep apnea testing with a technically adequate device, be used to diagnose OSA in uncomplicated adult patients presenting with signs and symptoms that indicate a high risk of moderate to severe OSA. (STRONG FOR)

4.2aii We recommend that if a single technically adequate home sleep apnea test is negative or inconclusive that an attended in-lab polysomnogram be performed for the diagnosis of OSA in symptomatic patients. (STRONG FOR)

4.2aiii We recommend that if a single home sleep apnea test is technically inadequate, that an attended in-lab polysomnogram be performed for the diagnosis of OSA in symptomatic patients. (WEAK FOR)

- **HSAT is administered by an accredited sleep center under the supervision of a board certified sleep medicine physician or clinician with equivalent training**

Contraindications of HST

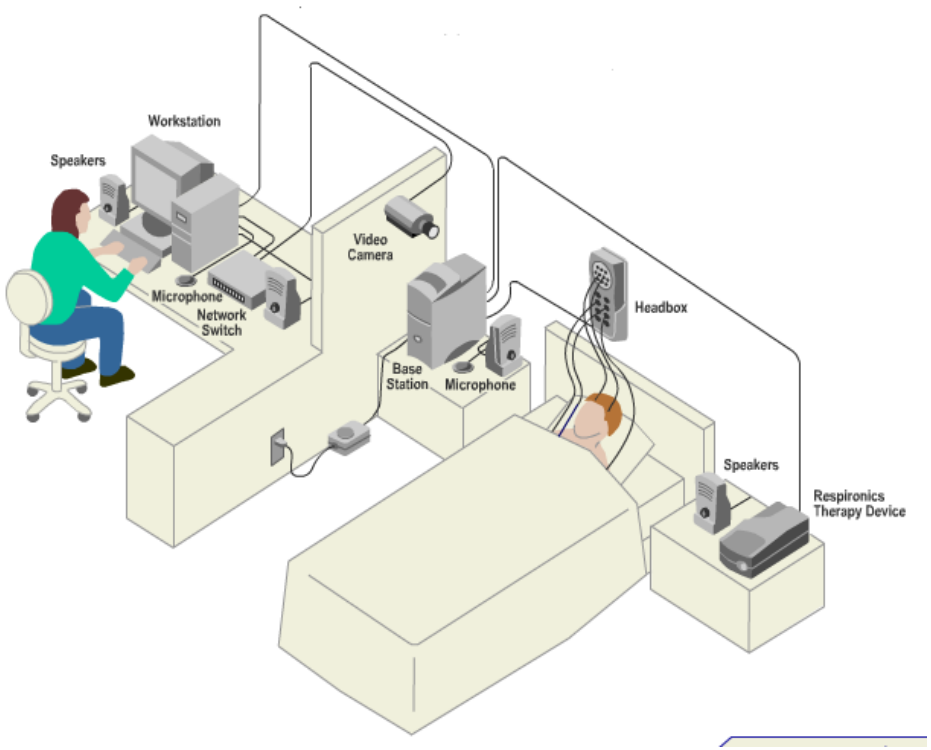
4.3 HSAT for the diagnosis of OSA in adults with comorbid conditions

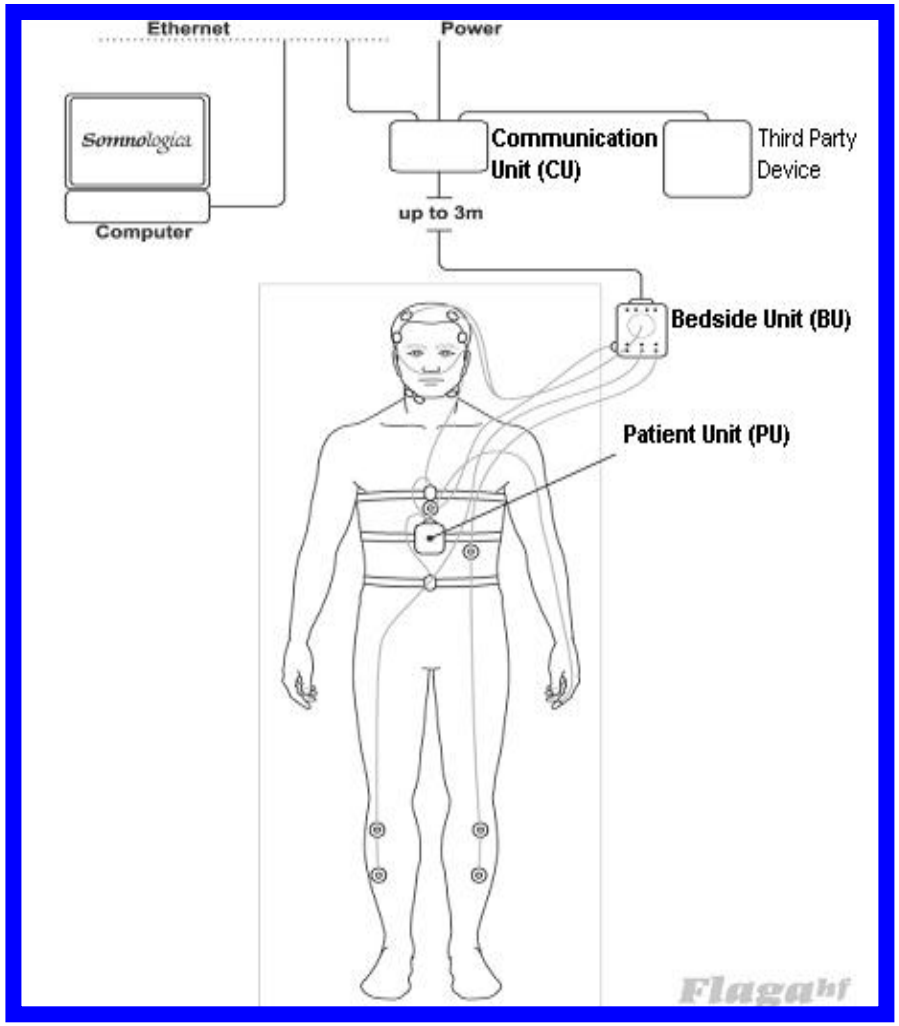
4.3a We recommend that polysomnography, rather than home sleep apnea testing, be used for the diagnosis of OSA in patients with severe cardiorespiratory disease, neuromuscular disease with respiratory muscle impairment, awake hypoventilation or high risk of sleep related hypoventilation, chronic opioid medication use, or severe insomnia. (STRONG FOR)

Polysmonography

Laboratory Setup

Laboratory Setup





INSTRUCTIONS BEFORE PSG

- To take bath and shampoo hair in the evening
- To make his shave properly
- Not to apply any kind of oil anywhere on the body
- To take his / her dinner at least 1 hr before coming for sleep study
- Avoid caffeine and naps the day of testing.

