수면다원검사의 시행 (Hook Up)

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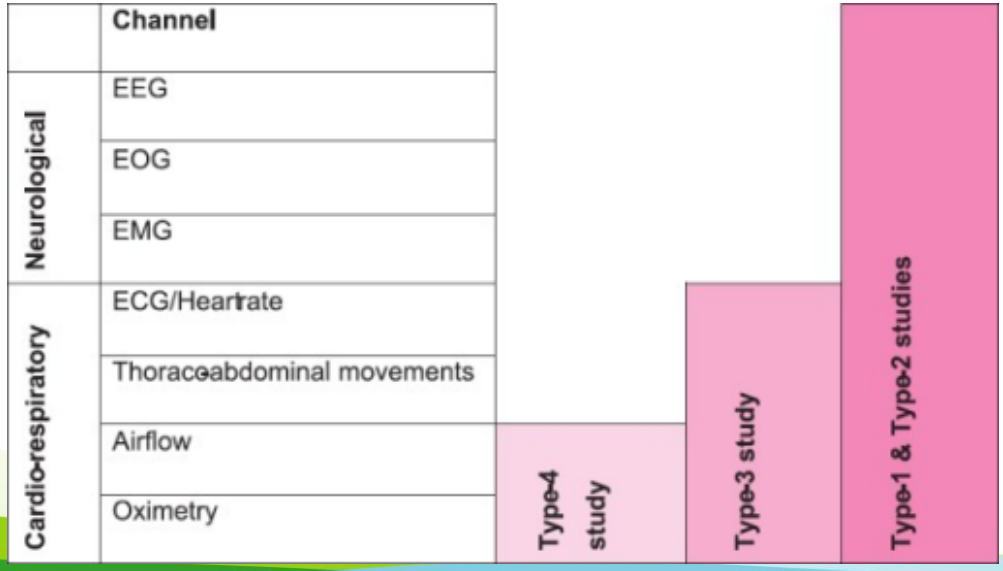
Polysomnography (PSG)

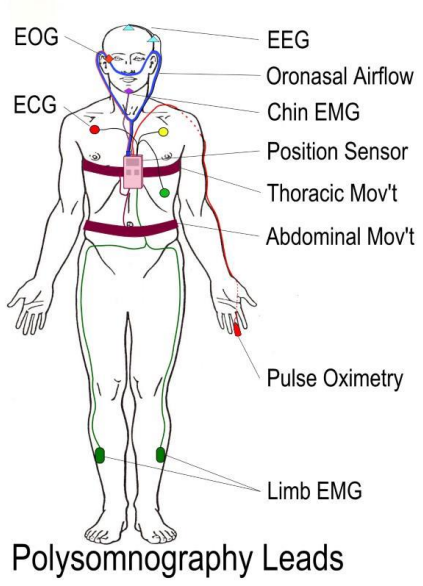
- **Quantitative & qualitative measures of sleep**
- **Gold standard**
  - Diagnostic test for sleep-related breathing disorders
- **Diagnose a variety of additional sleep disorders**
  - Narcolepsy
  - Periodic limb movement disorder
  - REM sleep behavior disorder
  - Unusual behaviors during sleep
  - Unexplained chronic insomnia

Type of PSG

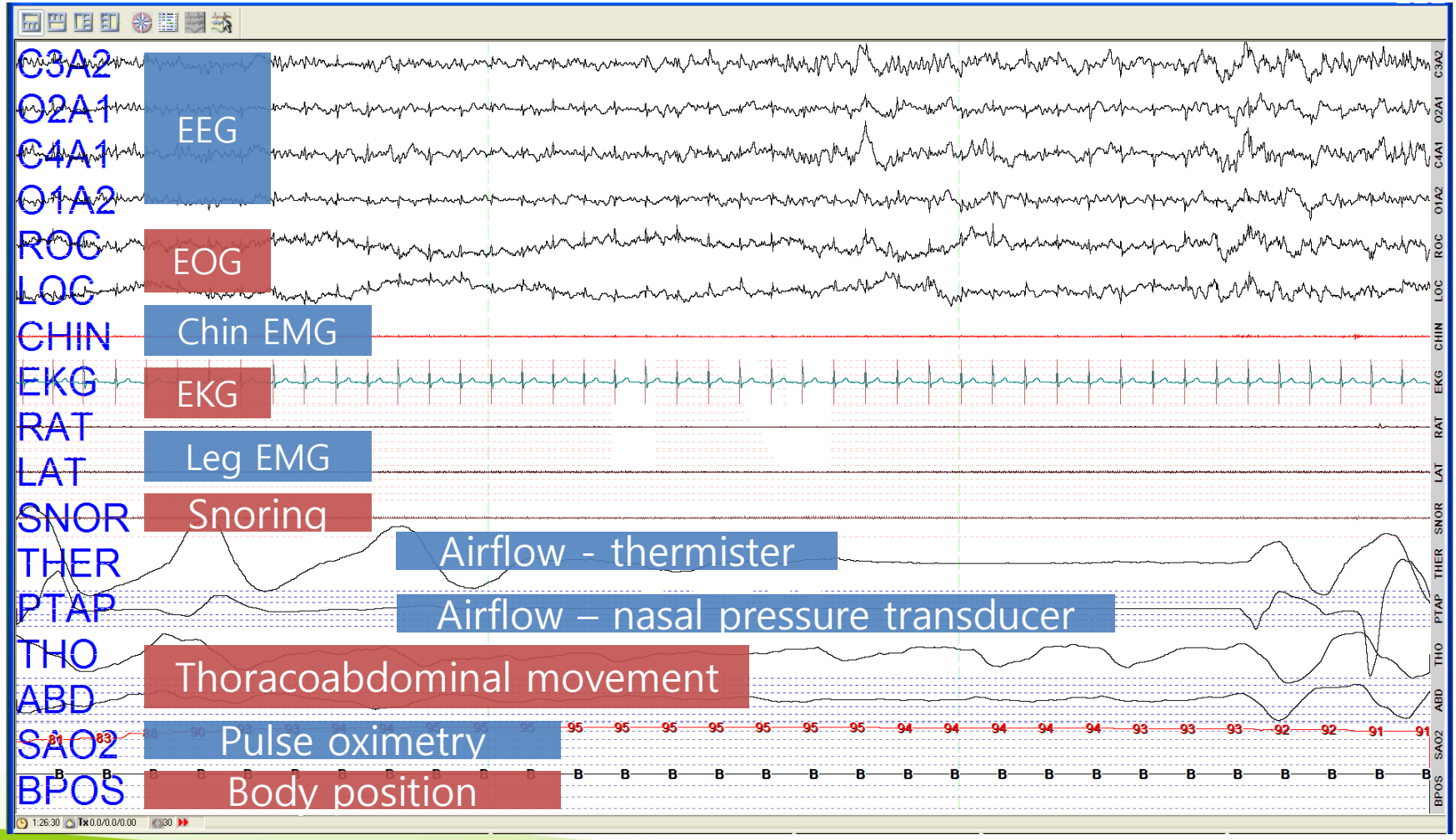
Test level	Description	Personnel	Signals required
Type 1	In-patient PSG performed in a sleep laboratory	Attended	EEG, EOG, chin EMG, ECG, airflow, respiratory effort and oxygen saturation
Type 2	Portable PSG	Unattended	Same as type 1
Type 3	Cardiorespiratory polygraphy	Attended and unattended	4–6 signals, including ECG or heart rate, and oxygen saturation
Type 4	1–2 signals	Unattended	

<American Academy of Sleep Medicine classification of diagnostic modalities>





Polysomnography (PSG)



Preparation

- Alcohol or caffeine prior to PSG
  - May alter the nature & severity of the underlying sleep disorder

- **Alcohol** : may exacerbate OSA & alter sleep architecture
  - Habitually consumes alcohol in the evening : absence of alcohol on PSG could yield a false negative
  - Neither safe nor practical to encourage patients to consume alcohol prior to presenting to the sleep laboratory

- **Caffeine** : may contribute to insomnia & sleep fragmentation
  - Abstain in the afternoon and evening of the PSG day

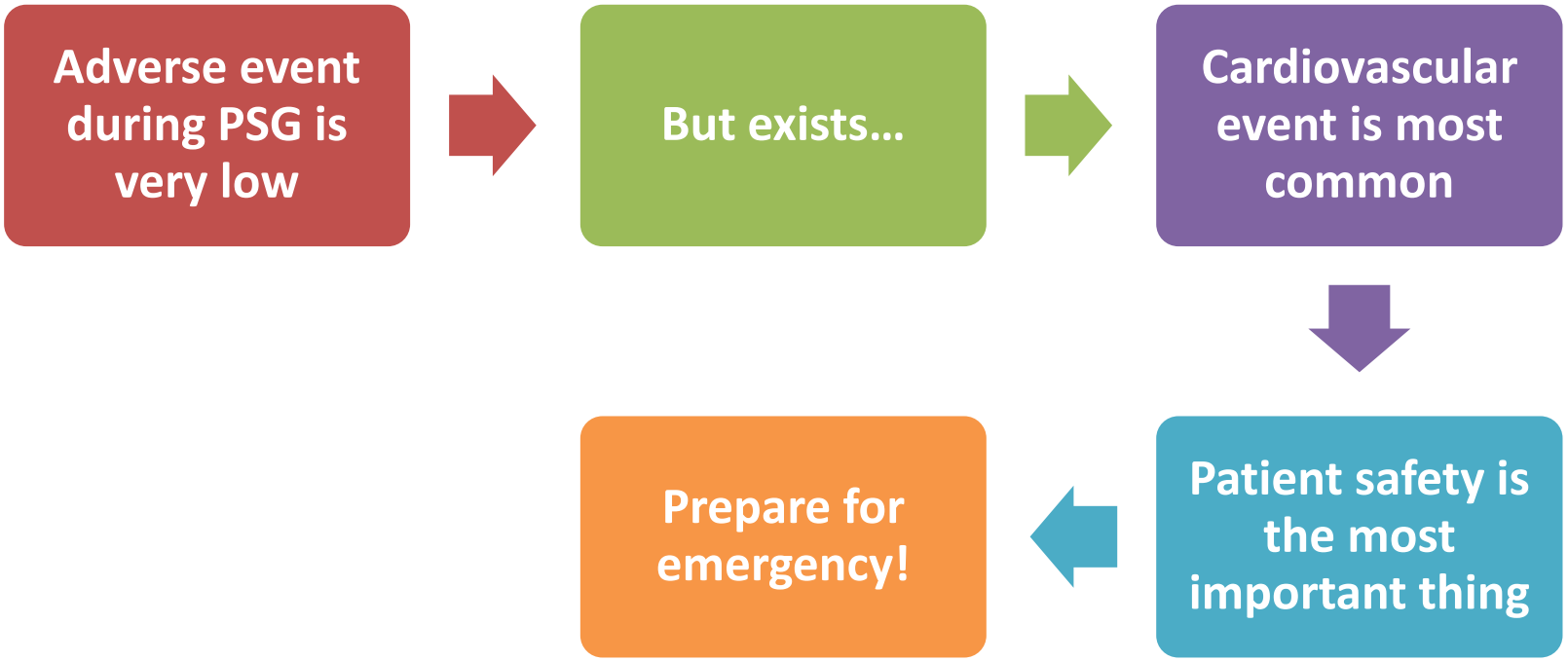
Preparation

- **Patients with suspected OSA**
  - Should continue their usual medications on the night of the PSG, including sleep aids
  - Benzodiazepines or opioids : may exacerbate sleep-disordered breathing

- **Zolpidem**
  - For patients with suspected OSA who have a history of severe insomnia, especially when sleeping in a new environment, or are very nervous about sleeping in the sleep lab
  - Improves sleep continuity & quality → improving the quality of PSG without exacerbating sleep apnea

Risks

- Noninvasive, painless test

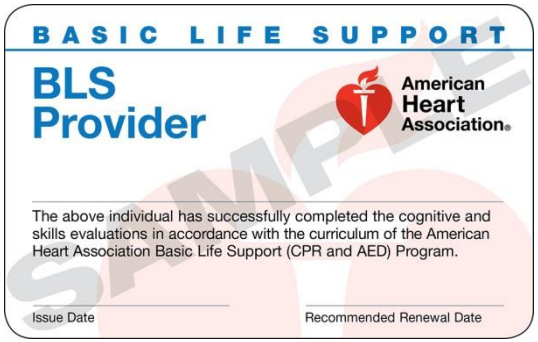


수면다원검사 급여기준 질의응답

보건복지부 고시 제2018- 135 호('18.7.1.시행) 관련

□ 2018.7월1일부터 수면다원검사의 건강보험 적용시 급여기준 및 수가산정에 대해 다음과 같이 안내드립니다.

