Basics in Polysomnography

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Polysomnography (PSG)

- **수면다원검사**

- 수면 중에 여러 가지 수면 관련 신호를 기록
  - 뇌파, 안전도, 근전도 등의 신경생리, 심장 및 호흡기, 기타 생리적, 신체적 변수들

→ 수면의 단계와 각성 빈도를 결정하여 수면의 질을 평가

→ 수면 중 신체 전반의 문제를 진단하는 검사

Contents

- Indication for PSG
- Parameters of PSG
- Terminology of Sleep Architecture
- Interpretation of PSG Report

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Indication for PSG

- **Diagnostic PSG**
  - Diagnosis of suspected sleep-related breathing disorders (OSA, CSA)
  - Repeat PSG is indicated if the initial PSG was negative
    + high clinical suspicion for OSA
  - Preoperative PSG before planned surgery for snoring or OSA
  - Evaluation of suspected narcolepsy (in combination with MSLT)
  - Evaluation of suspected periodic limb movement disorder (but *not* restless legs syndrome)

Indication for PSG

- **Diagnostic PSG**
  - Evaluation of suspected **complicated** parasomnia
    - Nocturnal behavior possibly caused by seizures
    - Atypical parasomnia behavior (frequent episodes each night, stereotypical behavior, or behavior unusual for age)
    - Nocturnal behavior or parasomnia that has resulted in injury to the patient or others (or has the potential to do so)
    - Presumed parasomnia or nocturnal seizure disorder that does not respond to conventional treatment
    - Legal or forensic implications of nocturnal behavior

Indication for PSG

- **PAP Titration (PSG on PAP)**
  - Patients
    - AHI > 15/hour (hr) with or without symptoms
    - AHI ≥ 5/hr with symptoms or comorbidities
  - Full night of PSG titration
  - Split
    - AHI > 40 during 2 hours of monitoring in the initial diagnostic portion
    - AHI 20–40 special clinical circumstances (long apnea or severe desaturation)
    - 3 hours remain for PAP titration
    - Repeat PSG for PAP titration if inadequate PAP titration portion of study

Indication for PSG

- **Follow-up PSG**
  - After surgery for moderate to severe OSA
    - usually 3–6 months after surgery
  - After previous surgery for OSA if symptoms return
  - After adequate adjustment of oral appliance for OSA (all severities)

- **Repeat PSG (Diagnosis or PAP Titration)**
  - After ≥ 10% weight loss in patient on CPAP (PSG without CPAP) to determine if CPAP still needed
  - After ≥ 10% weight gain to determine whether CPAP is adequate
  - Clinical symptoms return in patient on CPAP (consider MSLT if narcolepsy suspected)
  - Clinical symptoms return after surgery for OSA or on OA treatment for OSA

수면다원검사 급여기준

- 1. 수면다원검사는 다음의 모든 조건에 해당되는 경우에 요양급여를 인정하며, 이를 충족하지 않는 경우에는 비급여로 함.
  - 가. 급여대상
  - 나. 검사항목
  - 다. 시설기준
  - 라. 실시 인력 기준

급여대상

- 1) 수면무호흡증
  - 아래의 가),나) 또는 가),다)의 조건을 만족하는 경우

    - 가) 주간졸림증(daytime sleepiness)·빈번한 코골이 (habitual snoring)·수면무호흡·피로감 (nonrestorative sleep)· 수면 중 숨막힘·잦은 뒤척임·수면 중 잦은 각성 등 하나 이상의 증상이 있는 경우

급여대상

- 1) 수면무호흡증
  - 아래의 가),나) 또는 가),다)의 조건을 만족하는 경우

  - 나) **신체검진상 후두 기관내 삽관 시 어려움의 평가 (Modified Mallampatti score) grade 3** 이상

    또는 Friedman 병기분류에 따른 편도 크기(Tonsil size) grade 2~3 이상
    ※ 만13세 미만 연령의 경우는 grade 3 이상,
    만13세 이상 연령의 경우는 grade 2 이상 적용

    또는 내시경검사를 이용한 Muller maneuver상 상기도 폐쇄의 소견이 확인될 경우

The Modified Mallampati Classification

급여대상

- 1) 수면무호흡증
  - 아래의 가),나) 또는 가),다)의 조건을 만족하는 경우

  - 나) 신체검진상 후두 기관내 삽관 시 어려움의 평가 (Modified Mallampatti score) grade 3 이상

    또는 **Friedman 병기분류에 따른 편도 크기(Tonsil size) grade 2~3** 이상
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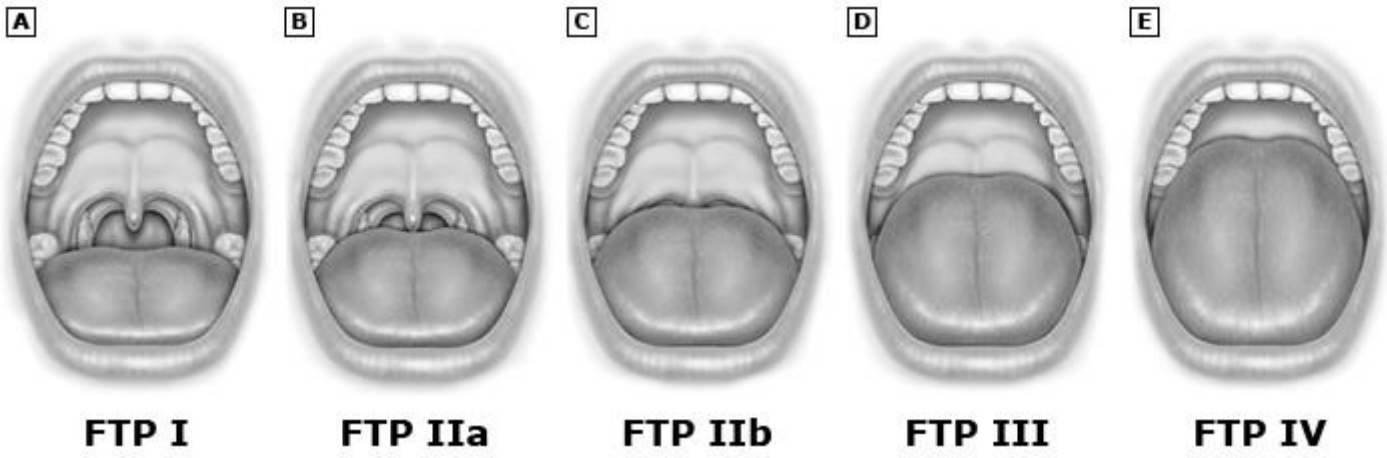
Friedman tongue position



급여대상

- 1) 수면무호흡증
  - 아래의 가),나) 또는 가),다)의 조건을 만족하는 경우

    - 다) 고혈압·심장질환·뇌혈관질환 또는 당뇨 기왕력이 있거나 체질량지수(BMI)가 30 kg/m^2이상인 경우

급여대상

- 2) 기면증 또는 특발성 과다수면증
  - 아래의 가),나) 또는 가),다)의 조건을 만족하는 경우

    - **가) 웹워스 졸음증 척도(Epworth Sleepiness Scale) 10** 이상
    - 나) 과도한 주간졸림증이 있고, 허탈발작이 동반될 때 (narcolepsy with cataplexy)
    - 다) 하루에 7시간 충분히 잠을 자도, 과도한 주간졸림증이 3개월 이상 지속되어 일상생활에 불편을 초래할 때 (narcolepsy without cataplexy or idiopathic hypersomnia)

TABLE 1. *The Epworth sleepiness scale*

THE EPWORTH SLEEPINESS SCALE

Name: _____
Today's date: _____ Your age (years): _____
Your sex (male = M; female = F): _____

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the *most appropriate number* for each situation:

0 = would *never* doze
1 = *slight* chance of dozing
2 = *moderate* change of dozing
3 = *high* chance of dozing

Situation	Chance of dozing
Sitting and reading	
Watching TV	
Sitting, inactive in a public place (e.g. a theater or a meeting)	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after a lunch without alcohol	
In a car, while stopped for a few minutes in the traffic	

Thank you for your cooperation

급여대상

- 2) 기면증 또는 특발성 과다수면증
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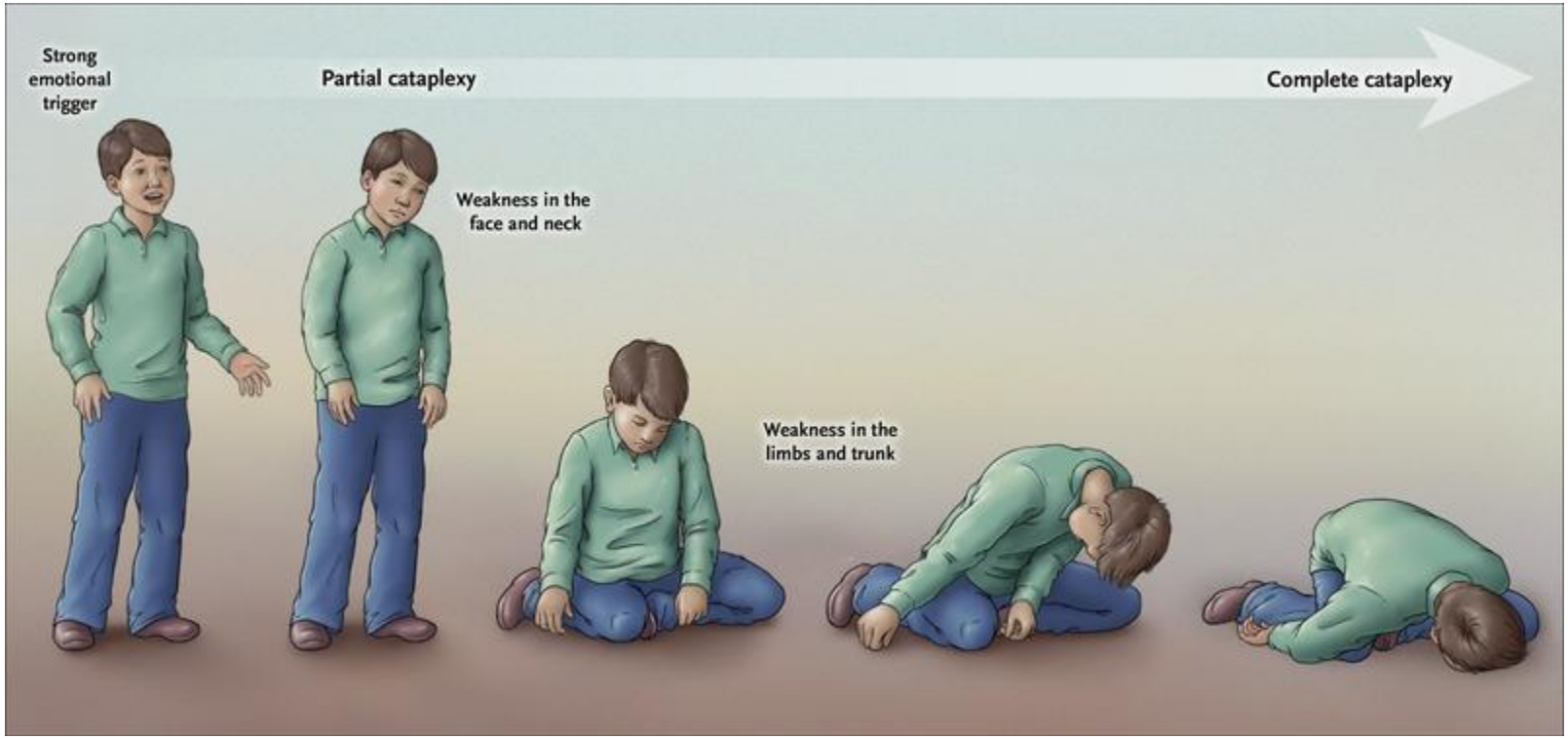

N Engl J Med 2015; 373:2654-2662

급여대상

- 2) 기면증 또는 특발성 과다수면증
  - 아래의 가),나) 또는 가),다)의 조건을 만족하는 경우

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검사항목

- 뇌파(EEG), 안전도(EOG), 근전도-턱(EMG-submental), 심전도(ECG), 호흡기류(Airflow), 호흡노력(Respiratory effort), 산소포화도(SaO2), 체위감시(Body position), 하지근전도(EMG-ant.tibialis)를 모두 포함하여 실시하여야 함

시설기준

- 수면평가장치(Polysomnograph), 검사 조정실(Control Room), 적외선카메라, 검사 중 검사대상자와 검사자가 연락할 수 있는 연락장치, 검사대상자에 부착된 센서와 연결되는 신호 전환 장치 등이 설치된 환자별로 **독립된 수면검사실**을 갖추고 시행해야 함.