INSTRUCTIONS BEFORE PSG

- To take his medication if he is taking any in the normal way
- Not to consume alcohol on the day of sleep study
- Patient should not have fever,cough,cold on the day of sleep study
- To wear the same clothes in which he / she routinely goes to sleep

INSTRUCTIONS BEFORE PSG

- **To be accompanied by one attendant**
- **To remove all ornaments**
- **To bring all previous medical reports**
- **The patient is called for sleep study on the stipulated day at around 9:00 pm**

EPOCH

A measure of duration of the sleep recording that typically is 30 seconds in duration, depending on the paper speed of the *polysomnograph*, and corresponds to one page of the polysomnogram

Signals for Polysomnography

- Sleep scoring
- Respiration
- Cardiovascular
- Movement
- Position
- Behavior

Signals of Sleep Scoring

- Electroencephalogram (EEG)
- Electro-oculogram (EOG)
- Electromyogram (EMG)

Signals of Respiration

- Oronasal airflow
- Respiratory Movements
  - Chest Movement
  - Abdominal Movements
  - Diaphragmatic EMG
- Oxygen Saturation
- Transcutaneous pCO_2

Miscellaneous Variables

- **Cardiovascular : ECG (electrodes below the rt clavicle & left 6th or 7th intercostal space)**
- **Movement : EMG tibialis**
- **Position : Body Position Sensor**
- **GI system : Esophageal pH sensor**
- **Behavior : Video, Audio**

Sleep Scoring

Applying Electrodes

EEG (Electroencephalogram)

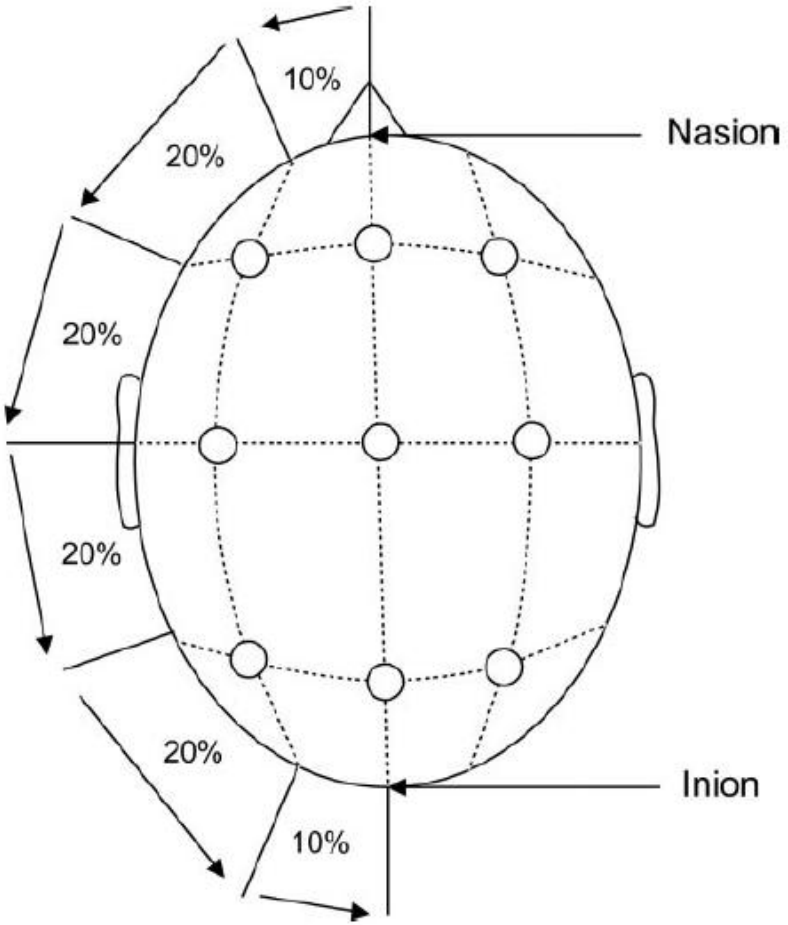
- **Hans Berger recorded the first human EEG in 1929**