3	시설기준에서 응급상황에 정한 응급상황시 심폐소생술 등이 가능하여야 한다는 의미는?	수면다원검사 중 응급상황이 발생할 경우 심폐소생술 등을 지체없이 실시하는데 필요한 장비 등을 갖추어야 함을 의미함.



Hook up

빨강 색연필

줄자

거즈

면봉

Electrode

Nu Prep

EEG Cream

Snap Lead

Gold Cup

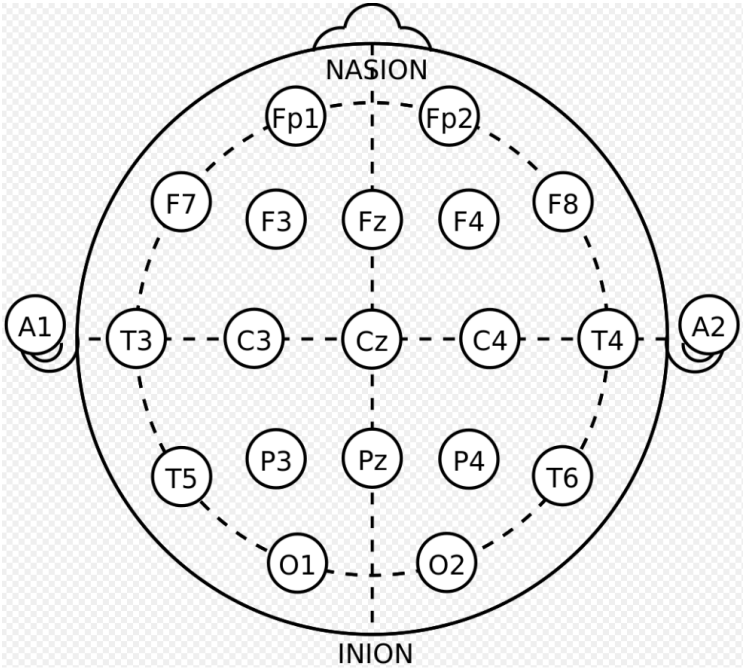
Air Compressor

- Electroencephalography (EEG) monitoring
- Electrooculography (EOG) monitoring
- Electromyography (EMG) monitoring
- Respiratory sensors
- Etc

- Electroencephalography (EEG) monitoring
- Electrooculography (EOG) monitoring
- Electromyography (EMG) monitoring
- Respiratory sensors
- Etc

EEG monitoring

- **International 10-20 system**
  - Standardized EEG electrode placement
  - Covers all brain regions
    - F : frontal
    - P : parietal
    - C : central
    - T : temporal
    - O : occipital
    - M : mastoid
  - Numbering
    - Even : right
    - Odd : left
    - Z : midline

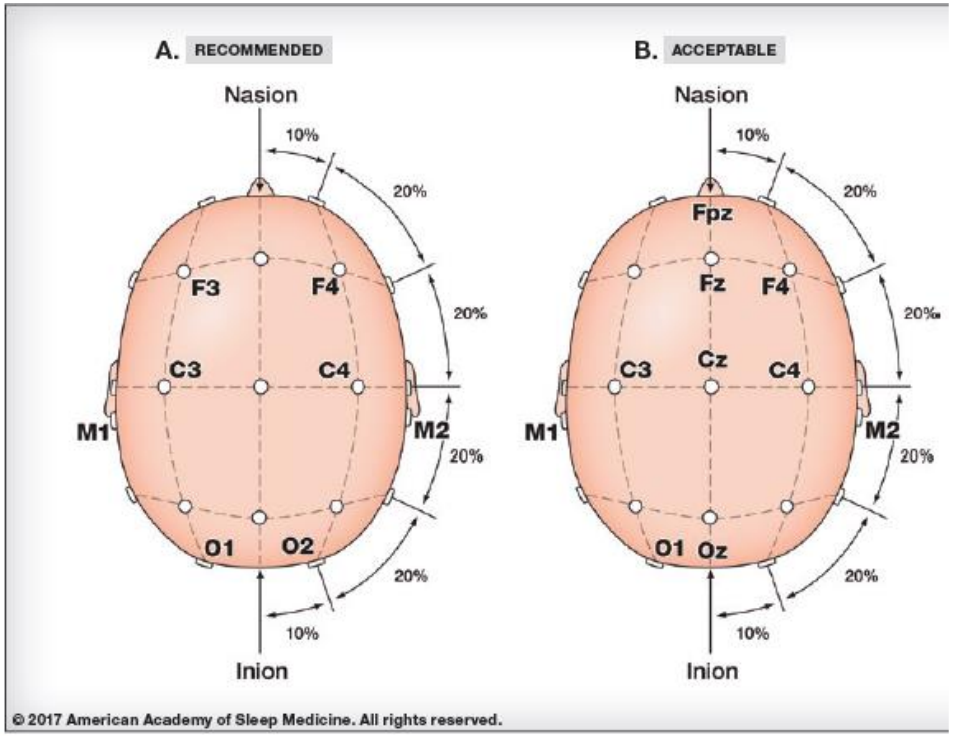


Sleep PSG EEG

- **Sleep PSG montage**
  - At a minimum, frontal, central, and occipital derivations (3 EEG channels) are required to stage sleep
  - 8 channels + References(Cz) & ground(Fpz)

- **Recommended**
  - F4-M1
  - C4-M1
  - O2-M1

- **Backup electrodes**
  - F3-M2
  - C3-M2
  - O1-M2

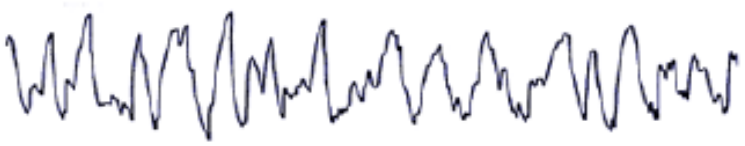


Sleep PSG EEG

- Why a minimum 3EEG channels?

F4-M1 – best for slow waves

0.5-2.0hz



C4-M1 – best for spindles

11-16hz (most common 12-14hz)

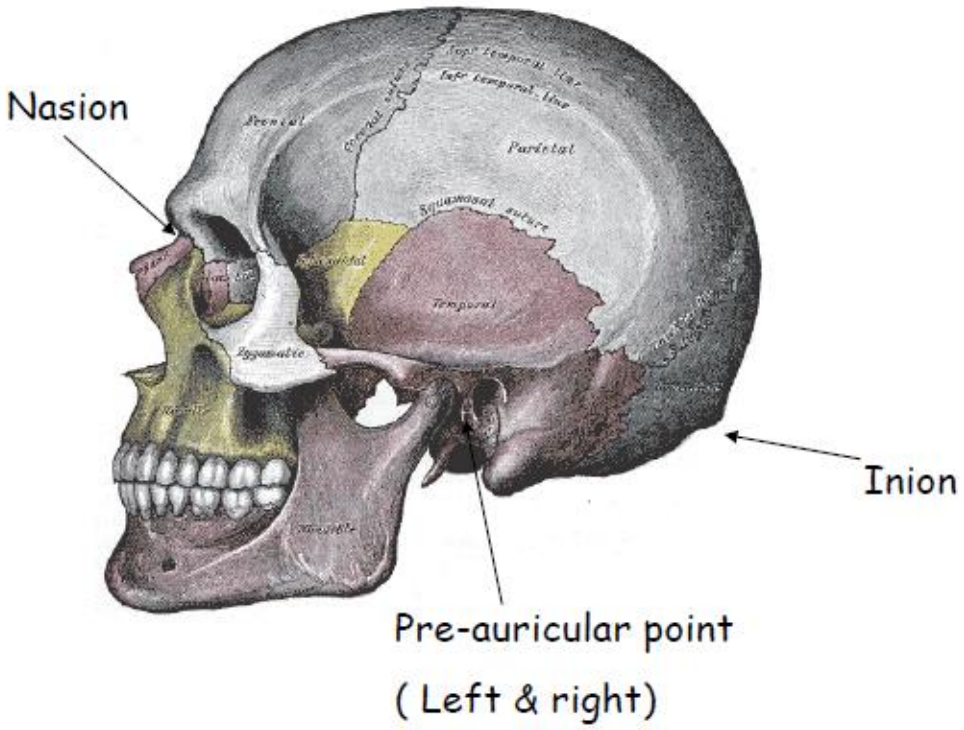
O2-M1 – best for alpha rhythm

(8-13hz)

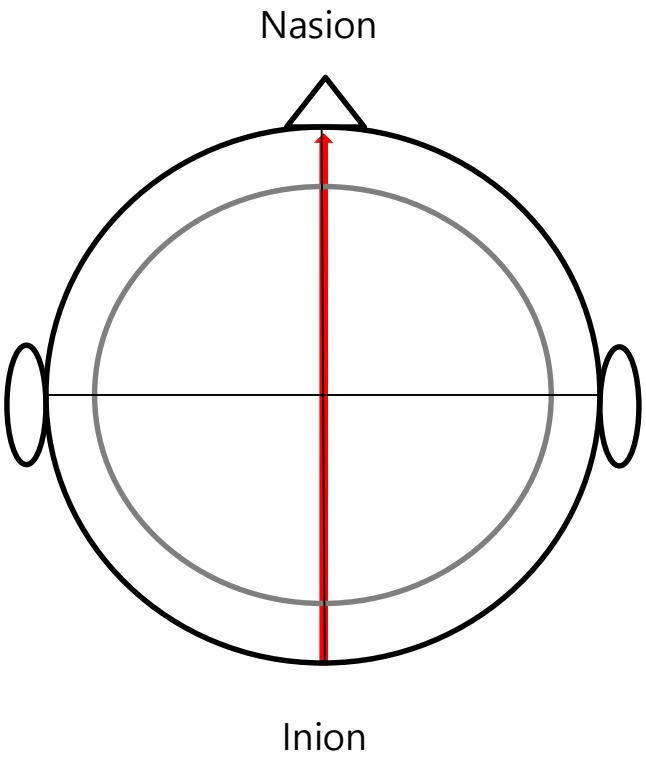
https://www.ers-education.org/lrmedia/2016/pdf/298830.pdf

10-20 EEG placement

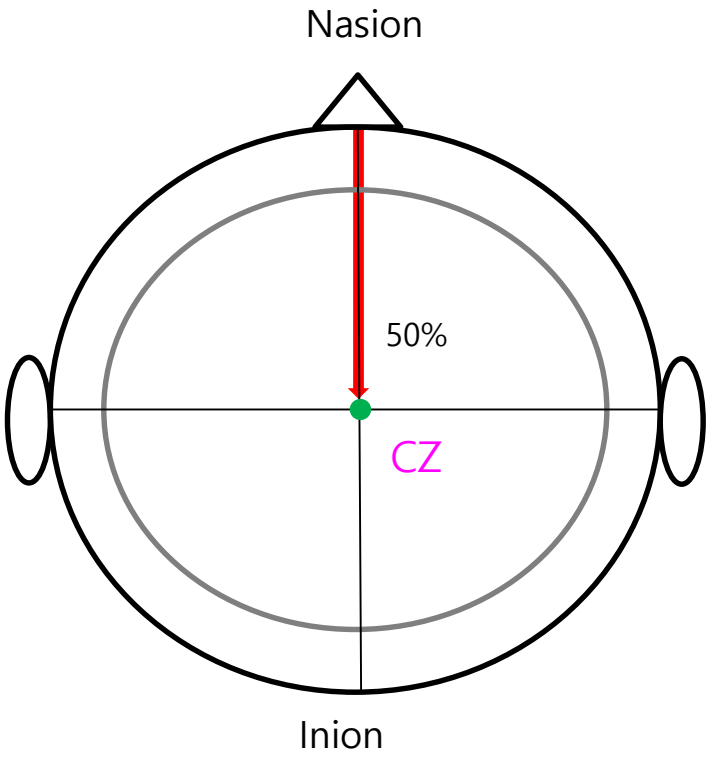
- **Four skull landmarks**
  - Nasion
  - Inion
  - Left Pre-auricular point
  - Right Pre-auricular point