- 또한, 검사 중 환자에 대한 기본처치 및 응급 상황시 심폐소생술 등이 가능하여야 함.


2
검사실
Room 2
1
검사실
Room 1


N1
N1
N1

실시 인력기준

- 보건복지부장관이 인정하는 **수면다원검사 정도관리위원회**에서 정한 기준을 충족한 전문의가 시행(검사 결과에 대한 해석・판독 포함)한 경우에 인정하며, 수면다원검사를 실시하는 요양기관은 해당 인력에 대한 변동사항이 있을 경우 지체 없이 이를 건강보험심사평가원에 제출하여야 함.

수면다원검사 인정횟수

- 가. 진단시: 1회 인정
- 나. 진단 후 양압기 치료를 위해 적정압력을 측정하는 경우와 치료목적의 처치 또는 수술 후: 각각 1회씩 인정
- 다. 마지막 검사 시행 6개월 이후 환자상태의 급격한 변화로 임상적으로 필요한 경우에 사례별로 인정함.

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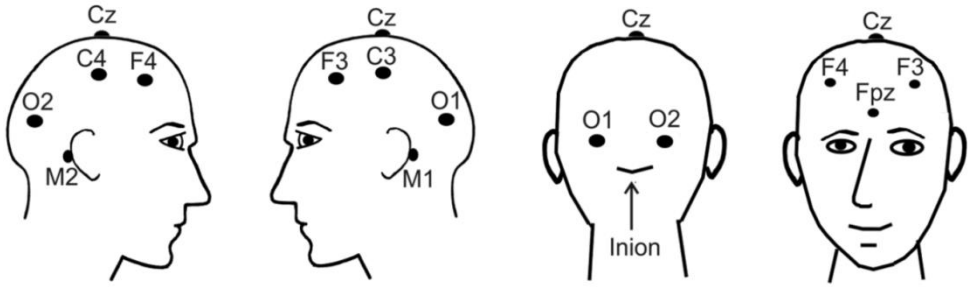
Parameters of PSG

Parameter	Sensors	Purpose
EEG derivations	F4-M1, C4-M1, O2-M1 (Frontal, central, occipital)	Staging of sleep
EOG derivations	E1-M2, E2-M2	
Chin EMG	Chin1, Chin2, ChinZ	
ECG	ECG	Cardiac rate and rhythm
Air flow (diagnostic study)	Nasal pressure	Detection of hypopnea
	Oronasal thermal flow	Detection of apnea
Air flow (PAP titration)	PAP device flow	Detection of apnea, hypopnea
Snoring	Microphone, piezoelectric sensor	Detection of snoring
Respiratory effort	Chest and abdominal RIP bands	Classify apneas as obstructive, mixed, or central
Arterial oxygen saturation (SpO_2)	Pulse oximetry	Detect arterial oxygen desaturation
Left anterior tibial (LAT) EMG	EMG surface electrodes	Detect periodic limb movements in sleep
Right anterior tibial (RAT) EMG	EMG surface electrodes	

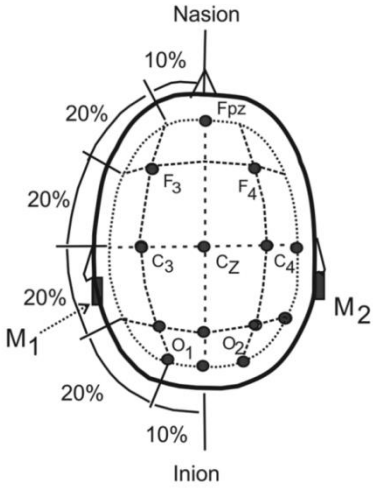
EEG

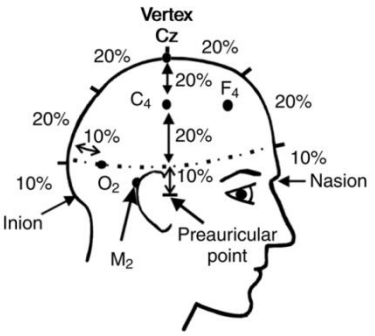
- Electroencephalography
- Sensors : F4-M1, C4-M1, O2-M1→ Staging of sleep



F Frontal
C Central
O Occipital

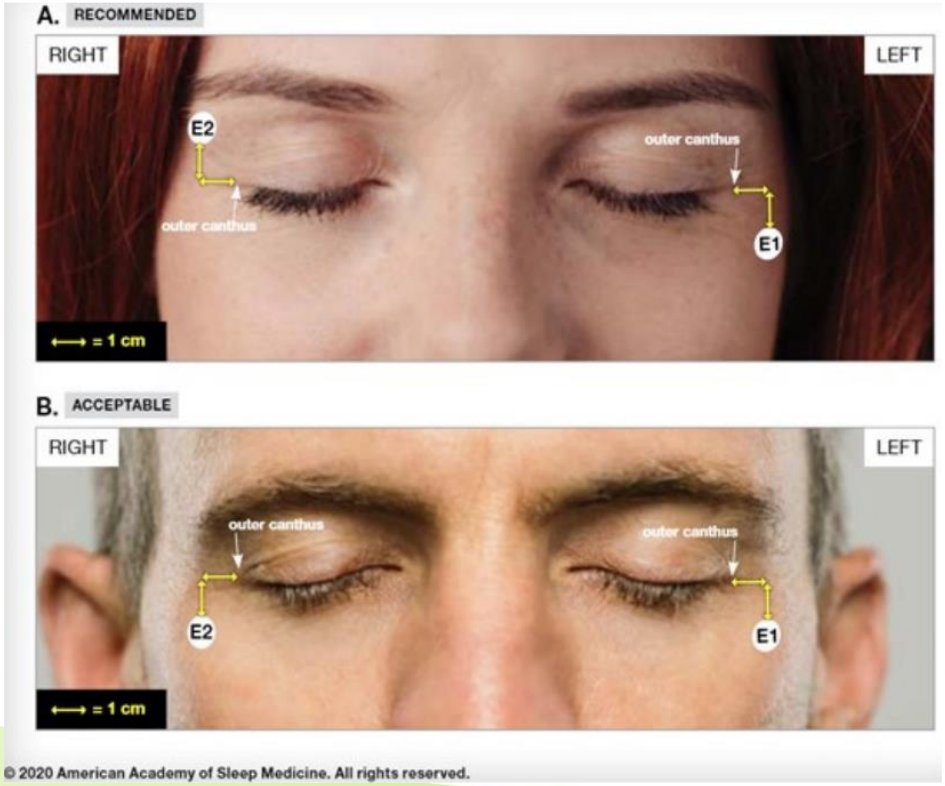
M Mastoid
Cz Central midline (vertex)
Fpz Frontopolar midline