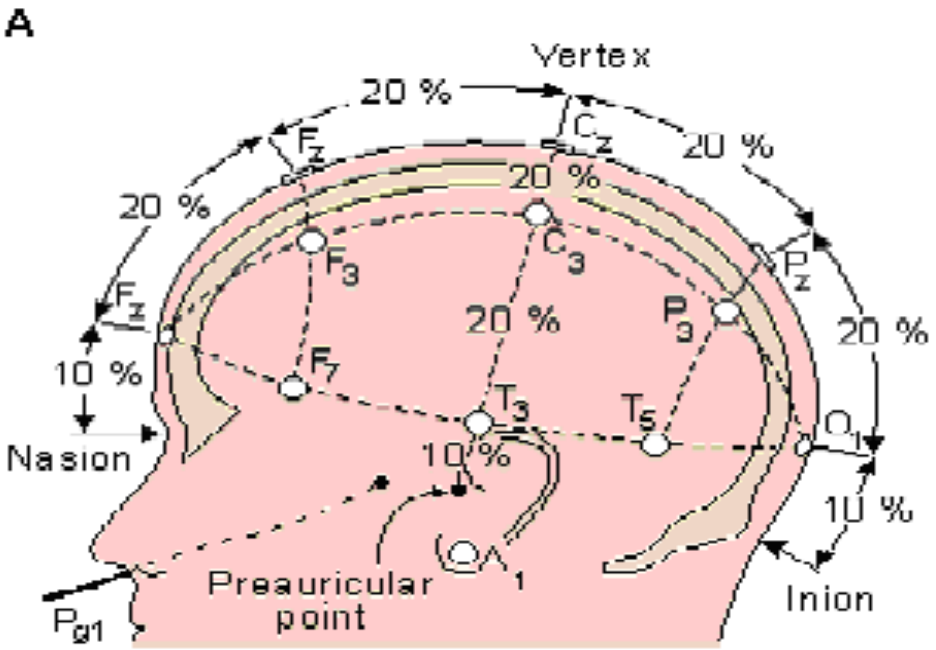
- **The EEG signal records electric potentials generated by the interaction between the cortex and the deeper brain structures, especially the thalamus.**

- **Electrodes should be positioned according to the international 10–20 electrode placement system for sleep developed by Jasper**

- **10–20 system uses a division of 10% and 20% distances between four primary skull based landmarks (*ie, nasion, inion, and each auditory canal)* to create a grid**

- **This allows for variations in skull shape and promotes placement over similar brain regions between individuals.**