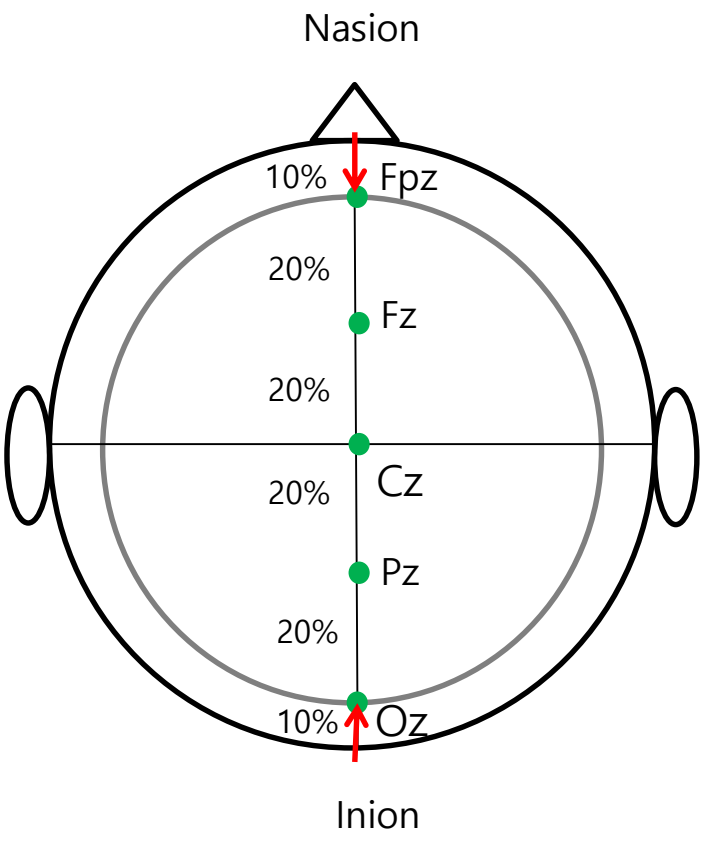
1. Nasion 과 Inion의 길이(A)를 측정한다.



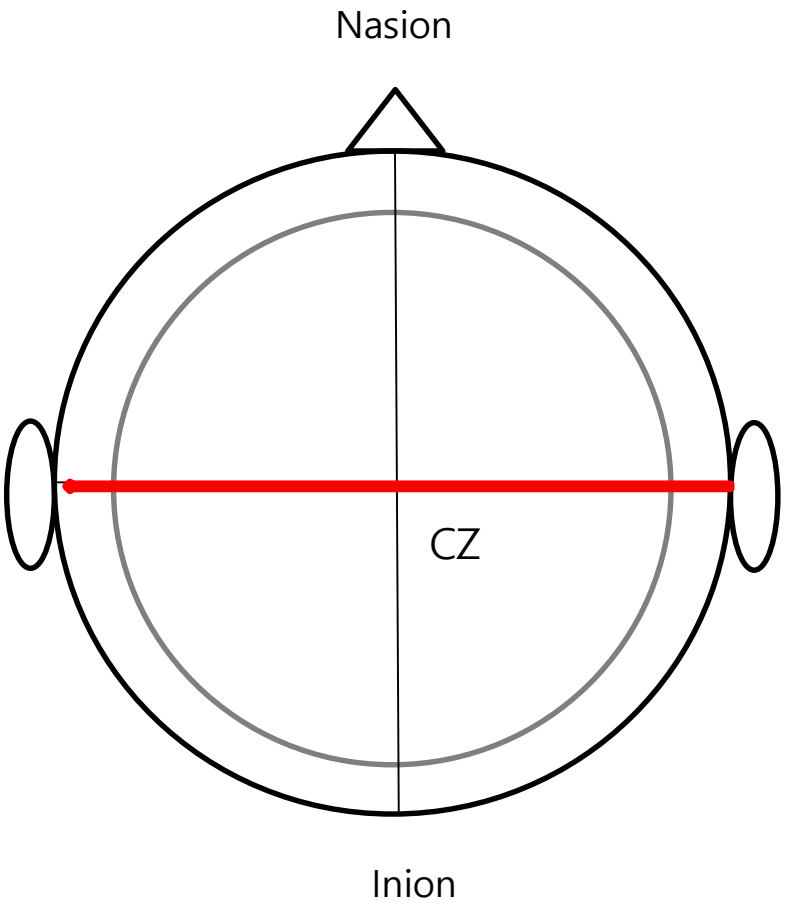
2. " A "의 50%인 Cz을 마킹한다.



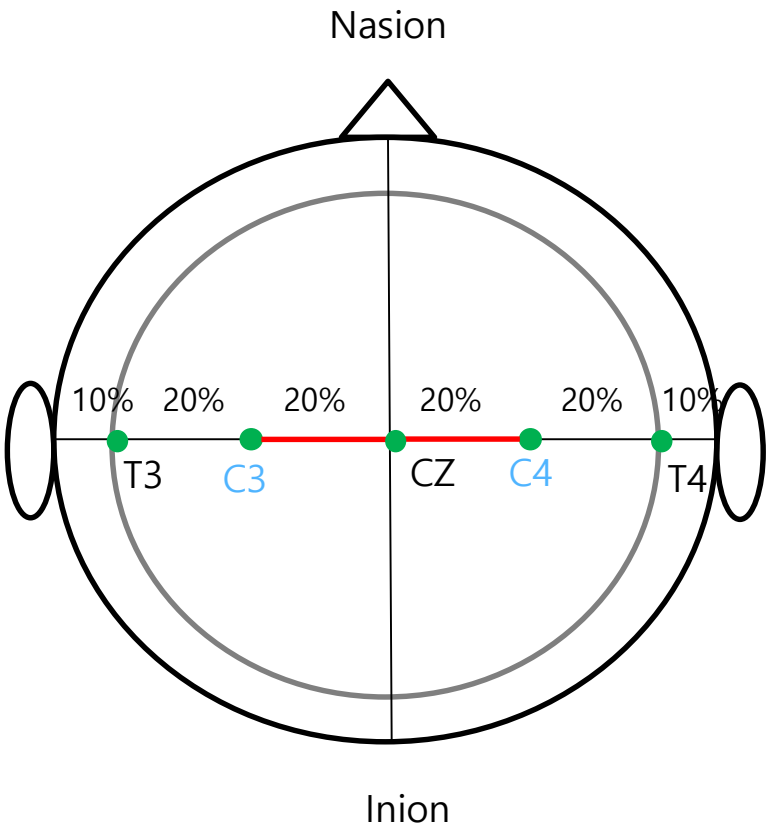
3. Nasion 과 Inion의 각각 10% 위로 측정한 지점 Fpz,Oz



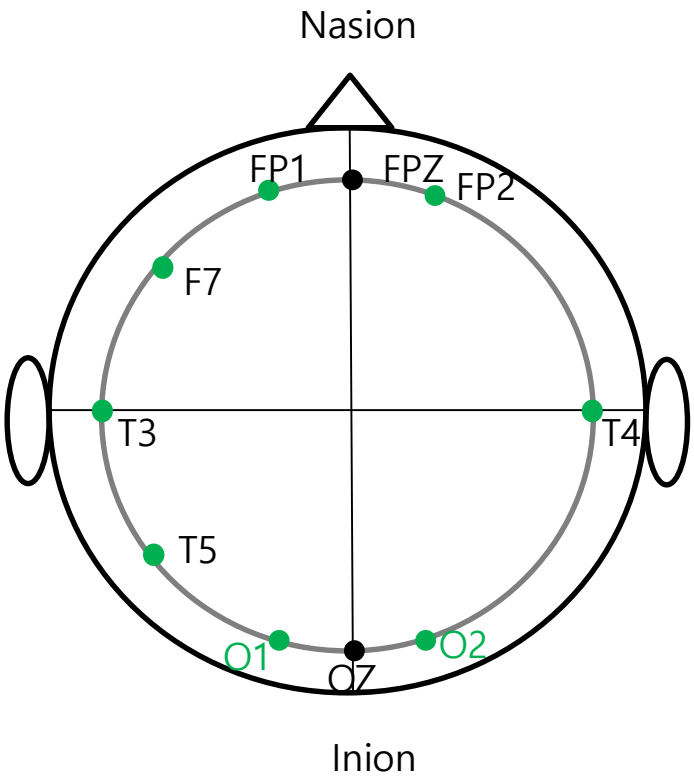
4. 양 측의 Preauricular point간 길이 측정



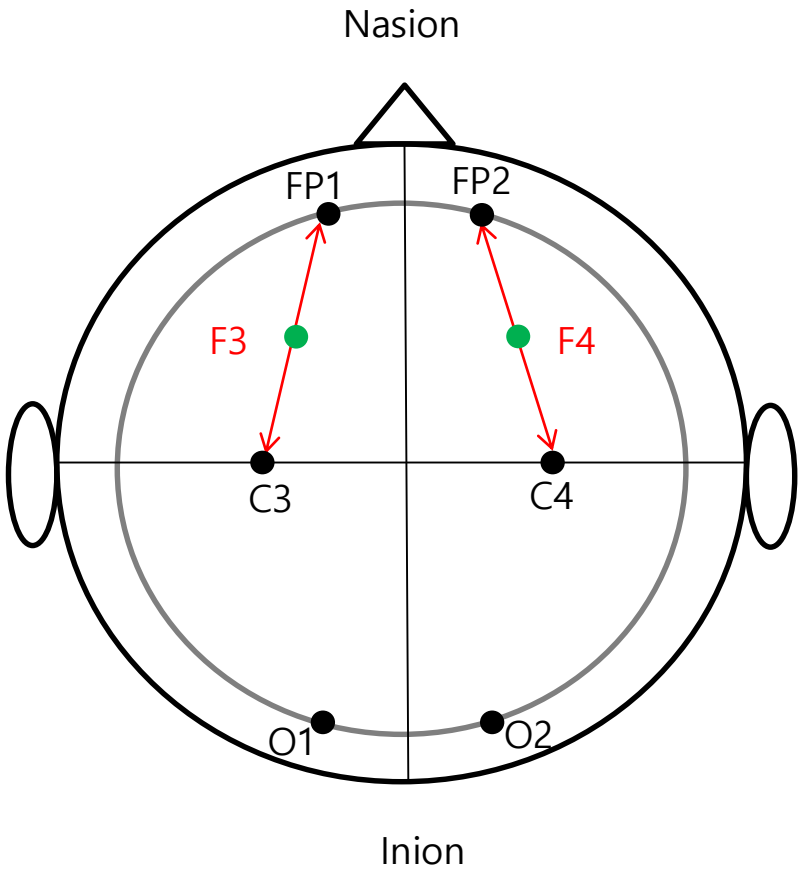
5. CZ으로부터 양 Preauricular point의 20% 부분을 C3/C4



6. T3를 지나가게 Fpz와 Oz길이 측정



11. FP1 - C3의 가운데 지점 - F3
FP2 - C4의 가운데 지점 - F4



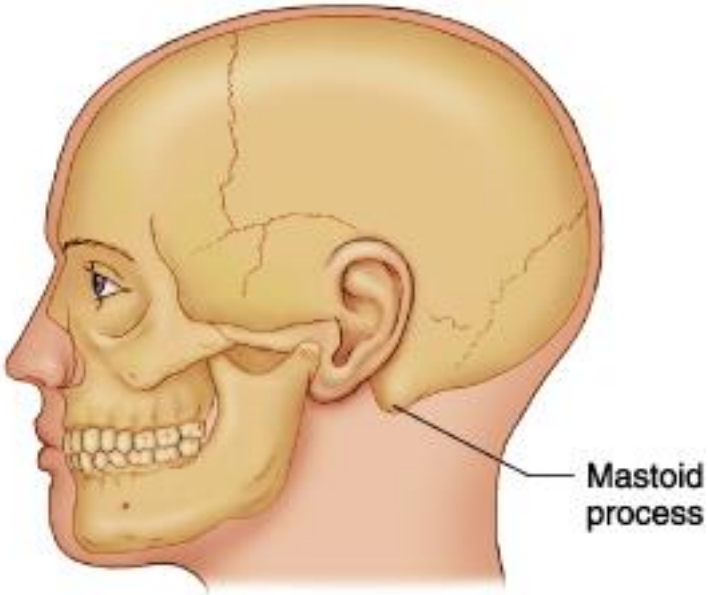
Reference M1/M2

Nu-prep를 이용해 붙일 위치를 살살 닦아준다.