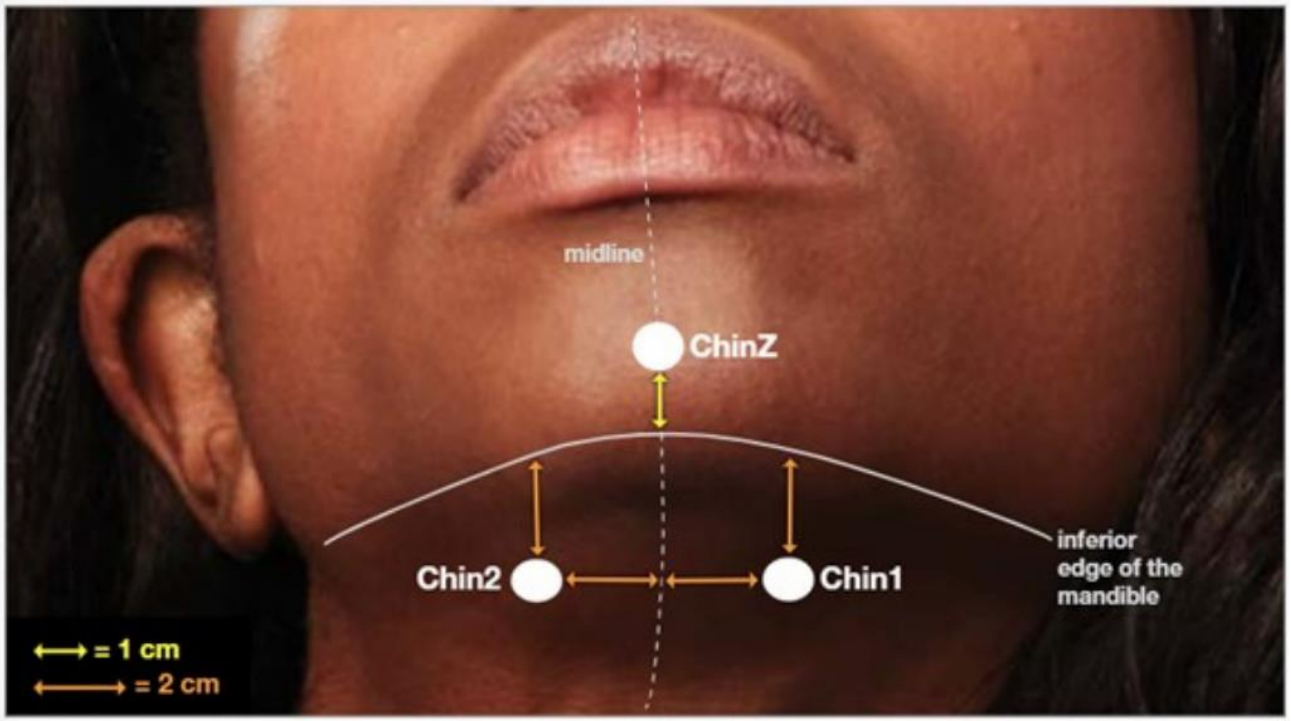
EOG

- Electrooculography
- Sensors : E1-M2, E2-M2



Chin EMG

- Submental Electromyography



ECG

- Electrocardiography → Cardiac rate & rhythm

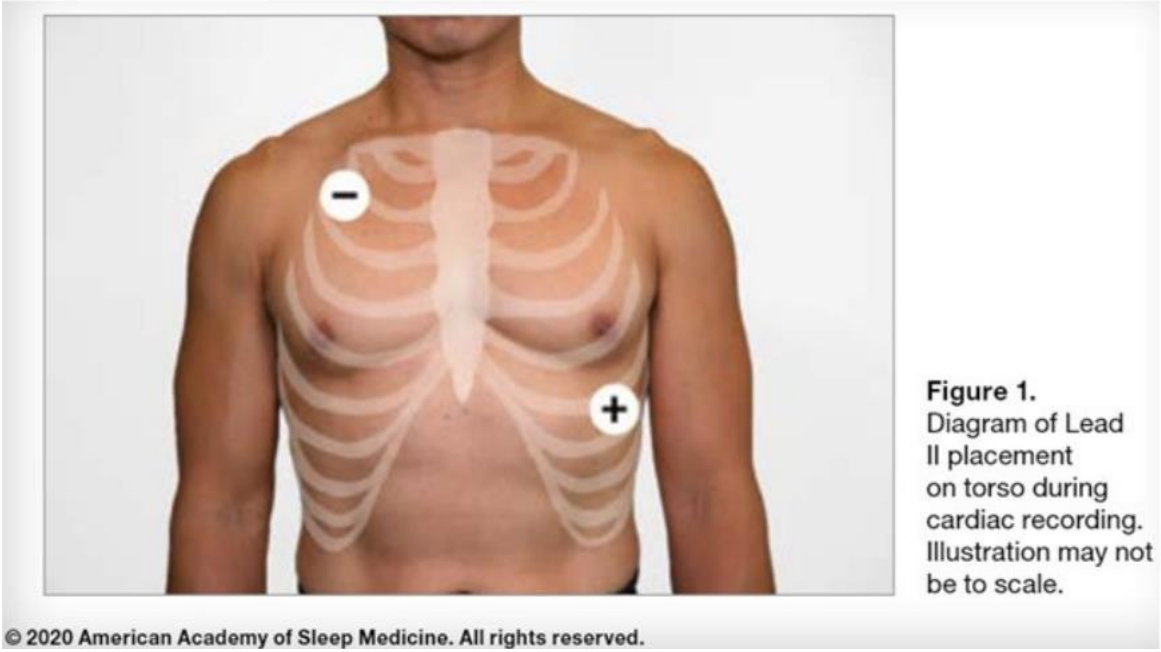
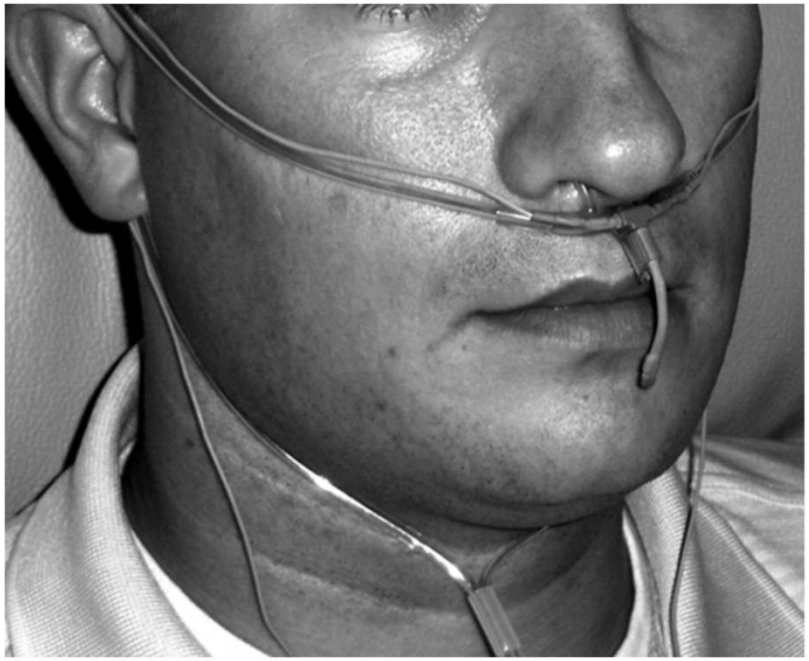


Figure 1. Diagram of Lead II placement on torso during cardiac recording. Illustration may not be to scale.

Air Flow

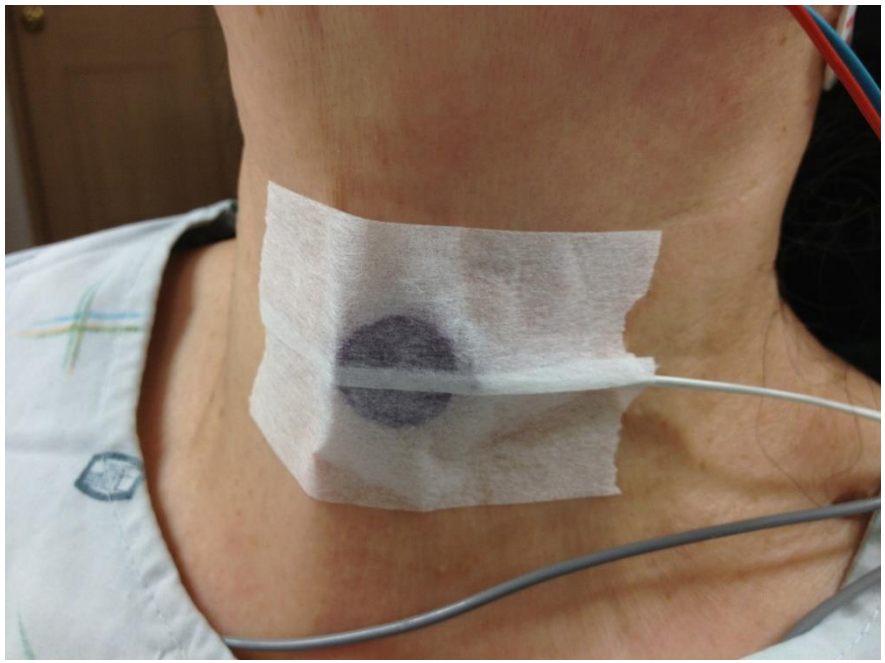
- Sensors
  - Nasal pressure → detection of hypopnea
  - Oronasal thermal flow → detection of apnea



Snoring

- Microphone, Piezoelectric sensors

→ detection of snoring

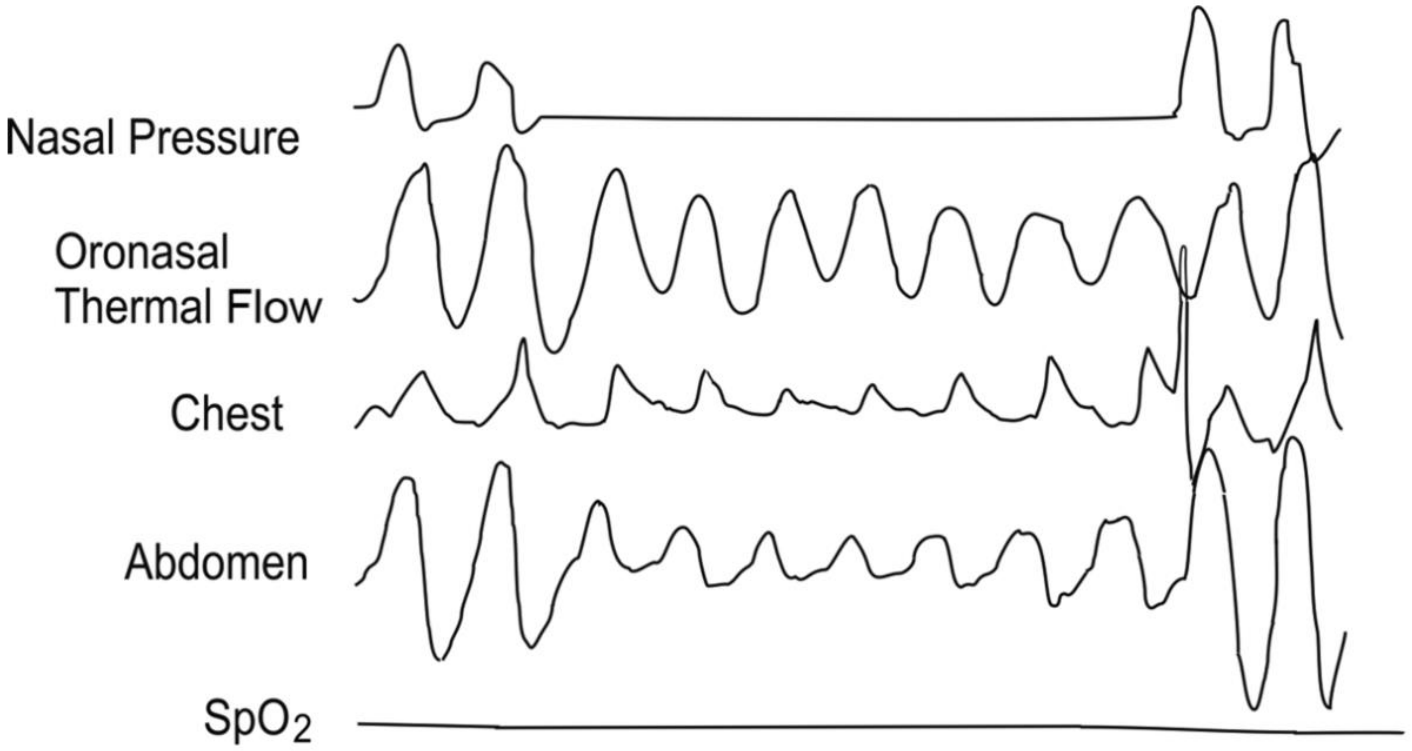


Respiratory Effort

- Chest & abdominal RIP (Respiratory Inductive Plethysmography) bands
  → Classify apnea as obstructive, mixed or central

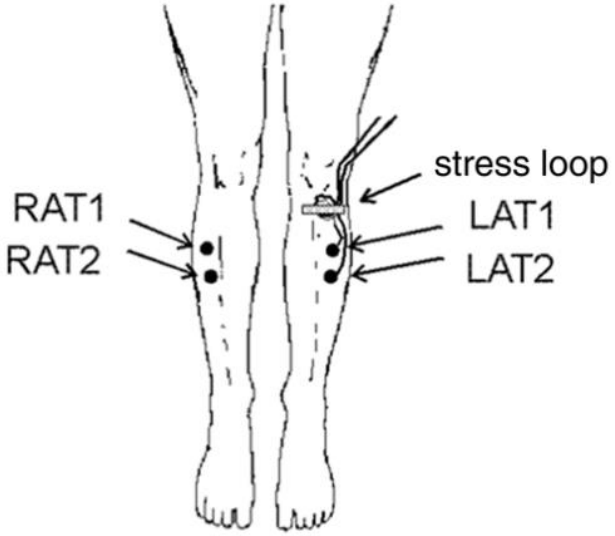
Arterial Oxygen Saturation

- Pulse oximetry → detect arterial oxygen desaturation



Anterior Tibial EMG

- Anterior Tibialis EMG (Electromyography)
  - Lt. & Rt. → detect periodic limb movements in sleep