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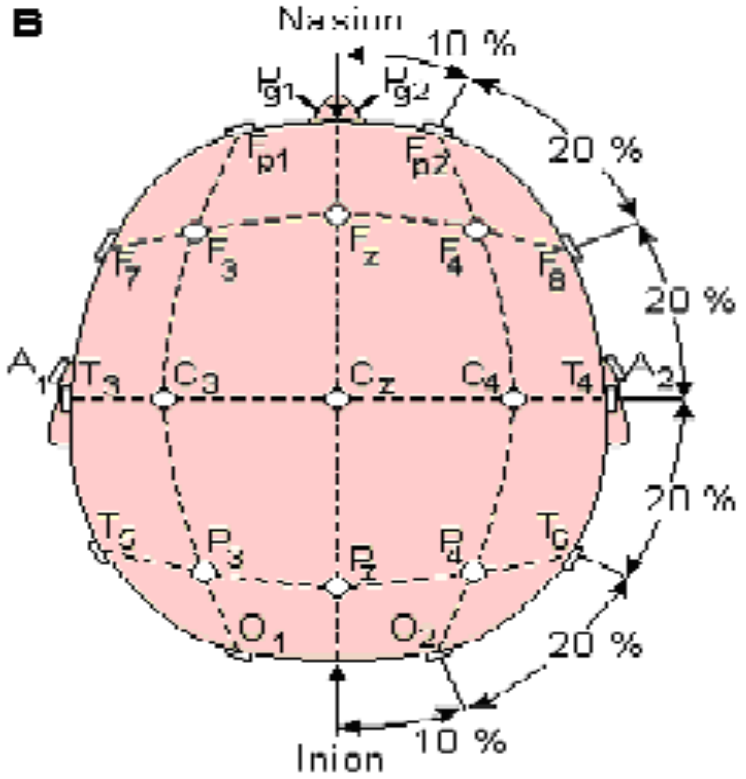
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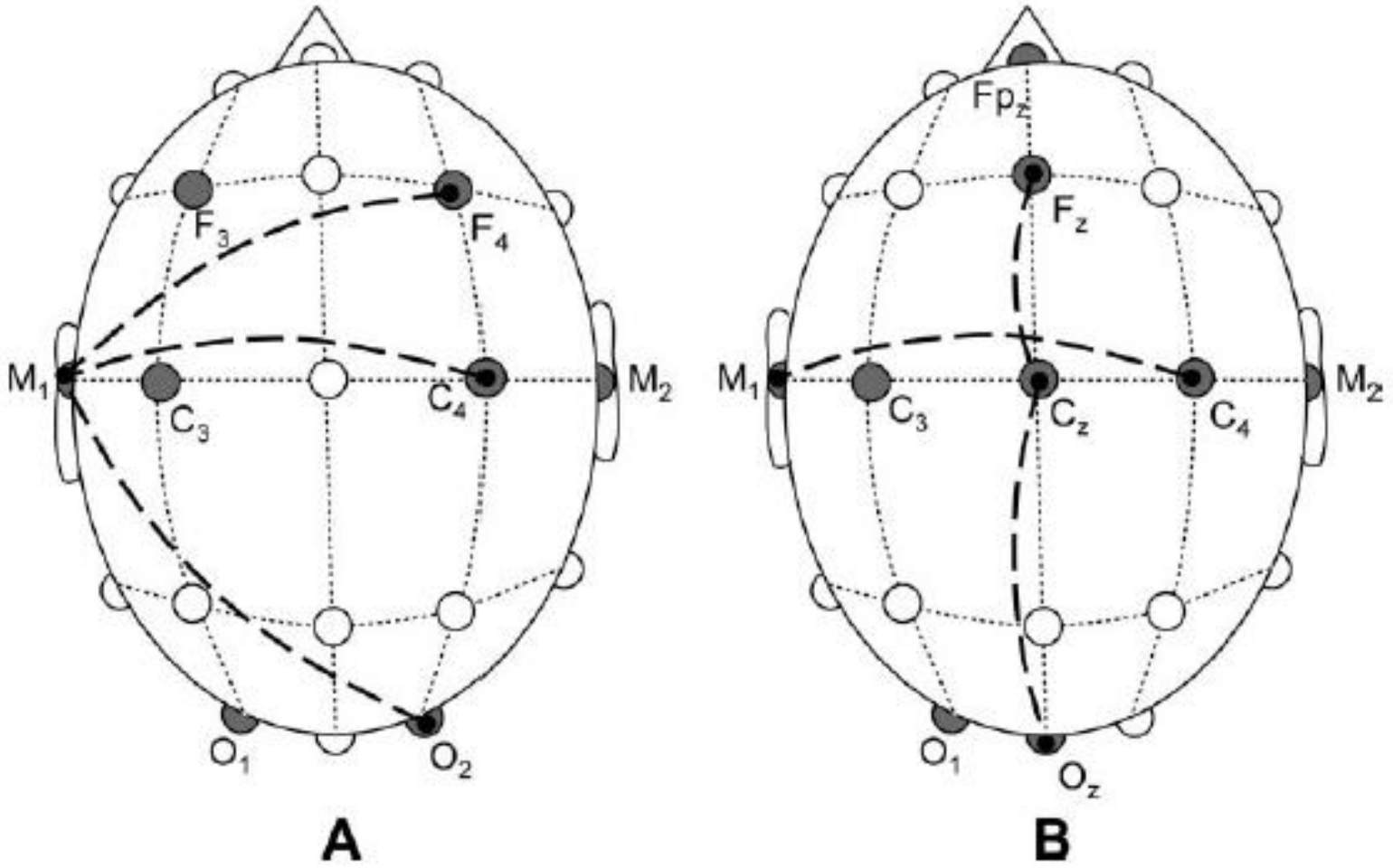
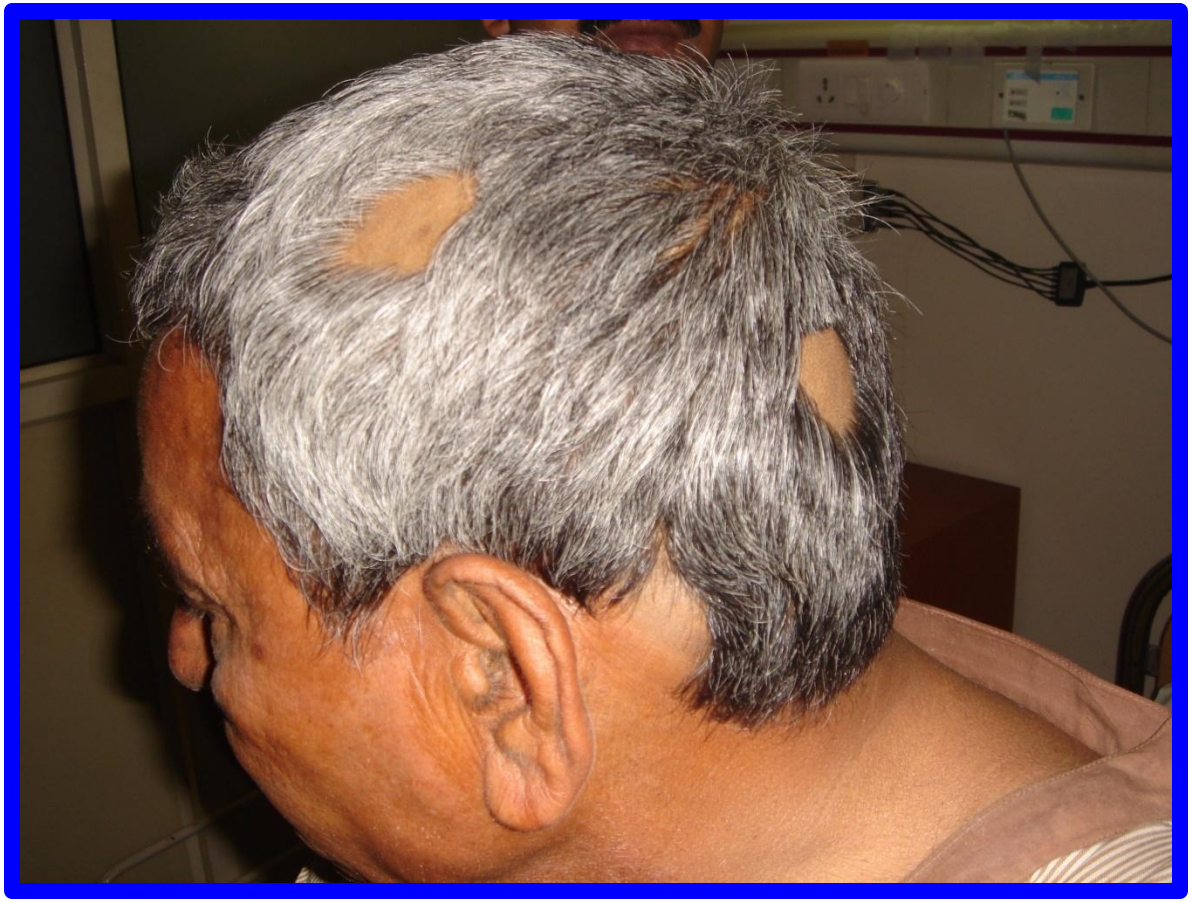


FIGURE 3. Recommended F_4-M_1, C_4-M_1, O_2-M_1 (*left*, *A*), and alternate F_z-C_z, C_z-O_z, C_4-M_1 (*right*, *B*) placements of EEG electrodes, with backup electrodes shown as set forth by the AASM. Adapted from Iber et al.[7]