M1은 왼쪽 귀 뒤에, M2는 오른쪽 귀 뒤에

Reference electrode M1/M2는 Mastoid process 위 에 붙인다.

Artifacts를 줄이기 위해서는 센서는 평평한 뼈 주위에 붙인다.



Ground

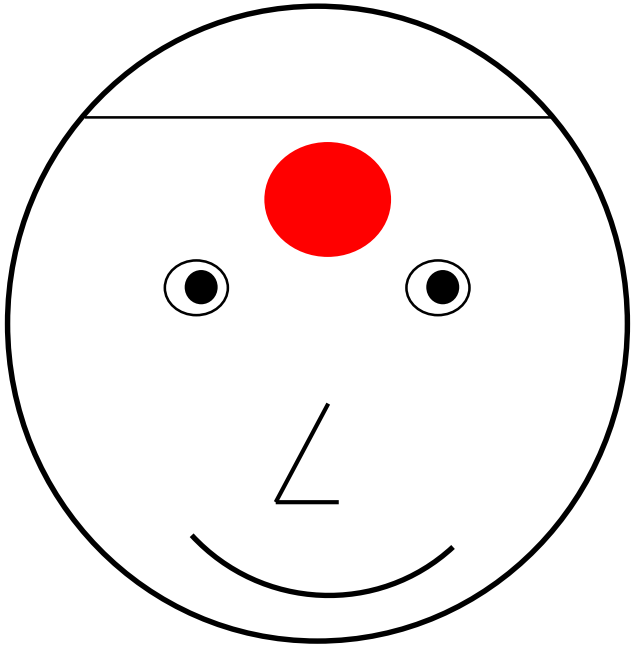
AC 채널의 Reference 역할

Nasion 과 헤어라인 시작 부분 사이에 부착한다.

주름 주위는 피하는 것이 좋다.

교류를 사용하는 채널에 참조 전극 역할을 한다. Ground 전극을

부착하지 않으면 참조 전극을 필요로 하는 모든 채널에 영향을 준다.

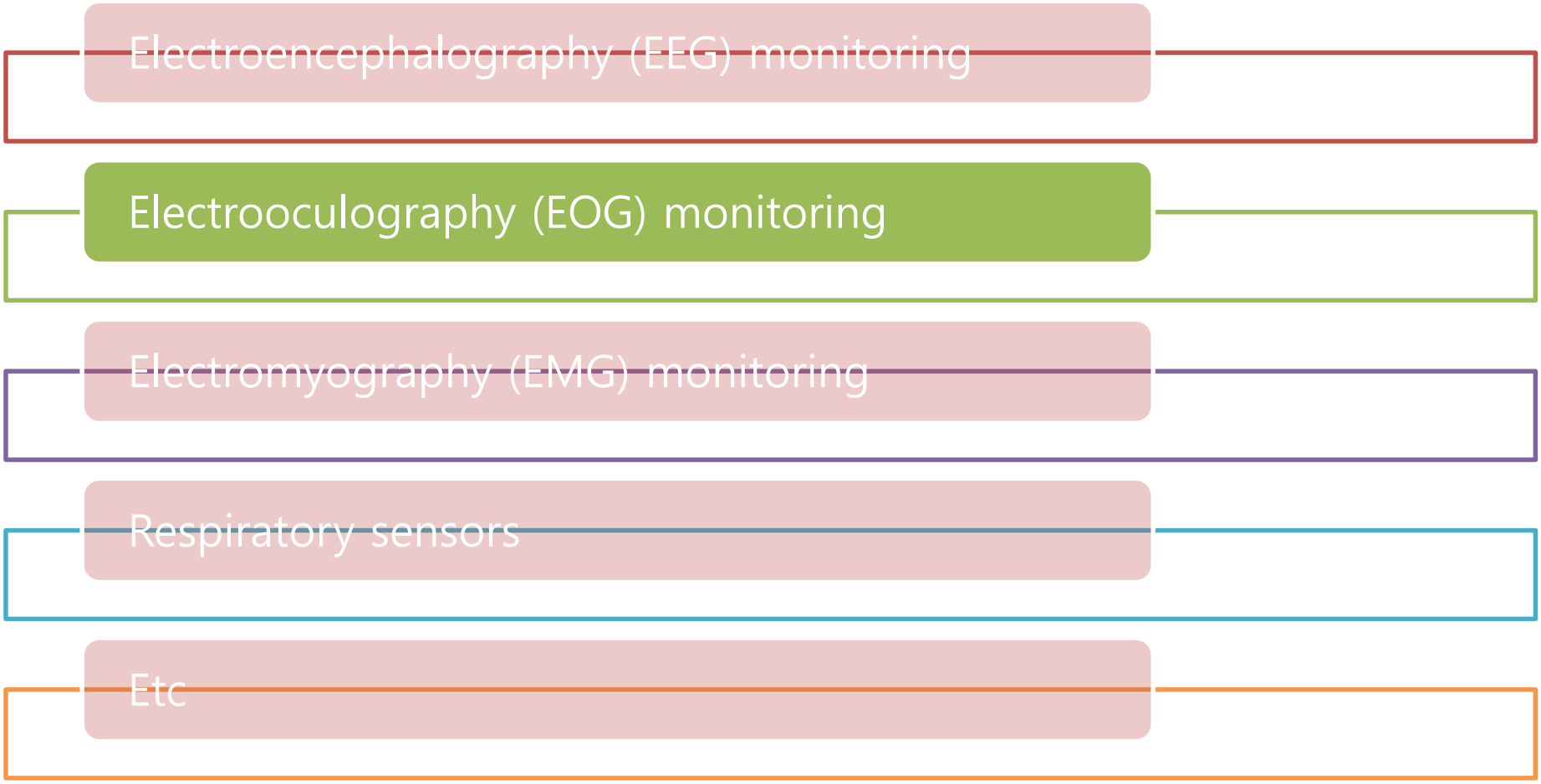


Skin preparation

- Clean the area with alcohol swab to eliminate any makeup or oil on the skin

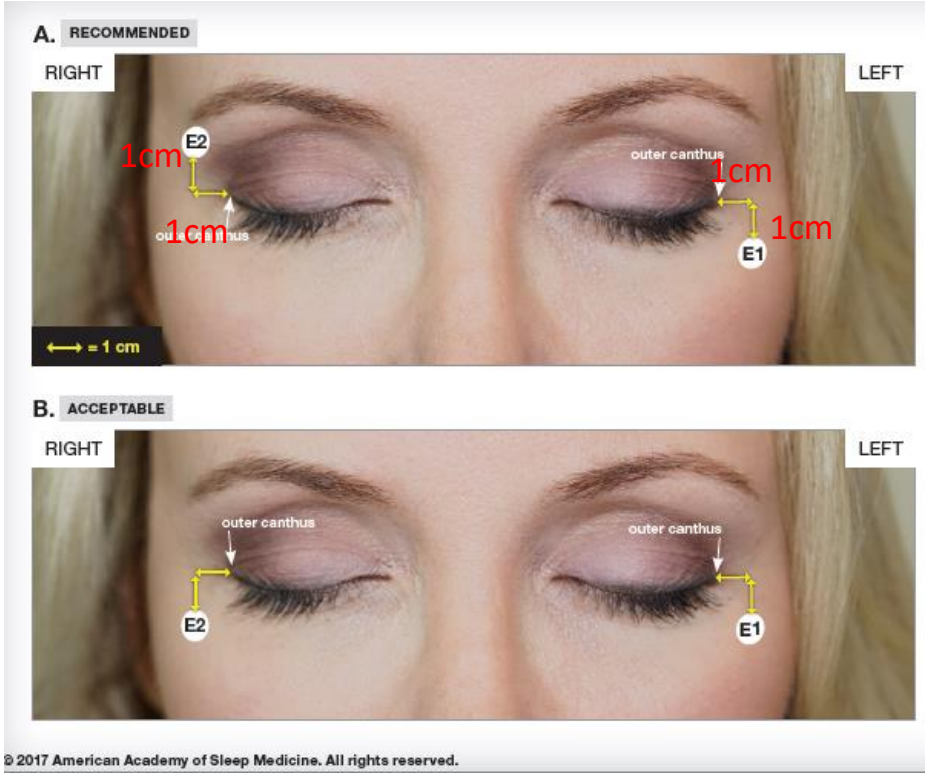
- Scrub the area with small cotton-tip
  - Abrasive skin prepping gel such as NuPrep or Lemon Preop
  - Remove dead skin cells to reduce skin impedance
  - Only scrub the area covered by the electrode cup

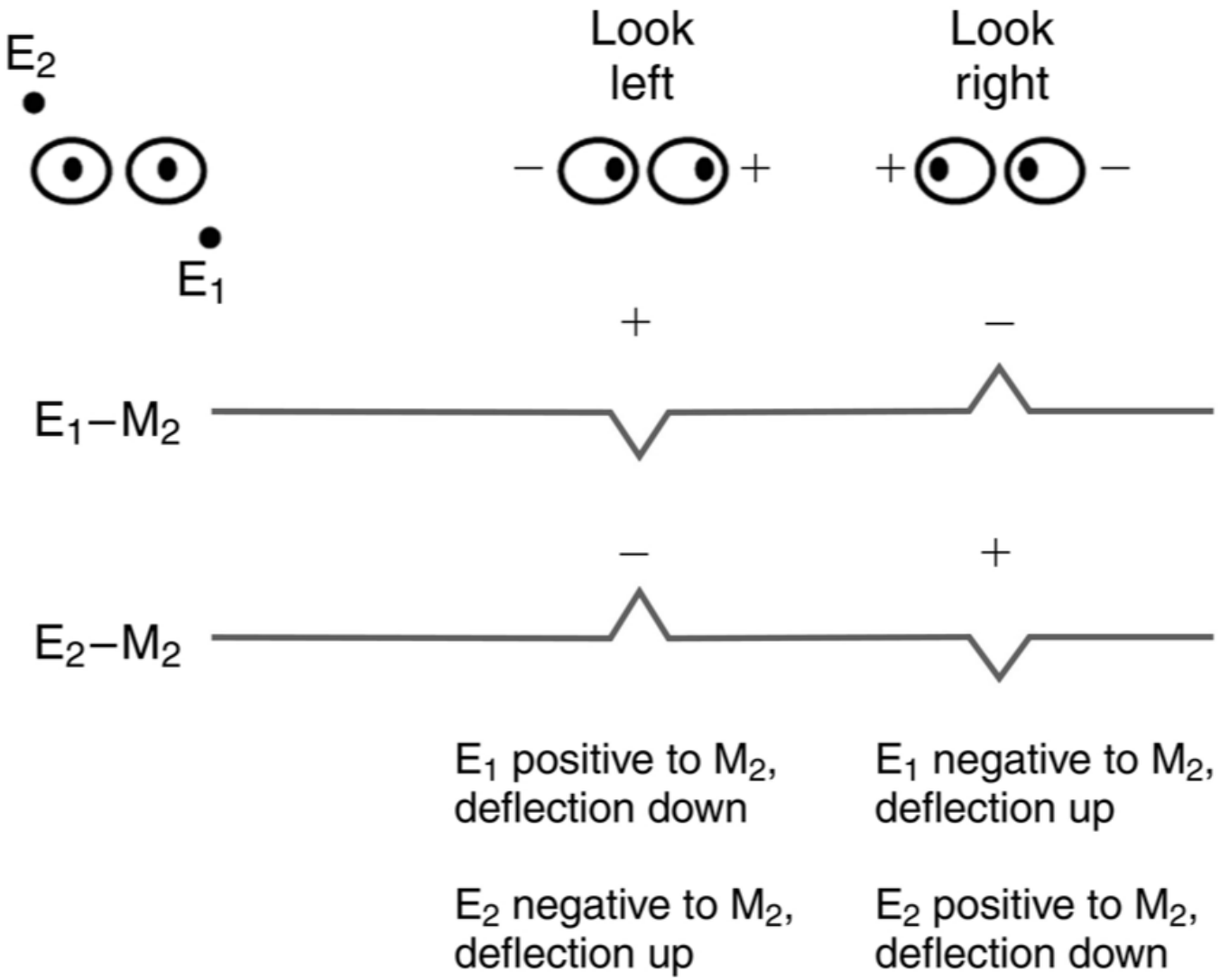
- Fill the electrode cup with EEG cream. Attach electodes with collodion using gauze and air-compressor