Natus SleepWorks - [Review: Kim JaeYun 6872010 Time of day:06/11/2019 00:36:59 20 uV/mm 30 sec/page]
File Edit View Trace Montage Events Analysis Window Help
Snoring (F1) Wake (F2) Leg Movement (F3) Artifact (F4) Toilet (F5) Sit Up (F6) Bruxism (F7) Taking (F8) Mumbing (F9) Seizure (F10) Custom...
Type EMG LFF 10 Hz HFF 70 Hz Notch 60 Hz Sensitivity 20 uV/mm Timebase 30 sec/page
Epoch Speed: 1.0
F3 - A2
F4 - A1
C3 - A2
C4 - A1
O1 - A2
O2 - A1
LOC - A2
ROC - A1
Chin1 - Chin2
Snore - Snore1
Airflow - Airflow1 breaths/min
PTAF
Chest - Chest1
ABD - ABD1
LAT1 - LAT2
RAT1 - RAT2
EKG1 - EKG2
Body Left
SpO2 98 %
HR 60 beats/min
EEG
EOG
Chin EMG
Snoring
Airflow
Respiratory Effort
Anterior Tibialis EMG
98.0/98.0
Kim JaeYun 6872010 Age: 67 y AHI-START: 0.0 evt/h AHI-LCPAP: 0.0 evt/h OSat: 98 %

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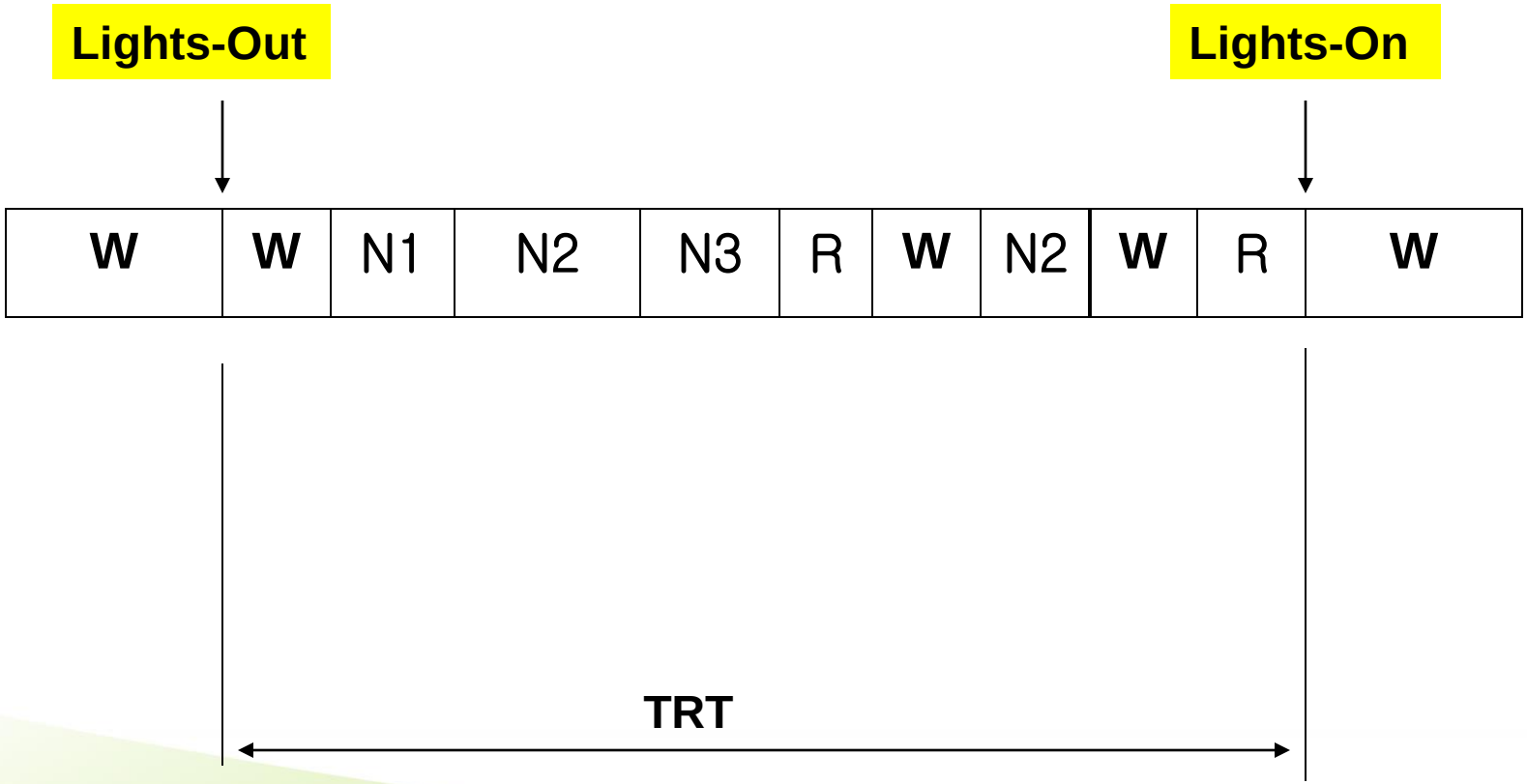
PSG Reports

Term	Abbreviation	Definition
Lights-out time (hr : min)	LOUT	Time of the start of the recording.
Lights-on time (hr : min)	LON	Time of the end of the recording.
Total recording time (min)	TRT	Time from lights-out to lights-on. TRT = SL + WASO + TST
Total sleep time (min)	TST	Time spent in stages N1, N2, N3, and R.
Sleep latency (min)	SL	Time from lights-out until the start of the first epoch of sleep (stages N1, N2, N3, or R).
Stage R latency or (REM latency) (min)	RL	Time from start of first epoch of sleep until the start of the first epoch of stage R.
Sleep efficiency (%)		= TST × 100/TRT.
Stage wake (min)	Stage W	All minutes of stage W during TRT.
Wake after sleep onset	WASO	Stage W recorded after sleep onset until lights-on time. = Stage W - SL
Time in each sleep stage (min)	N1, N2, N3, R	Minutes of stages N1, N2, N3, R.
Time in each sleep stage as a % of TST	N1%TST, etc.	Minutes or each sleep stage × 100/TST.
Arousal (number)	Ar#	Total number of arousals.
Arousal index (#/hr)	ArI	Total number of arousals × 60/TST (min).

Sleep Architecture Terminology

- **Lights-out time (hr : min)**
  - Time of the start of the recording
- **Lights-on time (hr : min)**
  - Time of the end of the recording
- **Total recording time (TRT, min)**
  - Time from lights-out to lights-on
  - TRT = SL + WASO + TST

Sleep Architecture Terminology



Sleep Architecture Terminology

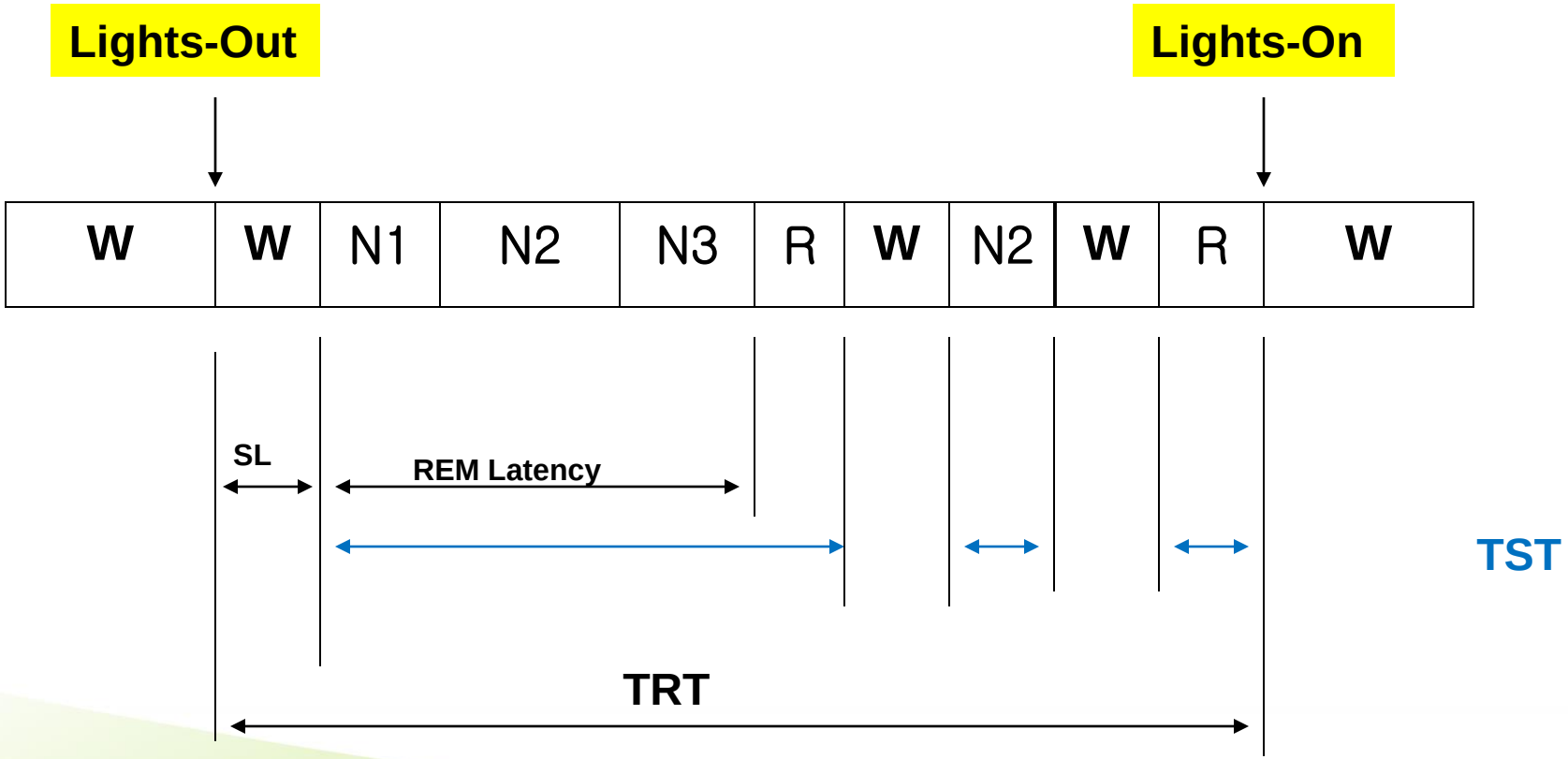
- **Total sleep time (TST, min)**
  - Time spent in stages N1, N2, N3, & R
- **Sleep latency (SL, min)**
  - Time from lights-out until the start of the first epoch of sleep (stages N1, N2, N3, or R)
- **Stage R latency or REM latency (RL, min)**
  - Time from start of first epoch of sleep until the start of the first epoch of stage R

TABLE F1-2 Optimal Window Duration for Viewing Events in Polysomnography

Window Duration	Use
30 seconds (an epoch)	Sleep staging
60–120 seconds	Respiratory Events
15 seconds	Clinical EEG
10 seconds	ECG rhythms Identifying wave form frequency

ECG, Electrocardiography; *EEG*, electroencephalography.