Applying EEG Electrodes

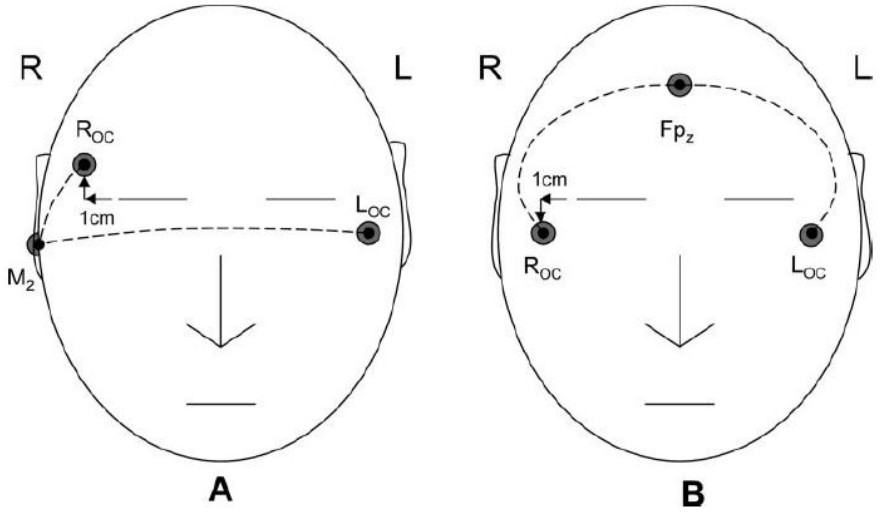


Applying EEG Electrodes

EEG Electrodes

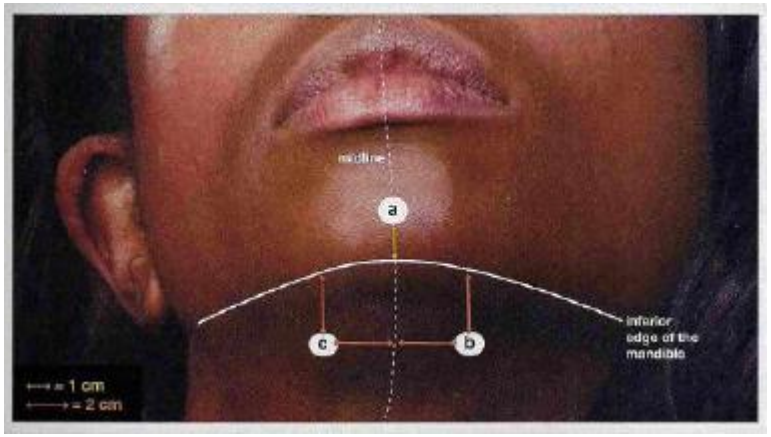
EOG (Electrooocculogram)

- **left outer canthus being 1 cm below the horizontal midline, and the right outer canthus 1 cm above the horizontal midline and referenced to a mastoid electrode**
- **These electrodes are abbreviated as**
  - **ROC (Right outer canthus)**
  - **LOC (Left outer canthus)**

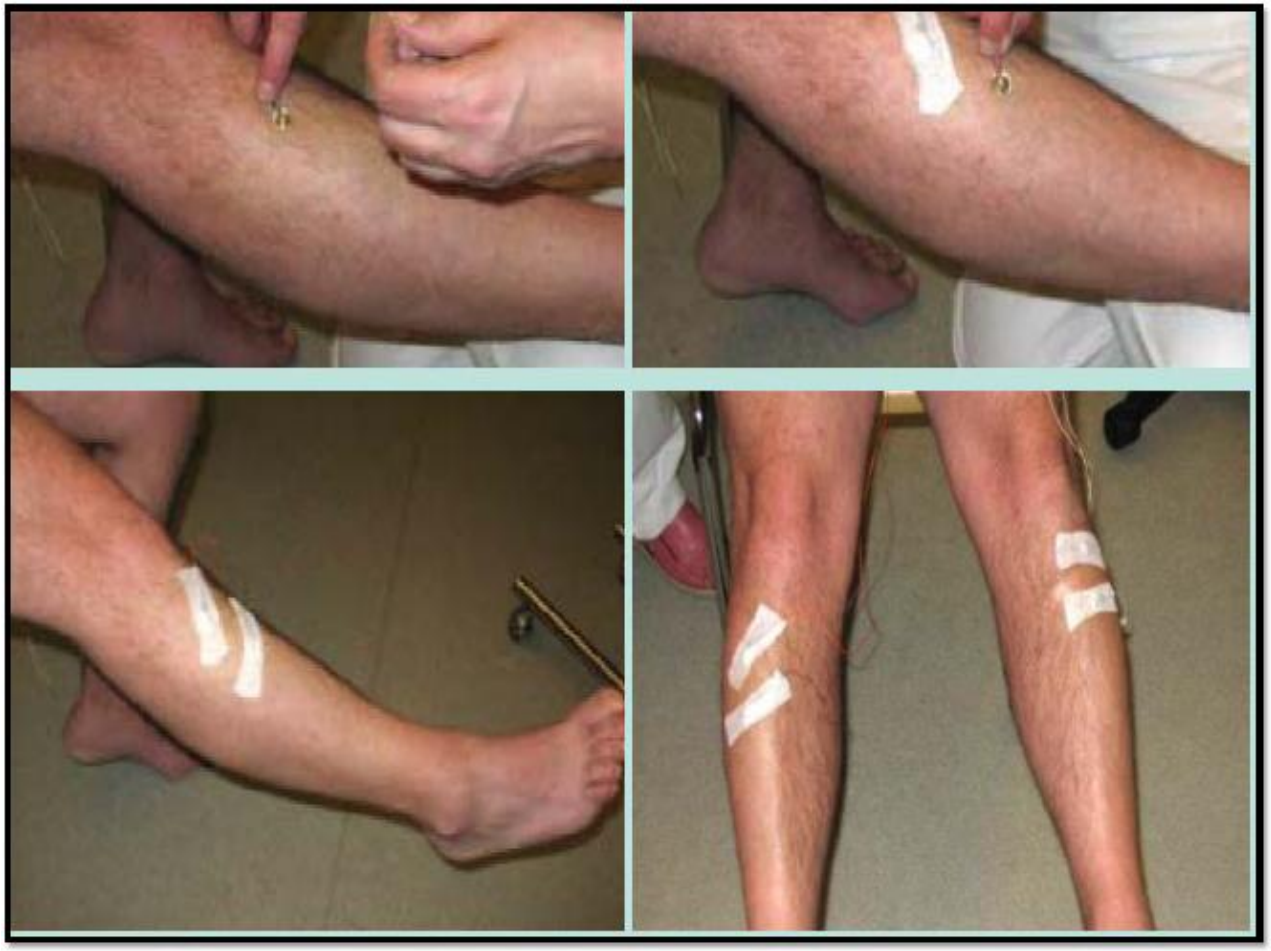


EMGsub (Electromyogram)