Electroencephalography (EEG) monitoring
Electrooculography (EOG) monitoring
Electromyography (EMG) monitoring
Respiratory sensors
Etc

EOG monitoring

- **Recording of eye movements**
  - front (cornea) positive (+)
  - back (retina) negative (−)
- **Recommended**
  - E1-M2 & E2-M2
- **Acceptable**
  - E1-Fpz & E2-Fpz



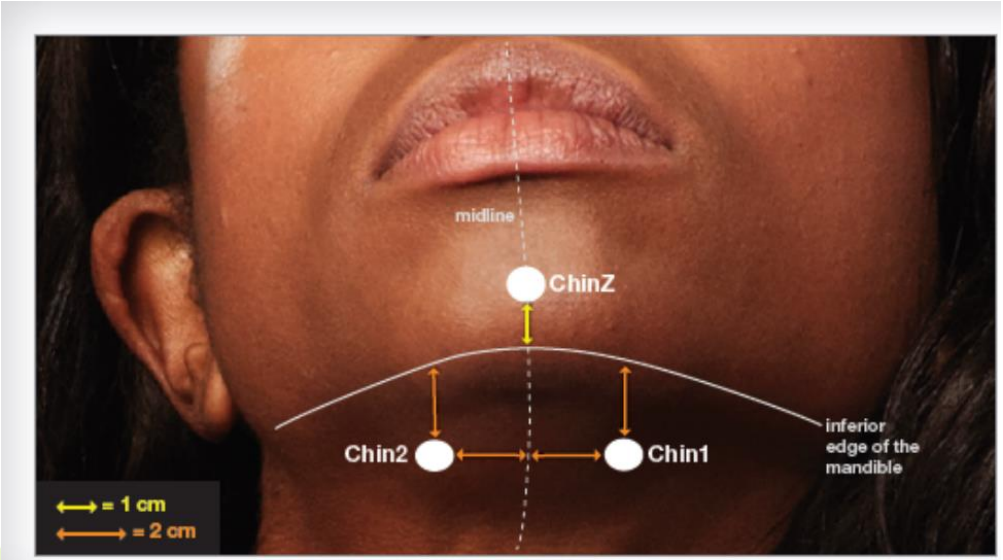

E_2
E_1
Look left
Look right
− +
+ −
+
−
E_1–M_2
−
+
E_2–M_2
E_1 positive to M_2, deflection down
E_1 negative to M_2, deflection up
E_2 negative to M_2, deflection up
E_2 positive to M_2, deflection down

- Electroencephalography (EEG) monitoring
- Electrooculography (EOG) monitoring
- **Electromyography (EMG) monitoring**
- Respiratory sensors
- Etc

Chin EMG monitoring

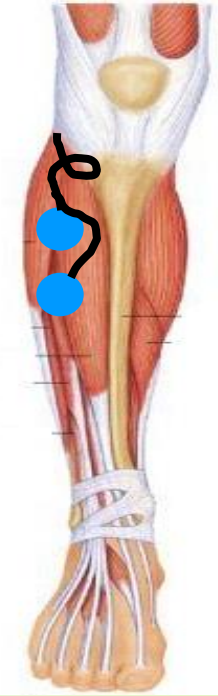
- Recommended
  - Either Chin1-ChinZ or Chin2-ChinZ
  - If Chin1 is faulty : Chin2-ChinZ is used
  - If ChinZ is faulty : ideally it should be replaced.

    If this is not feasible, Chin1-Chin2 can be used



Bilateral leg EMG monitoring

- Recording activity from the tibialis anterior muscles
- Using a gold cup or a silver–silver chloride electrode applied to a clean surface using a tape or electrode glue



- Electroencephalography (EEG) monitoring
- Electrooculography (EOG) monitoring
- Electromyography (EMG) monitoring
- **Respiratory sensors**
- Etc

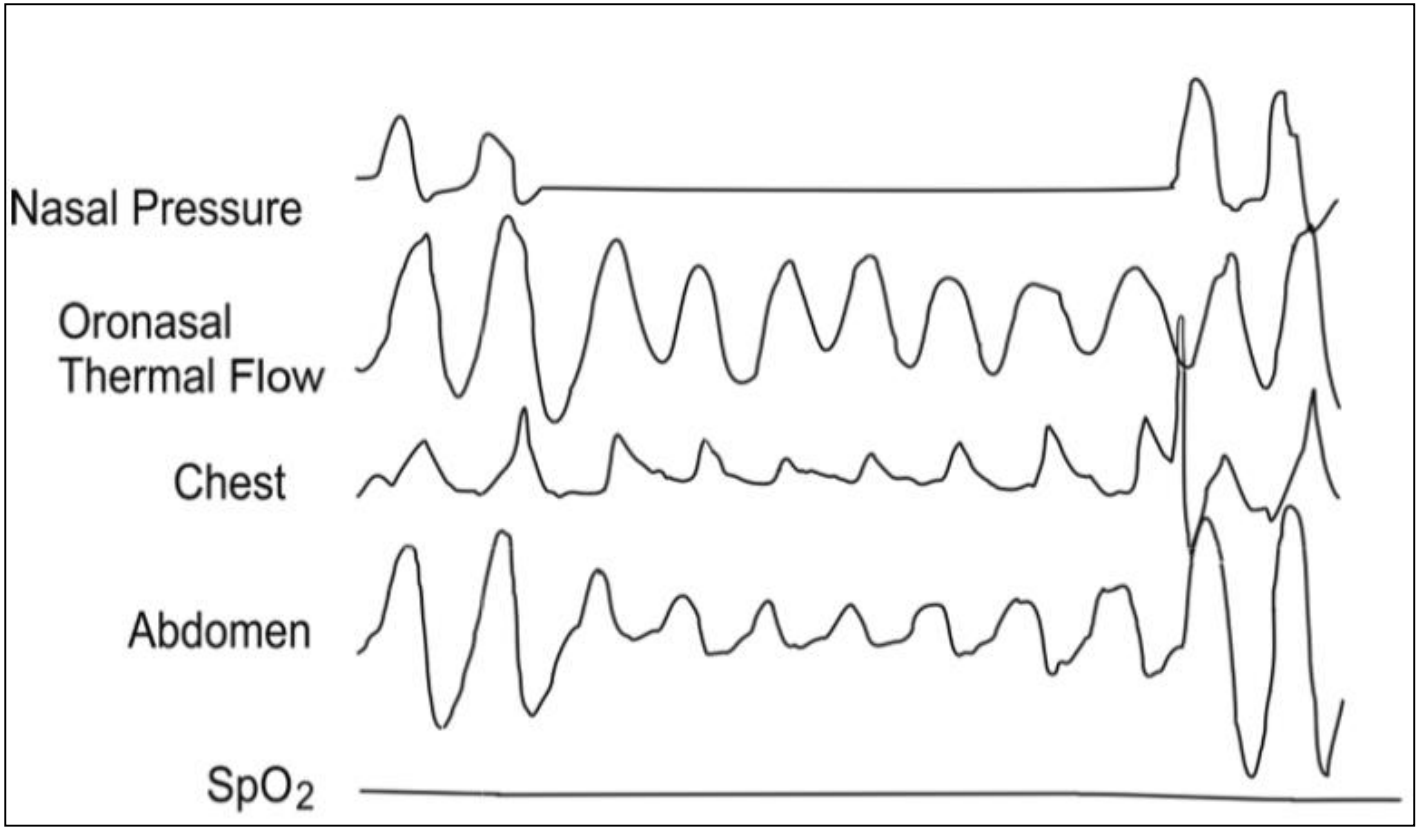
Oronasal thermal sensors

- Detect
  - Either nasal or oral air flow
  - By change in temperature of the sensor
- Limitation
  - Signal is not proportional to the magnitude of air flow
  - Not ideal for detection of hypopneas

Thermistor

Nasal pressure transducer

- Nasal cannula placed in the nares & connected to a pressure transducer
- Underestimates flow at low flow rates & overestimates flow at higher flow rates
  - Square root transformation of the NP signal : more accurate estimate
- Shape of the inspiratory NP waveform
  - Flattening of the signal occurs during air flow limitation