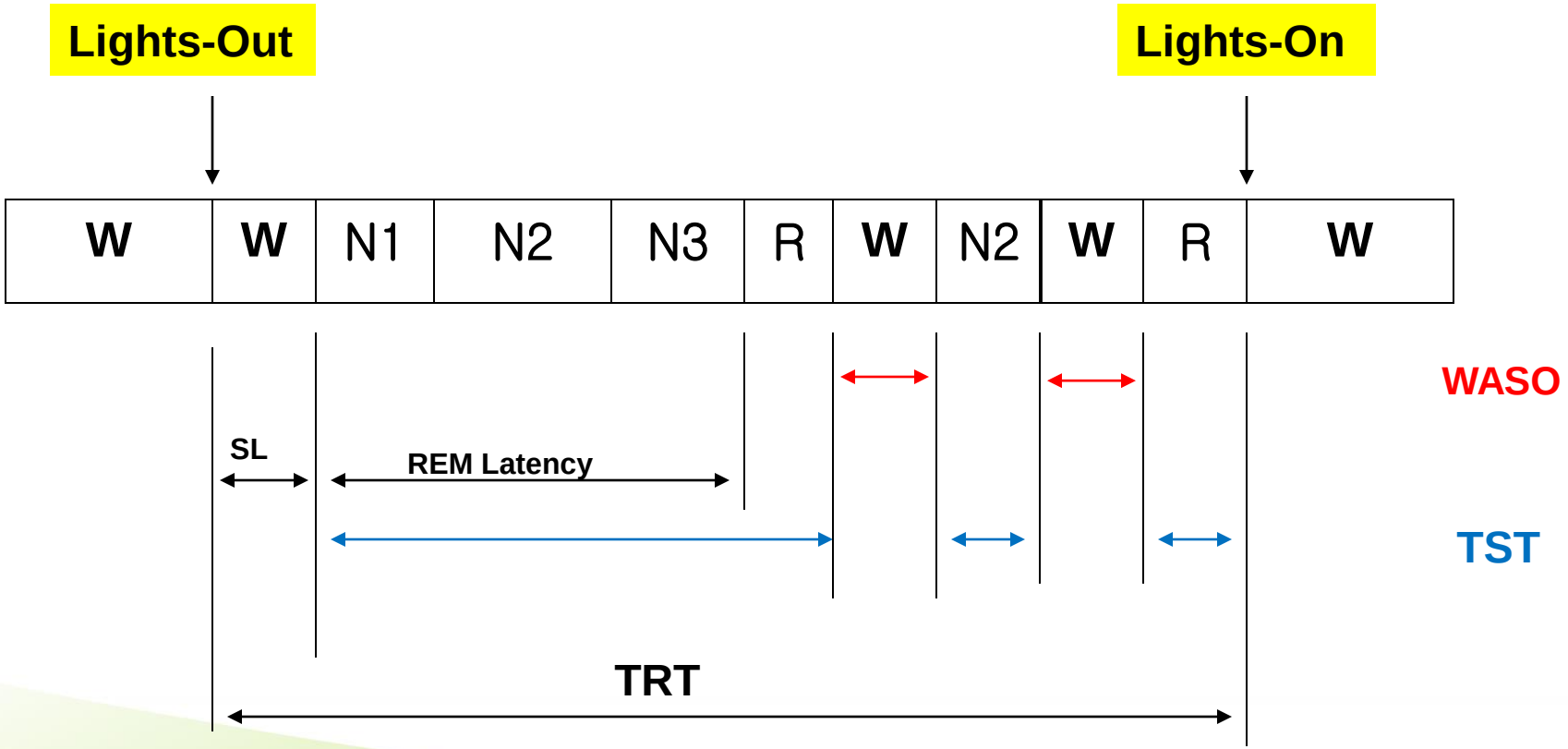
Sleep Architecture Terminology



Sleep Architecture Terminology

- **Sleep efficiency (%)**
  - TST (Total Sleep Time) × 100/TRT (Total Recording Time)
- **Stage wake (Stage W, min)**
  - All minutes of stage W during TRT
- **Wake after sleep onset (WASO)**
  - Stage W recorded after sleep onset until lights-on time
  - Stage W - SL

Sleep Architecture Terminology



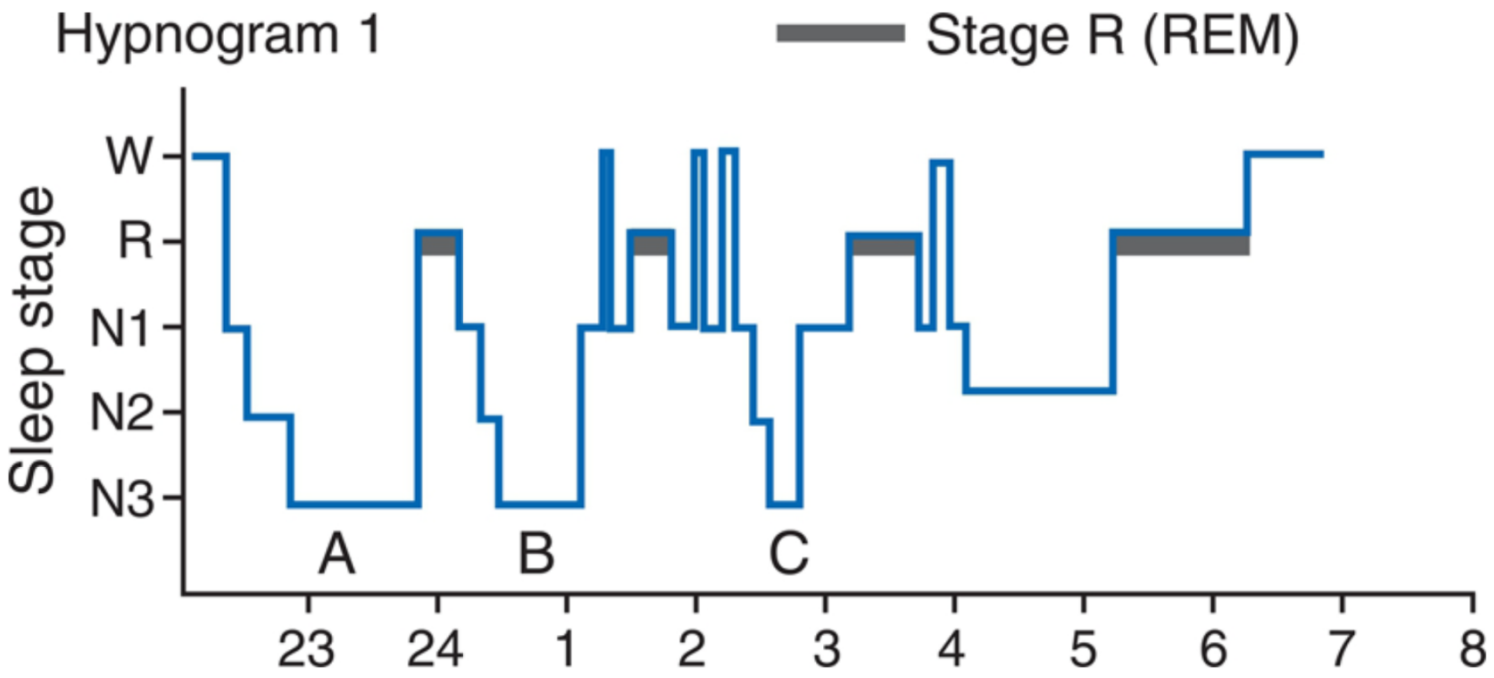
Sleep Stage

- Sleep
  - NREM (non-rapid eye movement)
  - REM (rapid eye movement)

	R&K	AASM
Wake	Stage W	Stage W
NREM	Stage 1	Stage N1
	Stage 2	Stage N2
	Stage 3	Stage N3
	Stage 4	
REM	Stage REM	Stage R

AASM, American Academy of Sleep Medicine; *NREM*, non–rapid eye movement; *REM*, rapid eye movement; *R&K*, Rechtschaffen and Kales.

Normal sleep



Sleep Architecture Terminology

- **Time in each sleep stage (min)**
  - Minutes of stages N1, N2, N3, R
- **Time in each sleep stage as a % of TST**
  - Minutes or each sleep stage × 100/TST
- **Arousal index (ArI, #/hr)**
  - Total number of arousals × 60/TST (min)

Sleep Stage Characteristics

	EEG	EOG	Chin EMG
Stage W (eyes open)	Alpha + beta	REMs, blinks, reading EM	Relatively high
Stage W (eyes closed)	> 50% alpha	± SEMs	Variable
Stage N1	< 50% alpha > 50% LAMF	± SEMs	Variable, usually < wake
Stage N2	SS, KC*	None	Variable
Stage N3	SWA ≥ 20% (6 sec) SS may occur	None	Variable
Stage R	LAMF, no SS or KC	REMs*	Lowest of night

KC, K complex; *LAMF,* low amplitude mixed frequency; *REM,* rapid eye movement; *Reading EM,* reading eye movements; ±, may or may not be present; *SS,* sleep spindle; *SEM,* slow eye movement; *SWA,* slow wave activity.