- **The EMGsub is recorded by surface electrodes placed 2 cm below the inferior edge of the mandible and 2 cm to the right and left of the midline**

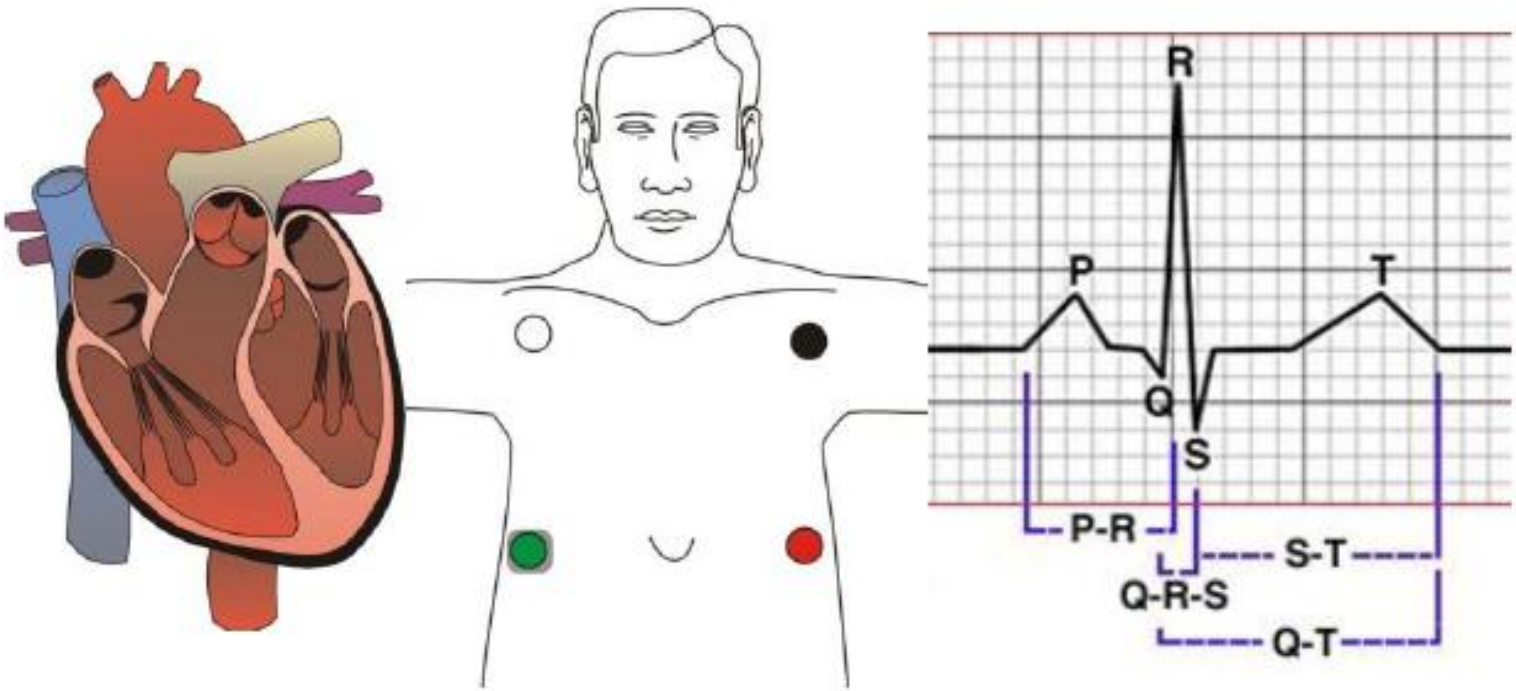


EMG TIBIALIS



Electrocardiogram (ECG)

Keeping track of the main pump.



Signals of Respiration

Applying Electrodes

Monitoring Airflow

- Pressure transducer (hypopnea)
- Thermistor (apnea)
- Pneumotachograph
- Expired carbon dioxide sensor

Pressure sensor

- **During Inspiration airway pressure is negative relative to atmospheric pressure and during expiration it is relatively positive**
- **The resulting alteration in nasal airway pressure can provide a surrogate estimate of airflow**
- **These devices are very sensitive to hypopneas or partial limitations of flow but do not differentiate between very low and absent air flow**

Thermistors

- **Exhaled air is warmer than ambient temperature**
- **Measuring temperature fluctuation in front of nares or mouth provides a simple measure of airflow**
- **Due to their high sensitivity, even slight air flow will produce a large amplitude deflection; thus, thermosensors are poor detectors of partial flow limitations**
- **–Advantage- Maximize sensing area while minimizing sensor size and mass**
- **–Used for defining apneas**

Thermistor

Monitoring Respiratory Effort

- Piezoelectric transducers
- Inductance plethysmography
- Respiratory EMG
- Pleural pressure
  - Catheter inserted in the distal portion of the oesophagus
  - Measures pleural pressure swings

Respiratory Effort (piezo crystal effort sensor)

- **Two Velcro bands, one placed around the chest under the breasts and one around the abdomen, serve to determine chest wall and abdominal movements during breathing.**
- **Each band is joined together by a piezo crystal transducer.**
- **The force of chest/abdominal expansion on the bands stretches the transducer and alters the signal to a physiological recorder.**

Respiratory Effort Sensors

Monitoring Gas Exchange

- **Pulse oximetry**
- **Transcutaneous oxygen**
- **Transcutaneous carbon dioxide**

Pulse Oxymeter

Position

- **Body position recording is done by body position sensors**
- **Important because many sleep related breathing disorders occur in one body position only.**

Biocalibration

- Close the eyes
- Open the eyes
- Move the eyes left and right
- Move the eyes up and down
- Cough
- Move the feet
- Hold breath
- Respiratory effort