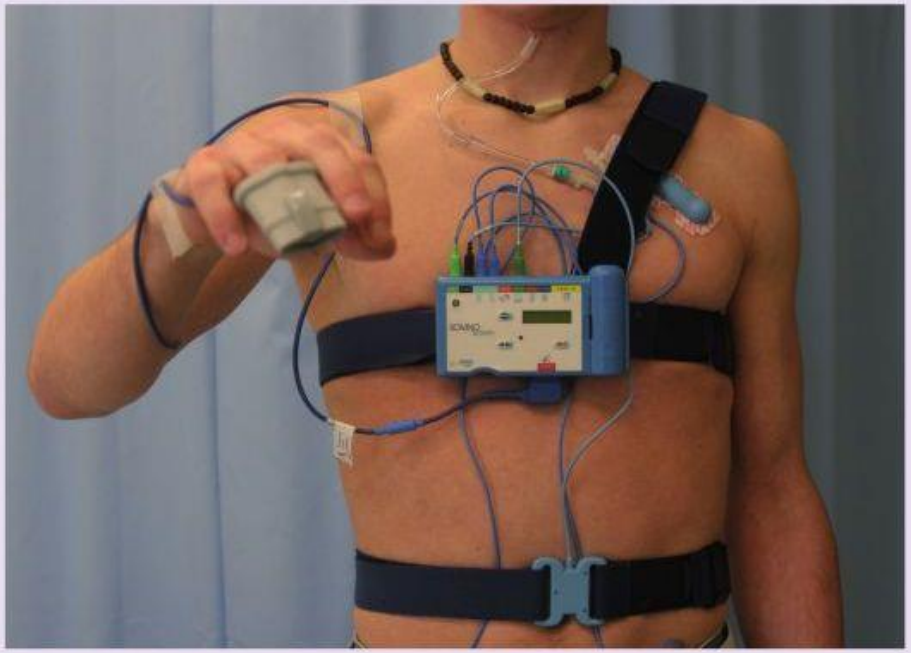
Sleep Medicine Pearls, 3rd edition

* Limitation of NP monitoring
: Mouth breathing during a hypopnea

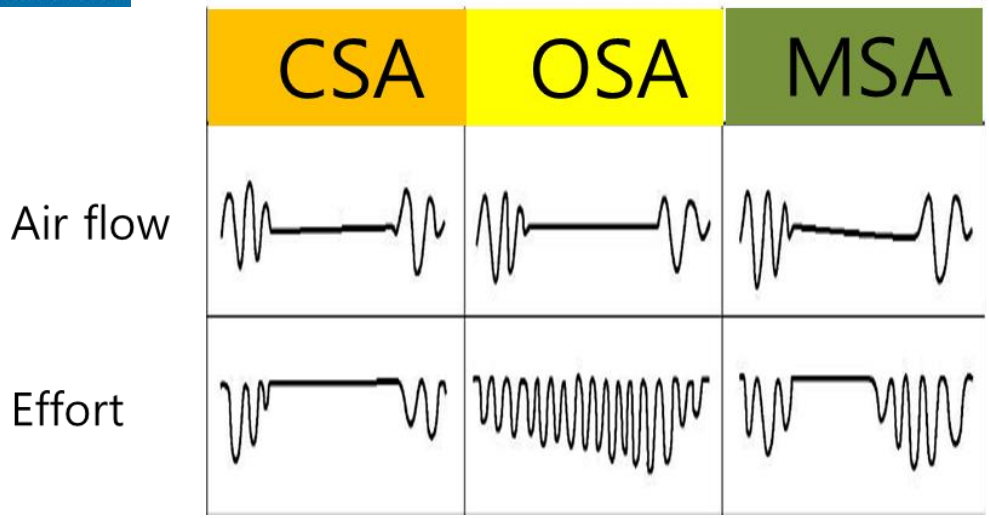
Respiratory effort

- 식도내압측정기
- Dual thoraco-abdominal RIP belts
- Dual thoraco-abdominal PVDF belts

Medscape

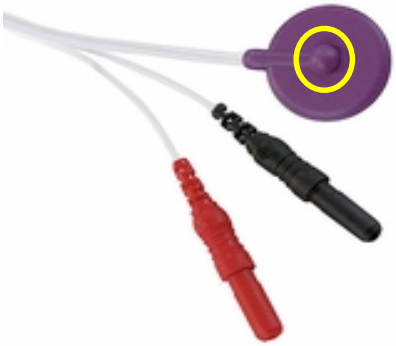


Source: Expert Rev Resp Med © 2011 Expert Reviews Ltd



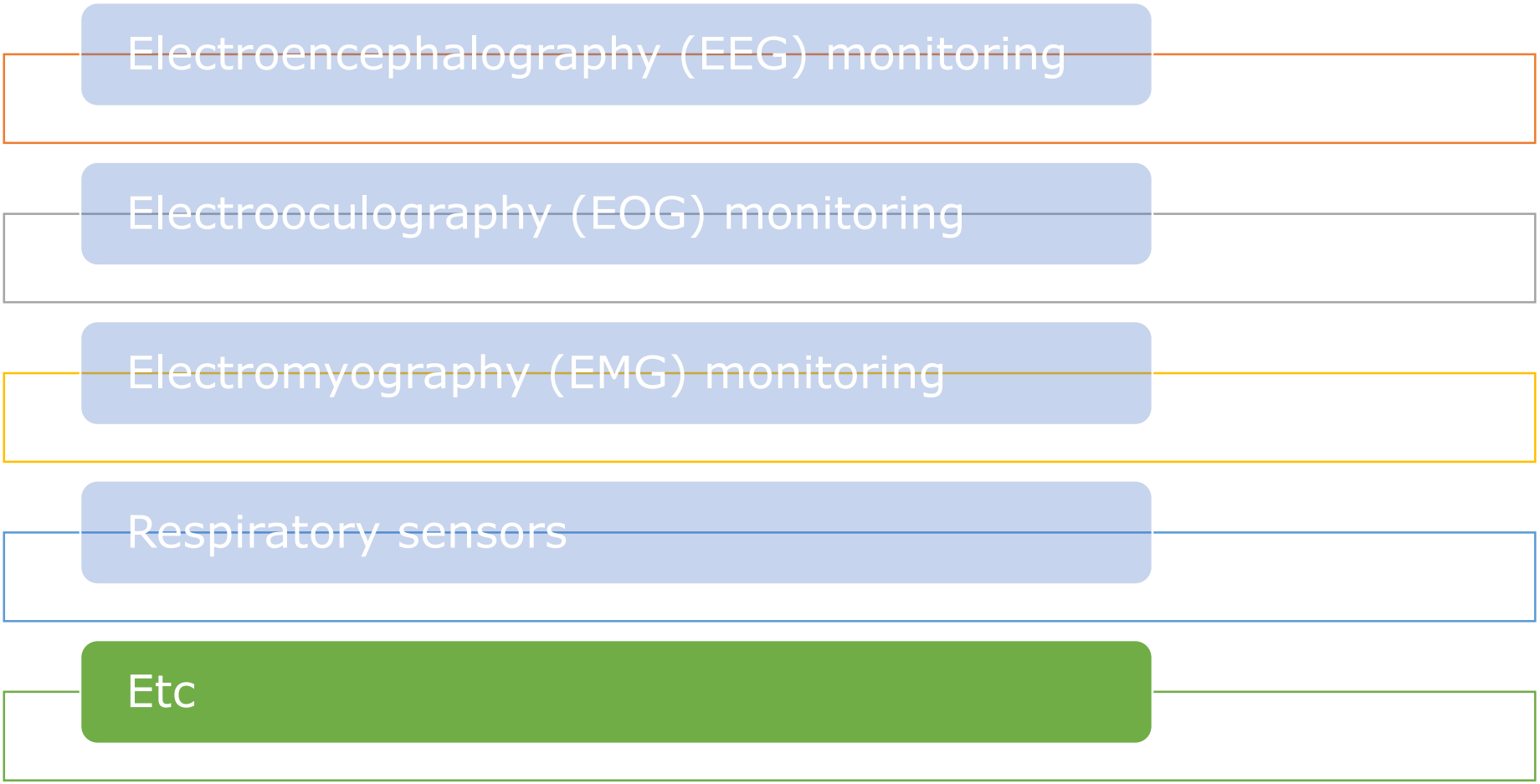
Other respiratory sensors

- **Snoring**
  - 음향 센서 (e.g. 마이크), 압전 센서, 비압력 측정기



- **Oxygen saturation**
  - 산소포화도 측정기

- **Hypoventilation**
  - 동맥혈 PCO2, 경피 PCO2, 호기말-tidal PCO2


Electroencephalography (EEG) monitoring
Electrooculography (EOG) monitoring
Electromyography (EMG) monitoring
Respiratory sensors
Etc

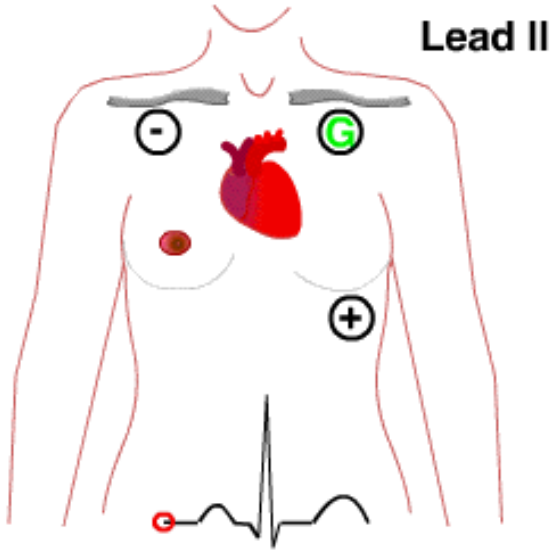
Body position sensor

- Visual analysis by the technologist
- Sensors over one shoulder or chest

Electrocardiogram(ECG)

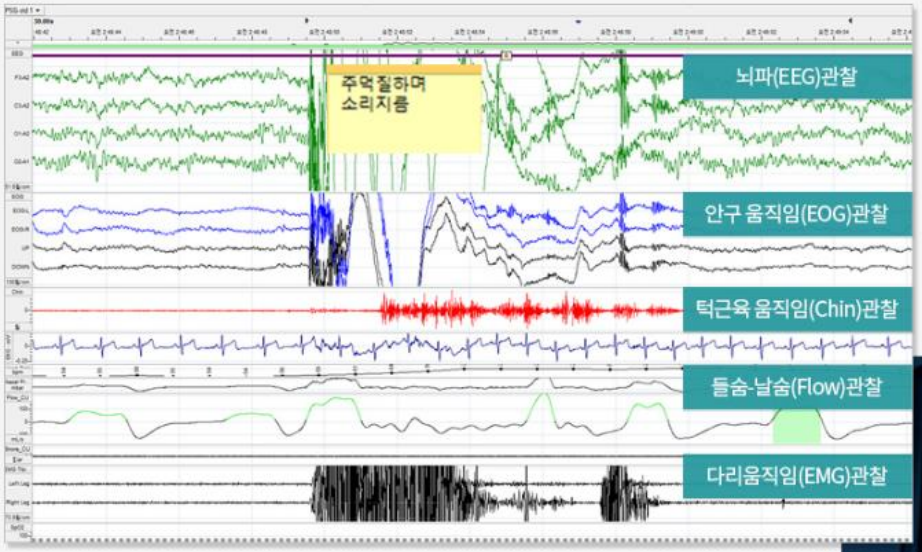
- Single channel, using lead II placement
  - Rt. Arm to Lt. hip

- Cardiac arrhythmias
  - Average HR during sleep
  - highest HR during sleep



Video recording

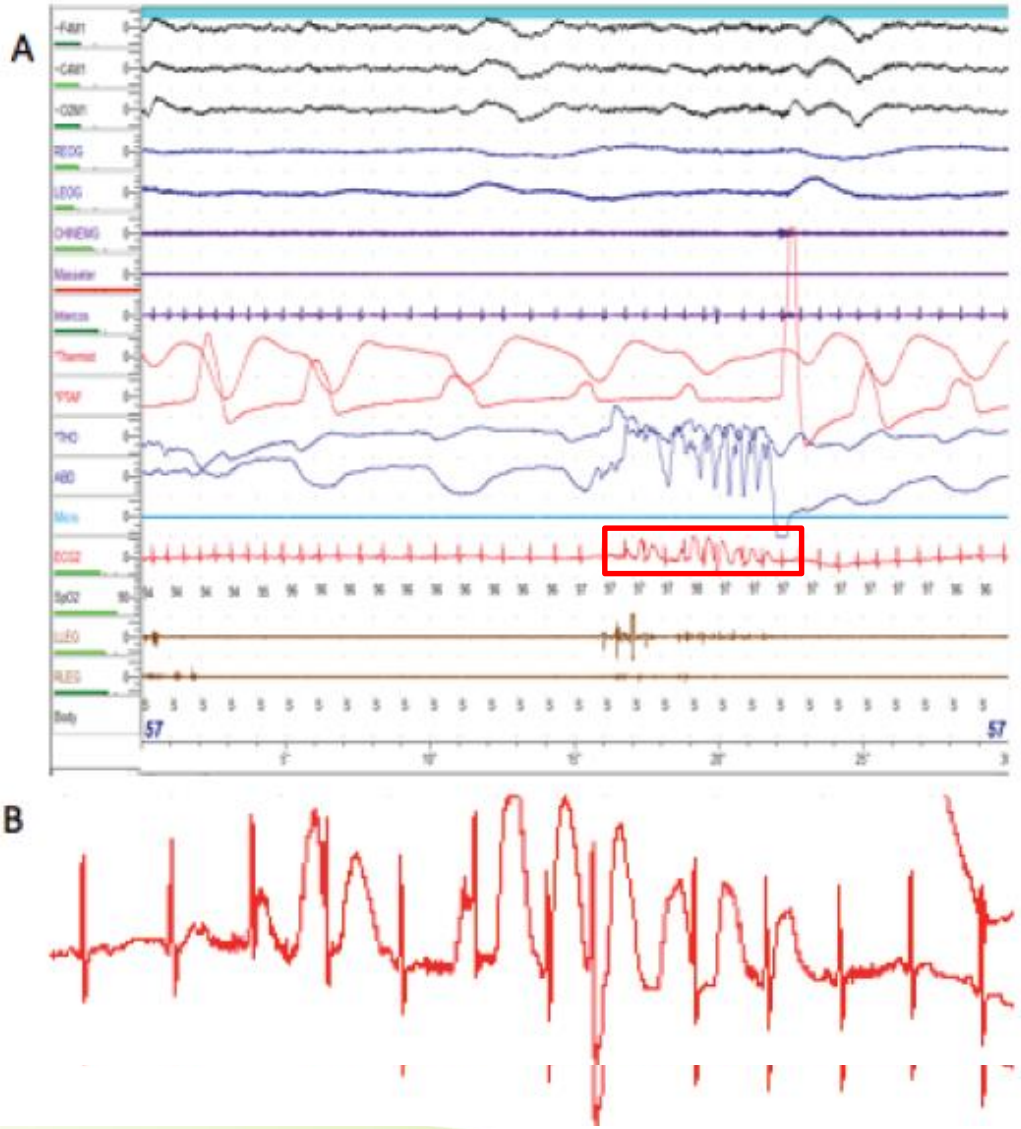
- Check the events during sleep
  - Sleep apnea, periodic limb movement syndrome, sleep walking, sleep talking etc.



수면다원검사

적외선 비디오 녹화

** 30yr-old man, asthma (inhaler), BMI 33,
Cardiac and respiratory exam : unremarkable



Pseudo-VT associated with tremor like movements

→ Evaluation of the video recording for movement & patient clinical status

Journal of Clinical Sleep Medicine, Vol. 9, No. 7, 2013

Calibration

- **Eyes closed for 30 seconds**
  - Ask the patient to close his/her eyes & lie quietly.
- **Eyes open for 30 seconds**
  - Ask the patient to open his/her eyes & look straight ahead.
- **Look right & left**
  - Ask the patient without their head to look to the right then to the left several times.
- **Look up & down**
  - Ask the patient without moving their head to look up then down several times.