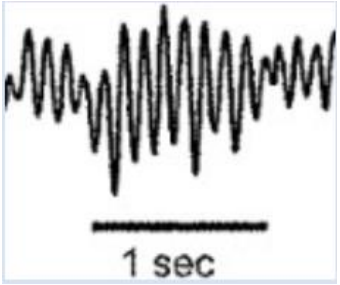
Wave Forms for Sleep Staging

- **EEG activity**
  - frequency in cycles per second (hertz [Hz])
    - delta (0–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), & beta (> 13 Hz)
  - amplitude (microvolts [μV])
  - shape

    - Alpha Activity (Alpha Rhythm)
    - Sleep spindle (SS)
    - K- complex (KC)
    - Slow Waves (Slow Wave Activity [SWA])

Alpha Activity (Alpha Rhythm)

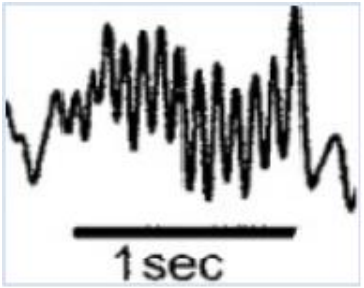
- 8–13 hertz (Hz)
- Most prominent over the occipital areas



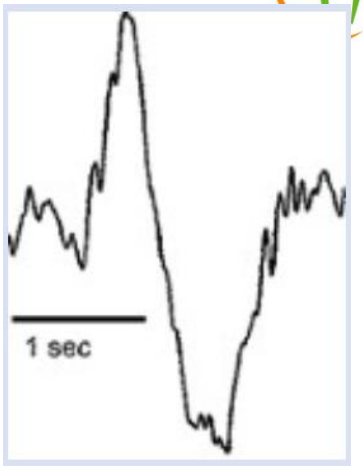
- increased by eye closure & attenuated by eye opening
  - Characteristic EEG activity in drowsy, eyes-closed stage W
  - Common in REM sleep (1–2 Hz slower than during stage W)
  - May occur with arousals (brief awakenings)
  - 10% of persons do not produce alpha rhythm with eye closure

Sleep Spindle

- 11–16 Hz (classically 12–14 Hz)
- Maximal over central areas
- Duration ≥ 0.5 sec (0.5–1.5 sec)
- One of the defining characteristics of stage N2
- May be seen in stage N3 sleep



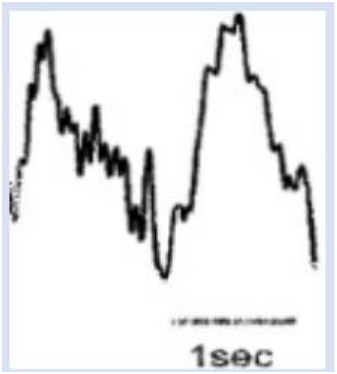
K- complex (KC)



- High amplitude – biphasic deflection
  - A well-delineated negative sharp wave (upward) followed by a positive (downward) slow wave
- Maximal over frontal areas (frontal > central > occipital)
- Duration ≥ 0.5 sec
- characteristic of stage N2 sleep

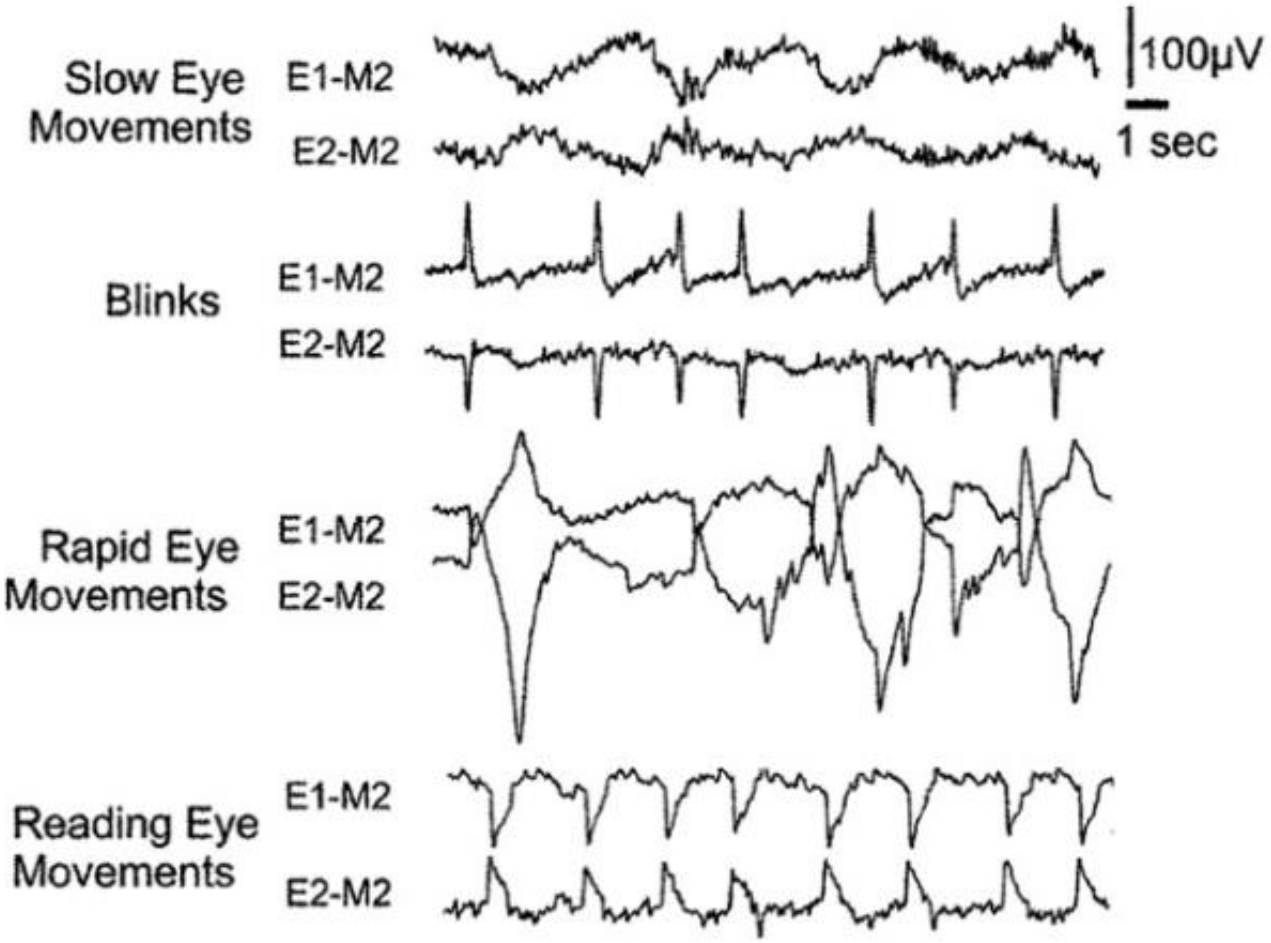
Slow Waves (Slow Wave Activity [SWA])

- Frequency 0.5–2 Hz & > 75 microvolts (μV) peak-to-peak amplitude in the frontal derivations



- Used to define stage N3 sleep
  - Stage N2 < 20% SWA (< 6 sec)
  - Stage N3 ≥ 20% SWA (≥ 6 sec)

Eye movement patterns



Eye movement patterns

- **Slow eye movements**
  - Conjugate, fairly regular, sinusoidal eye movements
  - With an initial deflection lasting > 500 msec

- **Eye blinks**
  - Conjugate vertical eye movements at a frequency of 0.5 to 2 Hz
  - Present in wakefulness with the eyes open or closed

Eye movement patterns

- **Rapid eye movements (REM)**
  - Conjugate, irregular, sharply peaked eye movements
  - With an initial deflection usually lasting < 500 msec

- **Reading eye movements**
  - Trains of conjugate eye movements
  - Consist of a slow phase followed by a rapid phase in the opposite direction as the subject reads

Sleep Stage Characteristics

	EEG	EOG	Chin EMG
Stage W (eyes open)	Alpha + beta	REMs, blinks, reading EM	Relatively high
Stage W (eyes closed)	> 50% alpha	± SEMs	Variable
Stage N1	< 50% alpha > 50% LAMF	± SEMs	Variable, usually < wake
Stage N2	SS, KC*	None	Variable
Stage N3	SWA ≥ 20% (6 sec) SS may occur	None	Variable
Stage R	LAMF, no SS or KC	REMs*	Lowest of night

KC, K complex; *LAMF,* low amplitude mixed frequency; *REM,* rapid eye movement; *Reading EM,* reading eye movements; ±, may or may not be present; *SS,* sleep spindle; *SEM,* slow eye movement; *SWA,* slow wave activity.

Typical Sleep Architecture in Men

	Age 20	Age 60
Total sleep time (TST; min)	450	380 ↓
Sleep efficiency (%)	95	85 ↓
Sleep latency (min)	10	15 ↑
REM latency (min)	90	70 ↓
Wake after sleep onset (WASO) (min)	15	30 ↑
Stage N1 (%TST)	5	15 ↑
Stage N2 (%TST)	45	55 ↑
Stage N3 (%TST)	20	10 ↓
Stage R (%TST)	25	20 ↓
Arousal index (#/hour)	5–10	15–20 ↑

Respiratory Events

- **Apnea**
- **Hypopnea**
- **Respiratory Effort–Related Arousal (RERA)**

Apnea

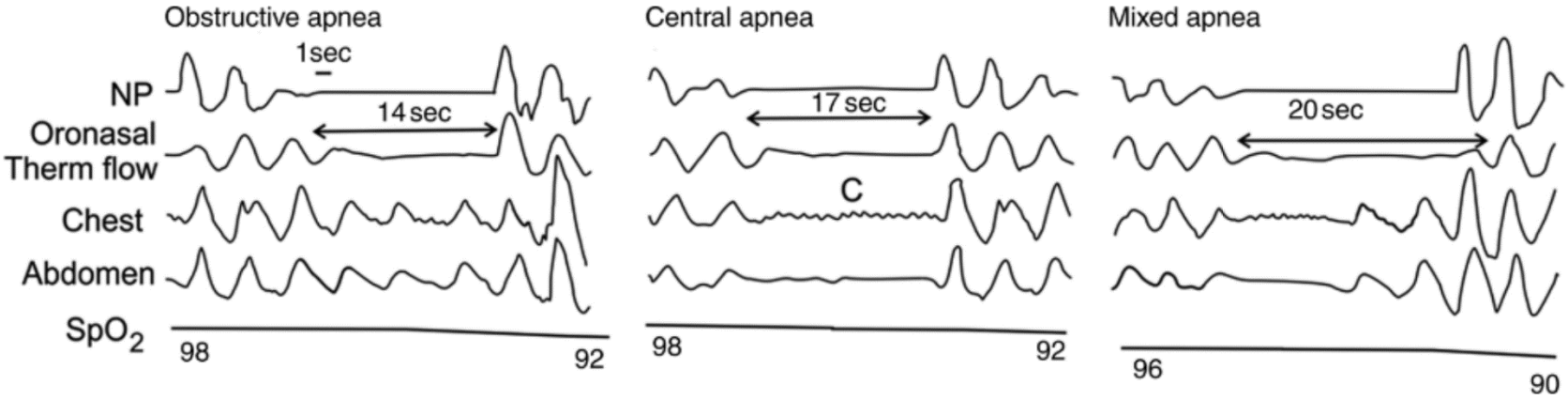
1) Drop in the peak signal excursion by ≥ 90% of baseline
   - Oronasal thermal sensor (diagnostic study)
   - PAP device flow (titration study)
   - an alternative apnea sensor (diagnostic study)

2) ≥ 10 seconds

not have to be associated with arterial oxygen desaturation

Classification of Apneas

- **Obstructive**
  - meets apnea criteria
  - continued or increased inspiratory effort throughout the entire period of absent air flow
- **Central**
  - meets apnea criteria
  - absent inspiratory effort throughout the entire period of absent air flow
- **Mixed**
  - meets apnea criteria
  - absent inspiratory effort in the initial portion of the event, followed by resumption of inspiratory effort in the second portion of the event


Obstructive apnea
1sec
14 sec
NP
Oronasal
Therm flow
Chest
Abdomen
SpO2
98
92
Central apnea
17 sec
C
98
92
Mixed apnea
20 sec
96
90

Hypopnea

1) Drop in the peak signal excursions by ≥ 30% of pre-event baseline
   - nasal pressure (diagnostic study)
   - PAP device flow (titration study)
   - an alternative hypopnea sensor (diagnostic study)

2) ≥ 10 seconds

3) ≥ 3% oxygen desaturation from pre-event baseline or the events associated with an arousal
   - ≥ 4% oxygen desaturation from pre-event baseline (acceptable)