Interpretation

- **Sleep staging**

Scoring of Sleep Stages in Adults

Stages of Sleep –

- Stage W
- Stage N1
- Stage N2
- Stage N3
- Stage R

Scoring by Epochs –

- Score sleep stages in 30 second sequential epochs commencing at the start of the study
- Assign a stage to each epoch
- If 2 or more stages coexist during a single epoch, assign the stage comprising the greatest portion of the epoch

Table 1—*Sleep Staging Requirements

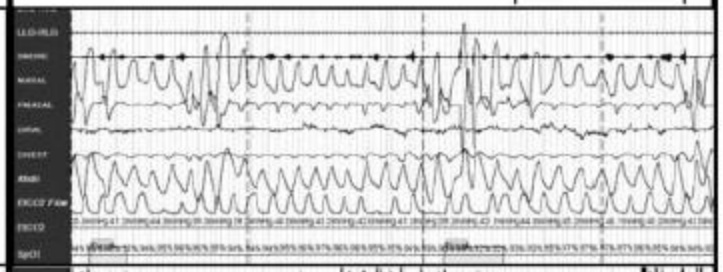
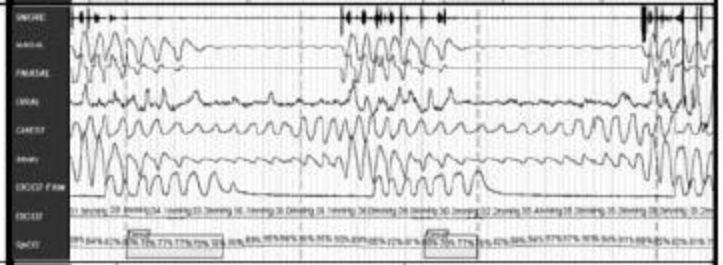
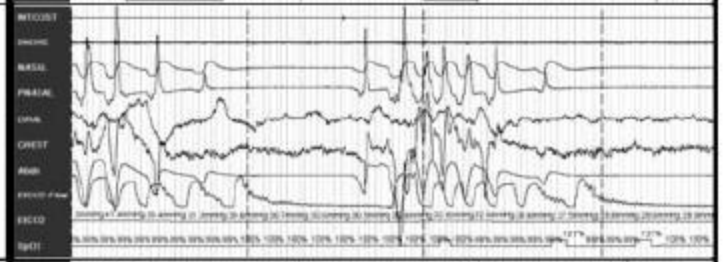
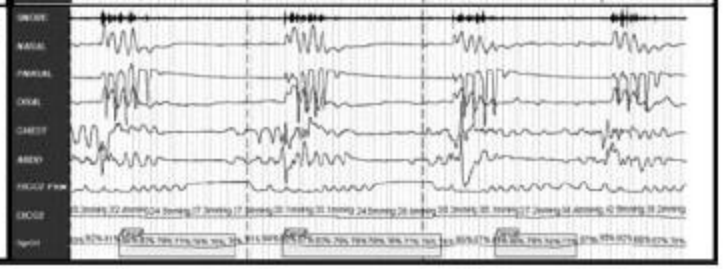
Stage	EEG Findings	Eye Movements (EOG)	EMGsub
W	**> 50% of an epoch has alpha rhythm over occipital region**	*Typically, no eye movements seen*	**Normal to high muscle tone**
N1	**Attenuation of alpha rhythm for > 50% of the epoch replaced with mixed frequency low-amplitude rhythm or a slowing of PDR from waking of ≥ 1 Hz if no alpha rhythm was noted**; *Vertex sharp waves*; N1 stage continues until beginning of N2 stage or arousal	*Slow, rolling eye movements typically*	*Variable, typically less than wake*
N2	**K complexes and/or sleep spindles occurring in the first half of an epoch**; *Low-amplitude, mixed frequency EEG*; N2 stage persists until transition to N3 stage, R stage, or an arousal	*Typically, no eye movements, but slow eye movements may persist*	*Variable amplitude, typically lower than W and higher than R*

N3†	**Slow-wave activity (0.5–2 Hz, > 75 μV) for > 20% of an epoch**; Sleep spindles may persist; N3 persists until transition to N2, R, or an arousal.	*Typically, no eye movements seen*	*Variable amplitude, typically lower than N2 and can be as low as R*
R	**Low-amplitude, mixed frequency EEG**; *Saw-tooth waves*; R persists until transition to N1, transition to N2, between K complexes without eye movements, or an arousal	**REMs**	**Low muscle tone**

RESPIRATORY EVENTS*

- **Apneas**
  - **Obstructive**
  - **Central**
  - **Mixed**
- **Hypopneas**
- **Respiratory Event Related Arousals (RERA)**
- **Hypoventilation**
- **Cheyne stokes breathing**
- **Periodic breathing**

*Iber C et al. ***The AASM manual for the scoring of sleep and associated events: rules, terminology and technical specifications. 1st ed. Westchester, IL:American Academy of Sleep Medicine*, 2007**

Event	Scoring Rules	Examples
Hypopnea	Nasal pressure drop in baseline of ≥ 30% at least 10s in duration** with a ≥4% desaturation in Pox **or** ≥ 50% drop in nasal pressure from baseline at least 10s in duration with either a 3% desaturation or an associated arousal.	
Obstructive Apnea (OA)	Drop in peak thermal sensor by ≥90% from baseline, duration of 10 seconds, persistence of respiratory effort during event.	
Cental Apnea*	Score a central apnea if the event meets the criteria for OA with the exception of an absence of any inspiratory effort during the event. In children, events must be 20s duration or at least 2 missed breaths with an associated arousal or a ≥3% desaturation.	
Mixed Apnea	Score a mixed apnea if it meets the criteria for an OA where the initial portion of the event shows an absence of inspiratory effort, and there is a resumption of effort during the second portion of the event.	