Calibration

- **Blink eyes**
  - Ask the patient to blink their eyes 5 times.
- **Clench jaw**
  - Ask the patient clench their jaw.
- **Flex foot**
  - Ask the patient to point & flex their foot. Repeat for other foot. Repeat for each leg and document on study.
- **Breathe in & out**
  - Ask the patient to breathe normally, and then take a breath in and out. Check polarity and mark IN & OUT on study.
- **Snore sound**
  - Ask the patient to imitate a snore sound.

Artifacts

- Any unwanted signal intruding into a channel during a PSG
- Find artifacts, identify the type of artifact, and to correct it
- Artifacts can originate from either the patient or the equipment

Patient-induced artifacts	Equipment-induced artifacts
ECG artifact	60Hz artifact(High Impedance)
Movement artifact	Electrode popping
Sweat artifact	Pen blocking
Muscle artifact	

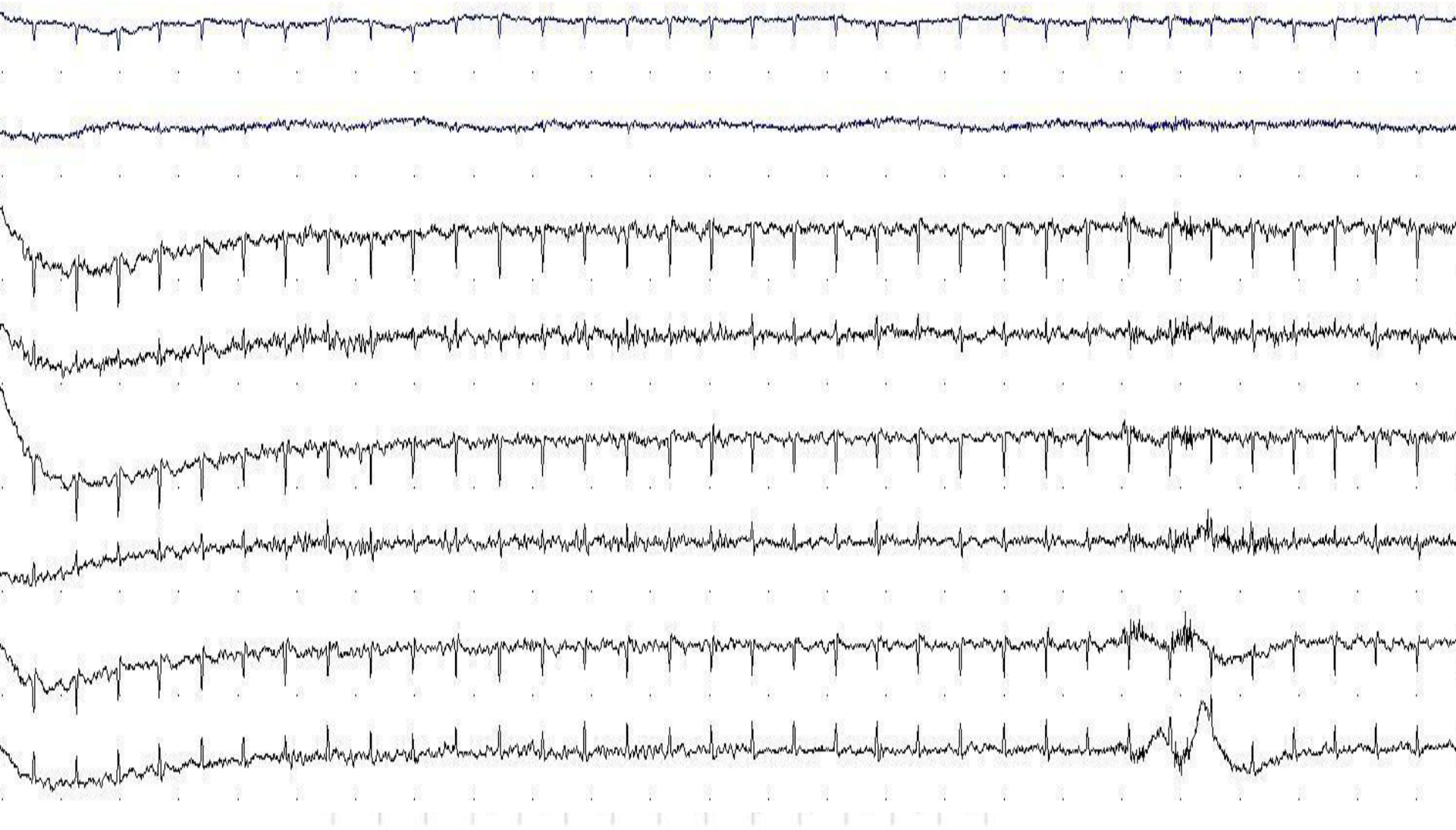
ECG artifact

- 가장 흔하고, 쉽게 알 수 있음, 환자의 심장 박동 빠르기에 맞춰 나타남
- EEG, EOG, Chin EMG, Leg EMG 채널에 나타날 수 있음

- 원인
  - 전극을 정맥이나 동맥 바로 위에 붙이게 되면 생길 수 있다.
  - M1/M2를 Mastoid의 너무 밑에 붙이게 되면, cartoid artery에 근접하게 되고 심장 박동이 EEG채널에 나타날 수 있다.

- 해결
  - Callibration 전 EKG artifact가 나왔다면 M1/M2를 조금 더 위 쪽이나 좀더 귓볼 쪽으로 옮겨 붙여서 제거 할 수 있다.
  - M1/M2 전극을 하나의 전극으로 합쳐지게 만드는 것이다. (montage에서 M1/M2->M+로 바꿔준다.)

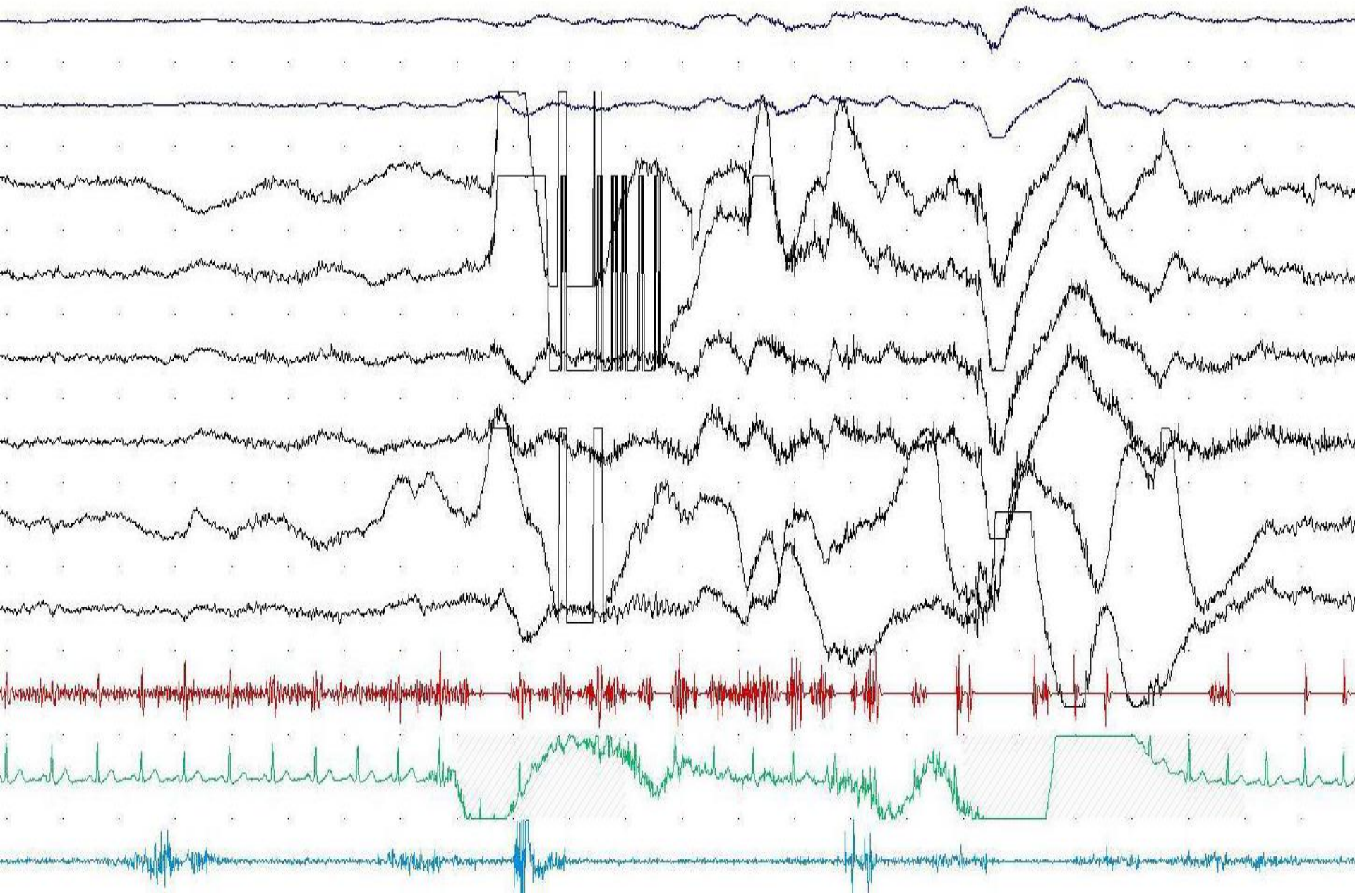
Sharp deflections in the affected leads corresponding to the QRS complex in the ECG lead



ECG artifact in left eye and most of the EEG.
Note how it can be matched up to the ECG channel

Movement artifact

- 수면다원검사 중 가장 흔한 artifact
- 환자가 움직이게 되면 한꺼번에 많은 파가 동시에 나타난다.
- 원인
  - 환자가 잠들기 전 뒤척이는 경우 주로 발생하며, 수면 무호흡이 끝난 후 뒤척이는 경우 발생할 수 있다.
- 해결
  - Movement artifact는 검사자가 바로 잡을 수 있는 것이 아니기 때문에, 환자가 잠들 때까지 기다리면 된다.
  - Hook-up시 타이트하게 잘 했을 경우, 환자의 움직임에 의한 artifact가 덜 할 수 있다.