Classification of Hypopneas

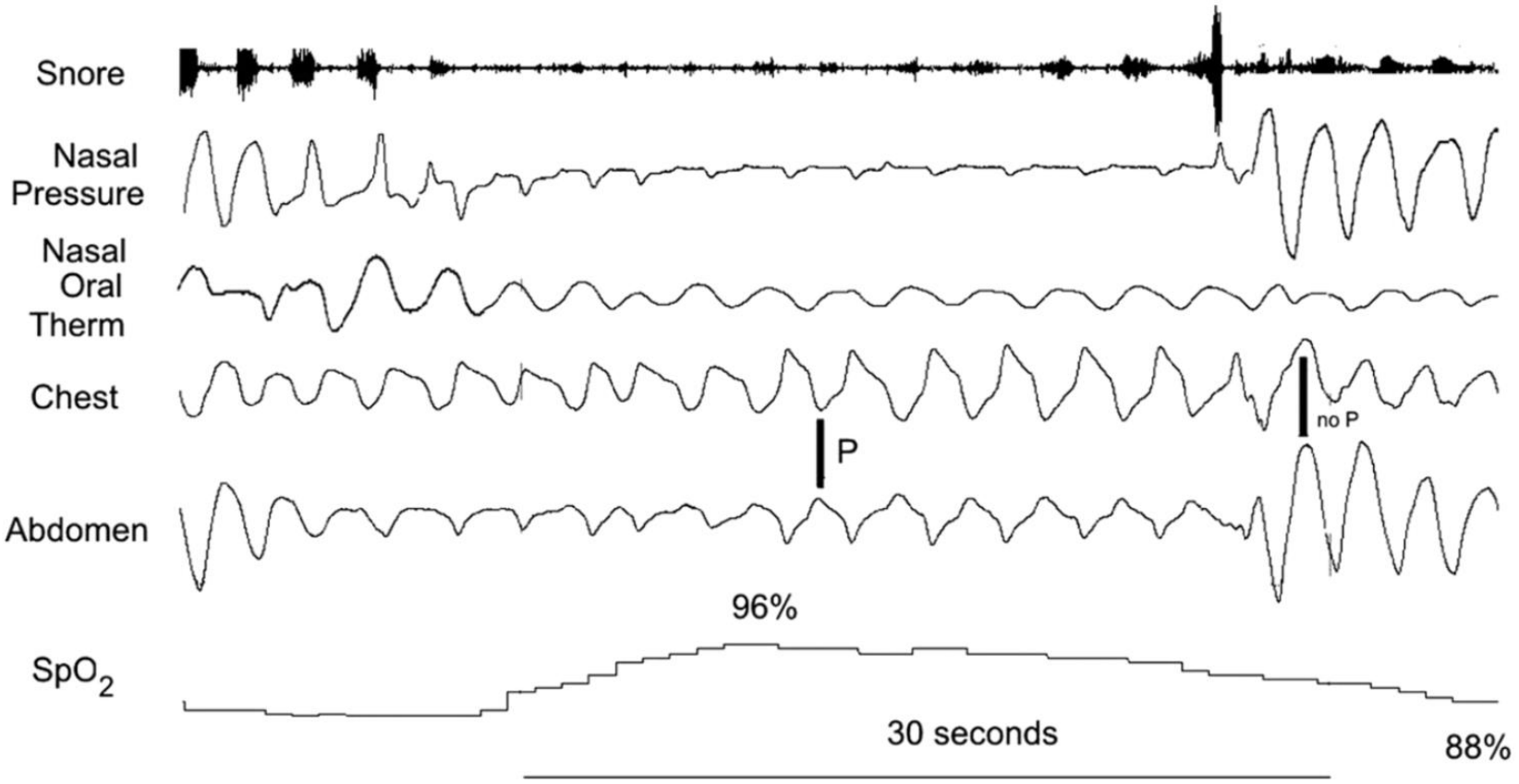
1) If **ANY** of the following criteria are met
→ **Obstructive**

2) If **NONE** of the following criteria are met
→ **Central**

1) Snoring during the event

2) Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared with baseline breathing

3) Associated thoracoabdominal paradox occurs during the event, but not during pre-event breathing


Snore
Nasal Pressure
Nasal Oral Therm
Chest
Abdomen
SpO2
P
no P
96%
30 seconds
88%

Arousal

- Transient phenomena that may lead to wakefulness or only briefly interrupt sleep
  - frequent arousals → daytime sleepiness

- Arousal Rules
  - an abrupt shift of EEG frequency
    - alpha, theta and/or frequencies greater than 16 Hz (but not spindles) that lasts at least 3 seconds
    - with at least 10 seconds of stable sleep preceding the change

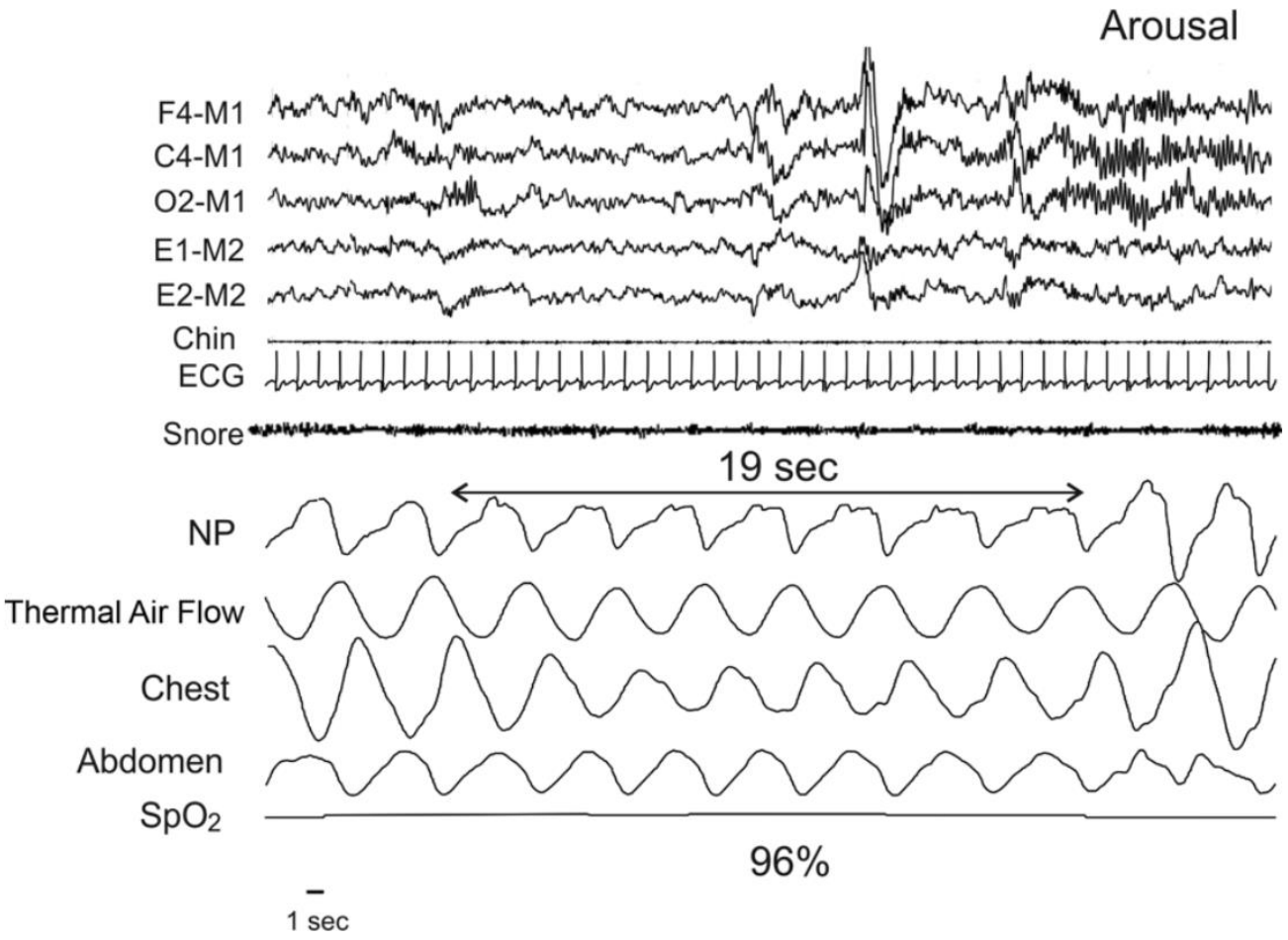
    - During REM sleep
      - requires a concurrent increase in submental EMG lasting at least 1 second

Respiratory Effort–Related Arousal (RERA)

1) A sequence of breaths lasting ≥ 10 seconds

2) Increasing respiratory effort or flattening of the inspiratory portion waveform leading to arousal from sleep
   - nasal pressure (diagnostic study) or PAP device flow (titration study)
   - when the sequence of breaths does **not** meet criteria for an apnea or hypopnea

- RERA events
  - sometimes called *upper airway resistance events*


Arousal
F4-M1
C4-M1
O2-M1
E1-M2
E2-M2
Chin
ECG
Snore
19 sec
NP
Thermal Air Flow
Chest
Abdomen
SpO2
96%
1 sec

Respiratory Event Index

- **AHI (Apnea-Hypopnea Index)**
  - number of apneas & hypopneas per hour of sleep
- **RERAI (Respiratory Effort–Related Arousal Index)**
  - number of RERAs per hour of sleep
- **RDI (Respiratory Disturbance Index)**
  - Sum of AHI & RERAI

Contents

- Indication for PSG
- Parameters of PSG
- Terminology of Sleep Architecture
- Interpretation of PSG Report

PSG Report (1)

Normal Values

- **Sleep Efficiency** ≥ 80~ 85%

- **Sleep Latency** : 5 ~ 30 min
- **REM Latency** : 60 ~ 120 min

- **WASO** : according to age

- **Sleep Stages**
- N1 (5%)
- N2 (50%)
- N3 (20%)
- REM (20-25%)

가톨릭대학교 의정부성모병원

Diagnostic PSG Report

경기도 의정부시 천보로 271, 의정부성모병원
대표번호: 1661-7500 검사실: 031-820-5399

Patient Name:	[redacted]	Study Date:	3/6/2019
Date of Birth:	12/26/1955	Study Type:	NPSG
Age:	63 year	Patient #:	-
Sex:	Male	Billing ID:	-
Height:	170 cm	Referring Physician:	-
Weight:	60.0 kg	Recording Tech:	System
BMI:	20.8	Scoring Tech:	Kim Ryeol

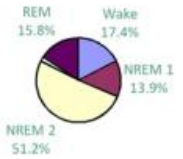
Study Overview

			COUNT	INDEX
First Lights Off:	10:11:43 PM			
Last Lights On:	04:53:16 AM	Awakenings:	35	6.3
Time in Bed:	401.6	Arousals:	127	22.9
Total Sleep Time:	332.5	Apneas & Hypopneas:	105	18.9
Sleep Efficiency:	82.8%	Limb Movements:	85	15.3
Sleep Period Time:	397.1	Snores:	53	9.6
Sleep Maintenance Efficiency:	83.7%	Desaturations:	35	6.3
Sleep Latency:	4.5	WASO	64.6	
REM Latency from Sleep Onset:	85.5	Minimum Oxygen Saturation during Desaturation:	89.0%	