APNOEA HYPOPNOEA INDEX

- **AHI is derived from the total number of apneas and hypopneas divided by total sleep time**

- **Recent recommendations for cutoffs are as follows:**
  - **Mild: AHI = 5-15 per hour**
  - **Moderate: AHI = 16-30 per hour**
  - **Severe: AHI > 30 per hour**

RESPIRATORY EFFORT RELATED AROUSAL (RERA)

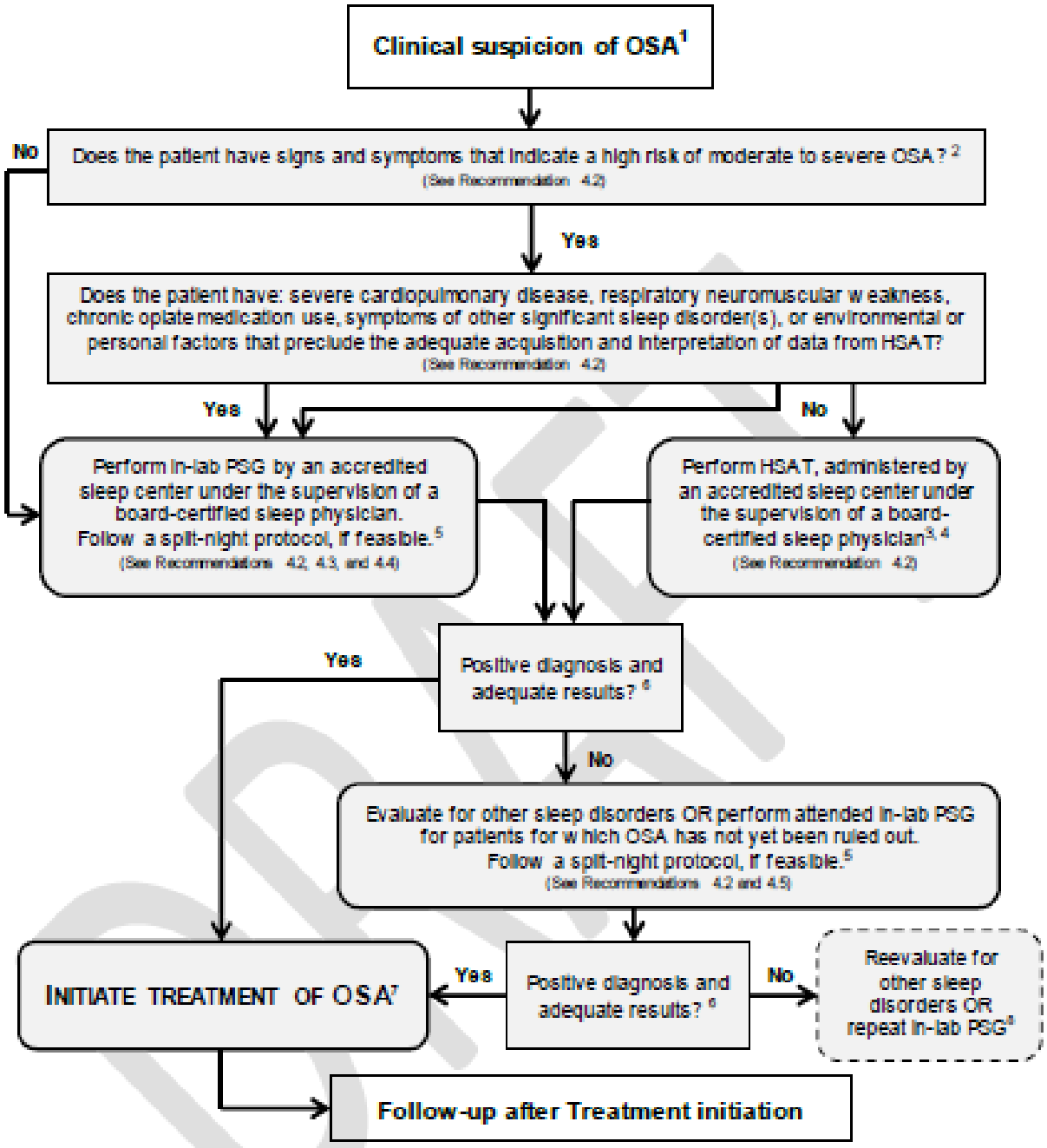
- **A respiratory effort-related arousal (RERA) is an event characterized by increasing respiratory effort for ≥ 10 s leading to an arousal from sleep but which does not fulfill the criteria for a hypopnea or apnea**

Post-test questionnaire-

- This is given in the morning after the study. Questions that are included in this are-
- How long did it take for you to fall asleep last night?
- How many times do you remember waking up last night?
- How did your sleep during the study compare with your normal night's sleep?
- How many hours do you feel you slept last night?
- The patient is now discharged after the study

Types of Reports

- **Diagnostic Report**
- **Titration Report**
- **Split Night Report**
- **MSLT Report**


Clinical suspicion of OSA[1]
No
Does the patient have signs and symptoms that indicate a high risk of moderate to severe OSA? [2]
(See Recommendation 4.2)
Yes
Does the patient have: severe cardiopulmonary disease, respiratory neuromuscular weakness, chronic opiate medication use, symptoms of other significant sleep disorder(s), or environmental or personal factors that preclude the adequate acquisition and interpretation of data from HSAT?
(See Recommendation 4.2)
Yes
No
Perform In-lab PSG by an accredited sleep center under the supervision of a board-certified sleep physician. Follow a split-night protocol, if feasible.[5]
(See Recommendations 4.2, 4.3, and 4.4)
Perform HSAT, administered by an accredited sleep center under the supervision of a board-certified sleep physician[3, 4]
(See Recommendation 4.2)
Yes
Positive diagnosis and adequate results? [4]
No
Evaluate for other sleep disorders OR perform attended In-lab PSG for patients for which OSA has not yet been ruled out. Follow a split-night protocol, if feasible.[5]
(See Recommendations 4.2 and 4.5)
INITIATE TREATMENT OF OSA[7]
Yes
Positive diagnosis and adequate results? [6]
No
Reevaluate for other sleep disorders OR repeat In-lab PSG[8]
Follow-up after Treatment initiation

Thank you