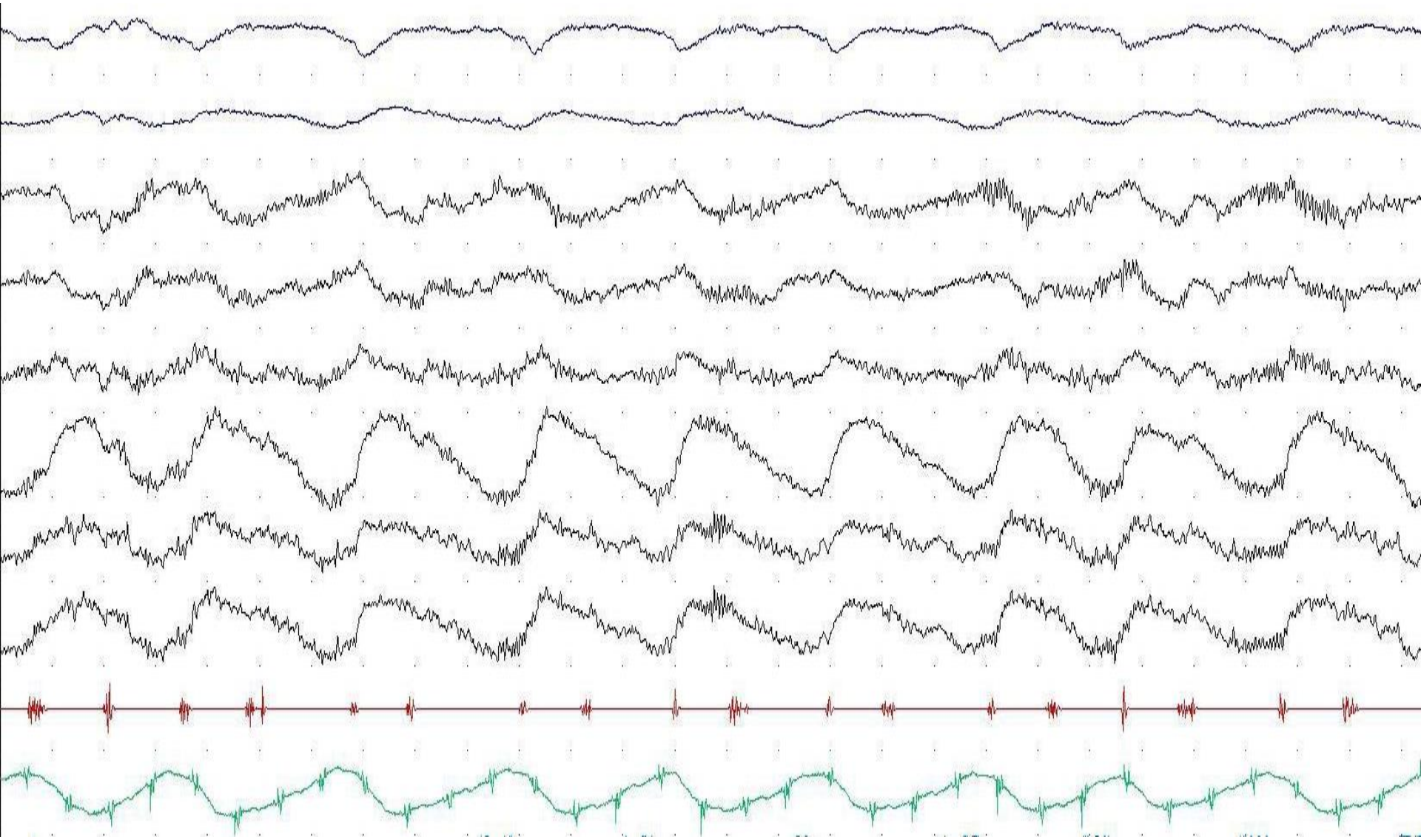


Sweat artifact (slow-wave artifact)

- Sweat (high in sodium chloride)
  - alters the electrode potential, thereby producing an artifact that mimics delta waves and results in overscoring of stage N3

- 가장 영향을 많이 받는 채널은 뇌파와 안전도
  - 환자 이마 Ground 전극이 가장 땀이 많이 나는 곳이기 때문

- 해결
  - 가장 근본적인 해결책은 땀을 없애는 방법으로 환자의 방의 온도를 낮춰 땀을 제거하는 것이다.
  - 이마의 Ground전극을 떼고 땀을 닦아내고 다시 붙이는 방법이다.
  - Sweat artifact는 Low frequency filter 수치를 증가 시키면 원하지 않는 Slow wave를 제거 할 수 있다



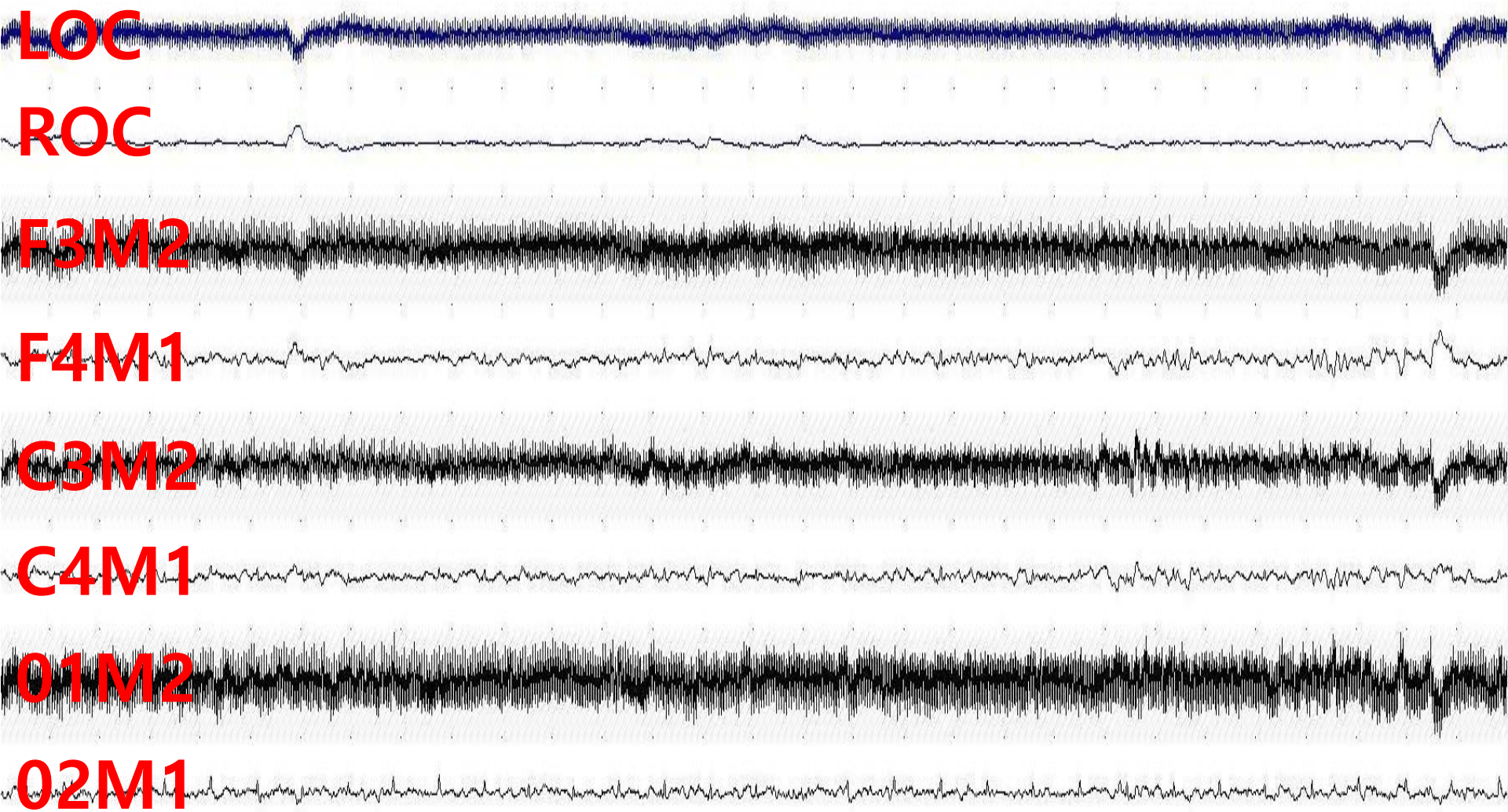
Sweat artifact in EOG, EEG, and ECG.
Notice the uniform artifact of all the channels.

60Hz artifact

- Contamination of the recorded signal with 60-Hz electrical activity from nearby power lines
- Very dense uniform squared off or “rope like” tracing that does not vary

- 원인
  - 전극이 고장 나거나 headbox에 연결되지 않았을 경우
  - 전동침대가 켜져 있을 경우
  - 의치나 금속 종류의 보석을 하고 있는 경우
  - Headbox에 전극이 너무 꽉 끼워져 있거나 TV가 켜져 있는 경우

- 해결책
  - 전극을 다시 붙이는게 가장 좋은 해결책이다.
  - 대부분의 수면장비는 60Hz필터 옵션이 있다. (뇌파에 적용)
  - EEG, EOG 채널에 60Hz artifact가 생겼을 경우 Ground 전극에 문제가 있을 가능성이 가장 높다. (제대로 붙어 있을 경우 전극 불량을 의심)



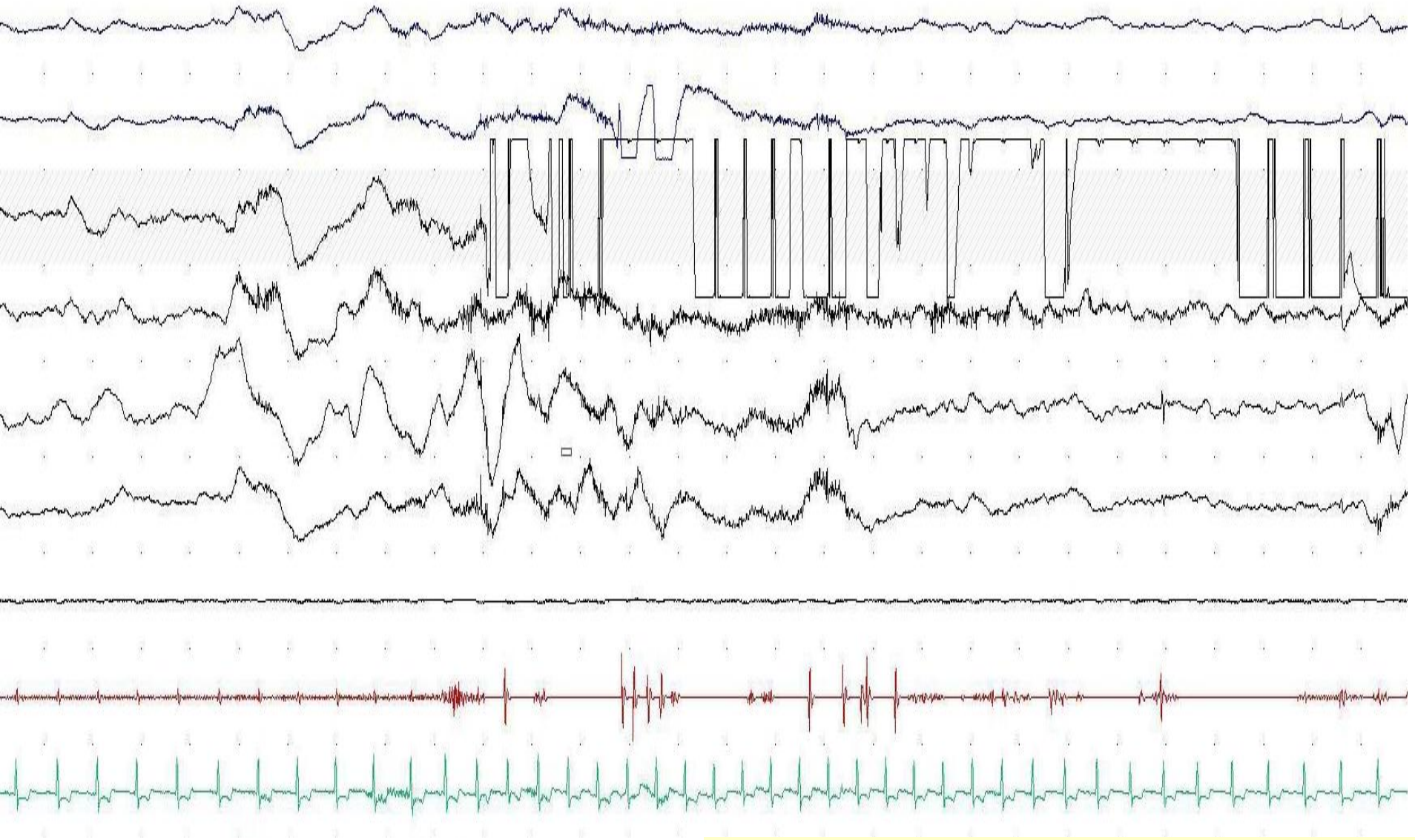
60 HZ in Left Eye, F3, C3, and O1.
The source is the reference lead – M2

Electrode popping

- Common artifact
- Sharp (short duration) high-amplitude deflection secondary to an electrode pulling away from the skin

- 원인
  - 전극이 느슨하게 붙여졌을 경우
  - Headbox에 전극이 느슨히 꽂혀 있는 경우
  - 외부에서 주기적인 전기적 신호를 보낼 경우(예: TV)

- 해결
  - 가장 바람직한 방법은 전극을 다시 붙이는 것이다.
  - 전극이 잘 붙여져 있는지 불량은 아닌지 확인한다.



C3 popping. This lead has either come off the pt or has become damaged.

Summary

- Preparation & risk assessment
- Hook up
  - EEG : International 10-20 system
  - EOG, EMG
  - Respiratory
    - oronasal thermal sensor, nasal pressure transducer, dual thoraco-abdominal belts, snoring, SpO_2, $EtCO_2$
  - Body position sensor, ECG, video recording
- Calibration, check artifacts

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Thank you for listening