Sleep Architecture

Stages	TIME (mins)	% SLEEP TIME
WAKE	70.0	
Stage N1	56.0	16.8%
Stage N2	206.0	62.0%
Stage N3	7.0	2.1%
REM	63.5	19.1%

% of Time in Bed



Arousal Summary

	NREM	REM	Total Sleep Time
Apnea Arousals	4	9	13
Hypopnea Arousals	61	15	76
PLM Arousals	3	-	3
Isolated Limb Movement Arousals	4	1	5
Spontaneous Arousals	26	3	29
RERAs	-	-	-
Snore Arousals	2	-	2
Total	99	28	127
Arousal Index	22.1	26.5	22.9

PSG Report (2)

- **AHI (Apnea-Hypopnea Index)**
- < 5 : normal
- 5~15 : mild
- 15~30 : moderate
- > 30 : severe

Respiratory Summary

	By Sleep Stage			By Body Position		TOTAL
	Wake	NREM	REM	SUPINE	NON-SUPINE	
Time (min)	70.0	269.0	63.5	175.0	157.5	332.5
Obstructive Apnea	-	9	10	19	-	19
Mixed Apnea	-	2	-	2	-	2
Central Apnea	-	2	1	-	3	3
Total Apneas	-	13	11	21	3	24
Total Apnea Index	-	2.9	10.4	7.2	1.1	4.3
Hypopneas w/Arousals	-	60	16	68	8	76
Hypopneas w/≥3% Ds (incl. Ds only)	-	1	2	1	-	3
Total Hypopneas (≥3%) (Hyp w/Ar + Hyp w/≥3% Ds)	-	61	18	71	8	79
Tot. Hypopnea Index (≥3%) (Hyp w/Ar + Hyp w/≥3% Ds)	-	13.6	17.0	24.3	3.0	14.3
Hypopneas w/≥4% Ds	-	-	-	-	-	-
Total Hypopneas (≥4%) (Hyp w/Ar + Hyp w/≥4% Ds)	-	60	16	68	8	76
Tot. Hypopnea Index (≥4%) (Hyp w/Ar + Hyp w/≥4% Ds)	-	13.4	15.1	23.3	3.0	13.7
All Apneas & Hypopneas All Apn + Hyp w/Arousal + Hyp with Desat Only	-	76	29	94	11	105
AHI (All Apn + Hyp w/Ar + Hyp. w/Ds)	-	17.0	27.4	32.2	4.2	18.9
Apneas & Hyp. (≥3%) All Apn + Hyp w/Arousals + Hyp w/≥3% Desat	-	74	29	92	11	103
AHI (≥3% Criteria) Index of All Apn + Hyp w/Ar + Hyp. w/≥3% Desat	-	16.5	27.4	31.5	4.2	18.6
Apneas & Hyp. (≥4%) All Apn + Hyp w/Arousals + Hyp w/≥4% Desat	-	73	27	89	11	100
AHI (≥4% Criteria) Index of All Apn + Hyp w/Arousals + Hyp w/≥4% Desat	-	16.3	25.5	30.5	4.2	18.0
RERAs	-	-	-	-	-	-
RERA Index	-	-	-	-	-	-
RDI Index of All Apn. + Hyp w/Ar + Hyp w/Ds + RERA	-	17.0	27.4	32.2	4.2	18.9

Respiratory Event Durations

	Apnea		Hypopnea	
	NREM	REM	NREM	REM
Average (seconds)	15.6	31.1	26.6	37.0
Maximum (seconds)	23.3	56.9	66.1	78.6

PSG Report (3)

- **PLMI (Periodic Limb Movement Index)**

number of total PLMs per hour of sleep > 5 → abnormal

Oxygen Saturation Summary

	WAKE	NREM	REM
Average OSat (%)	96.7%	97.4%	97.1%
Minimum OSat (%)	77.0%	88.9%	89.0%
Maximum OSat (%)	100.0%	100.0%	100.0%

Oxygen Saturation Distribution

Range(%)	Time in range (min)	Time in range (%)
90.0 - 100.0	399.7	99.5%
80.0 - 90.0	1.9	0.5%
70.0 - 80.0	0.0	0.0%
60.0 - 70.0	-	-
50.0 - 60.0	-	-
0.0 - 50.0	-	-

Time Spent Less than 88% OSat

Range(%)	Time in range (min)	Time in range (%)
0.0 - 88.0	0.6	0.1%

# of Desaturations	35
Minimum Oxygen Saturation During Desaturation	89.0%

	SUPINE	LEFT	RIGHT	PRONE
Minimum Oxygen Saturation During Desaturation by BP	89.0%	-	92.0%	-

Limb Movement Summary

	COUNT	INDEX
Isolated Limb Movements	63	11.4
Periodic Limb Movements (PLMs)	22	4.0
Total Limb Movements	85	15.3

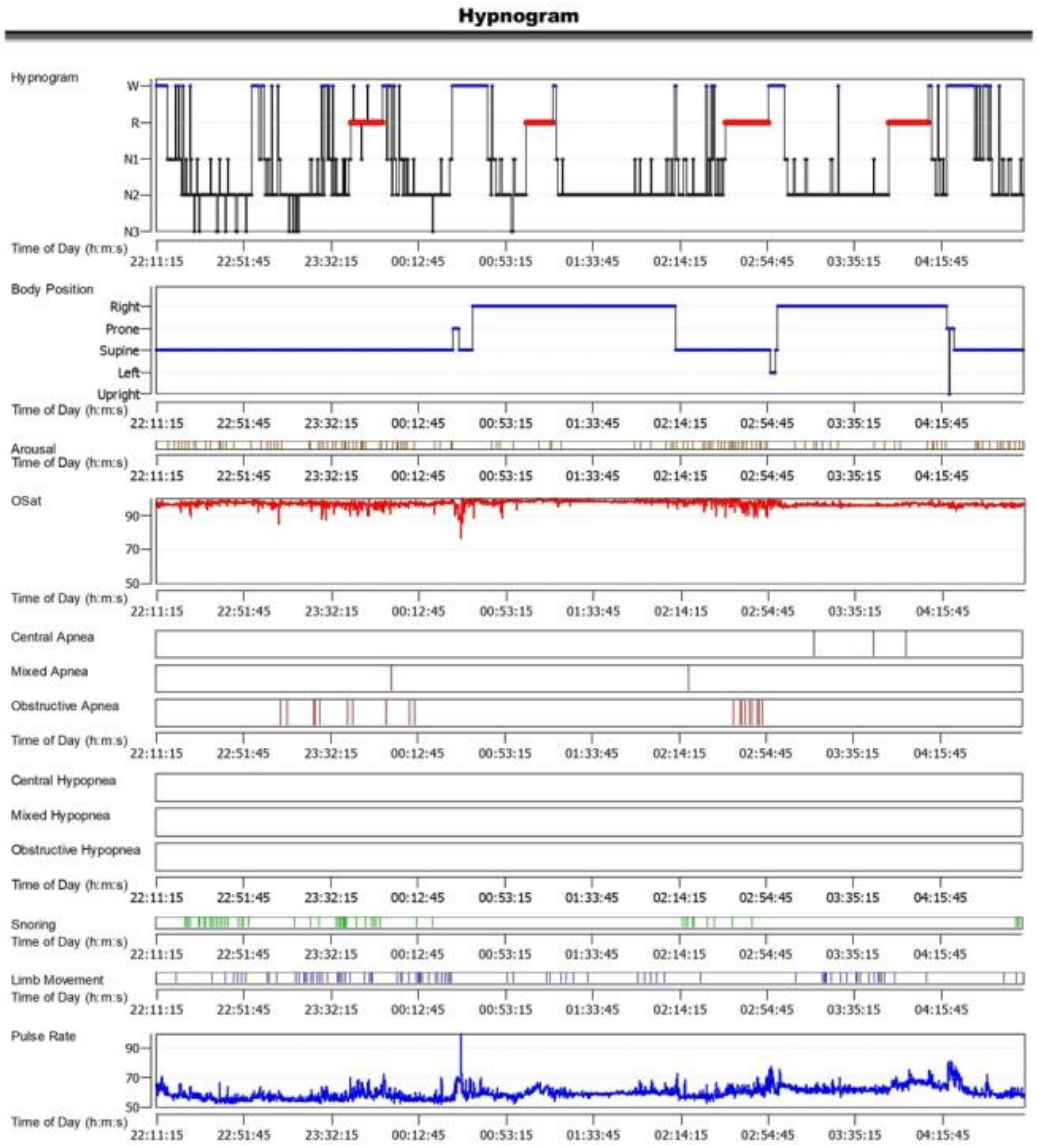
Cardiac Summary

	WAKE	NREM	REM	Sleep	TOTAL
Average Pulse Rate (BPM)	62.5	58.5	62.5	59.3	59.8
Minimum Pulse Rate (BPM)	53.0	52.0	54.0	52.0	52.0
Maximum Pulse Rate (BPM)	100.0	70.0	76.0	76.0	100.0

Pulse Rate Distribution

Range(bpm)	Time in range (min)	Time in range (%)
0.0 - 40.0	-	-
40.0 - 60.0	257.6	64.2%
60.0 - 80.0	143.4	35.7%
80.0 - 100.0	0.3	0.1%
100.0 - 120.0	-	-
120.0 - 140.0	-	-
140.0 - 200.0	-	-

PSG Report (4)


Hypnogram
Hypnogram
W
R
N1
N2
N3
Time of Day (h:m:s)
22:11:15
22:51:45
23:32:15
00:12:45
00:53:15
01:33:45
02:14:15
02:54:45
03:35:15
04:15:45
Body Position
Right
Prone
Supine
Left
Upright
Arousal
OSat
90
70
50
Central Apnea
Mixed Apnea
Obstructive Apnea
Central Hypopnea
Mixed Hypopnea
Obstructive Hypopnea
Snoring
Limb Movement
Pulse Rate

Take Home Message (1)

- **Indications for PSG**
  - 호흡기내과
    - Sleep apnea 의심 환자
      - 주간 졸림증, 빈번한 코골이, 피로감, 수면 중 숨막힘, 잦은 뒤척임, 수면 중 잦은 각성

- **Parameters of PSG**
  - EEG, EOG, chin EMG, ECG, Airflow, snoring, chest & abdomen RIP bands, anterior tibialis EMG

Take Home Message (2)

- **Terminology of Sleep Architecture**
  - Sleep
    - TST (Total Sleep Time), Sleep efficiency, SL (Sleep Latency), WASO (Wake After Sleep Onset)
  - Respiratory events
    - Apnea – obstructive, central, mixed
    - AHI (Apnea - Hypopnea Index)

- **Interpretation of PSG Report**
  - Sleep architecture, AHI (sleep stage, body position), oxygen saturation, periodic limb movement

Reference

- Richard B. Berry & Mary H. Wargner, SLEEP MEDICINE PEARLS, 3rd ed. 2015

- The AASM Manual for the Scoring of Sleep and Associated Events

경청해주셔서 감사합니다.