Troubles in the Sleep Center
Disclosures

I have no financial relationships to disclose.

And

I will not discuss off label use and/or investigational use in my presentation.
Signal Process

Patient to headbox

• Three sources for PSG signals:
  – Bioelectrical potentials
  – Transduced signals from sensors attached to the patient
  – Signals derived from ancillary equipment
Electrodes

Biopotential

- Ranges from millivolt to microvolt
- Conductors
- Non-conductors
- Type of conductive material
  - Matched

![Image of electrodes with different materials: Tin plated, Tin (pure), Silver, Silver/Silver chloride, Gold plated.](Image)
Headbox

- Portable interface system which allows multiple different inputs to be organized in a fashion to be quickly connected and disconnected
Connecting Cable

- Analog system used shielded cables, because the cables could act as antennae and pick up interference (artifact).
  - Usually limited to 100 feet in length
- Digital systems, digitize signal in room and send over unshielded cable
  - Less interference > 100-150 feet in length
  - Fiber optic
    - Beams of light
      - Faster
      - Greater distances
Selector Panel

• Means of selecting two inputs out of a larger matrix of possible inputs prior to leading into the amplifier

• Digital systems
  – Select via software
Amplifier

• **Differential Amplifier**
  – Amplifies the difference between two inputs
  – Can adjust the degree of amplification
    • **Gain**
      – Straight multiplication (volume knob on stereo)
    • **Sensitivity**
      – Inverse relationship
      – Sensitivity = µV/mm

• **Filters**
  • Hide unwanted frequencies
Common Mode Rejection (CMR)

• This is the process of two like signals canceling each other out.

• If voltage is applied simultaneously to both inputs of the differential amplifier

• then common mode rejection occurs
  – Reduces display of unwanted signals
CMR

- \( C_3M_2 = C3 - M_2 = \text{output} \)
  - \((C_3 + \text{Noise})\) minus \((M_2 + \text{Noise})\) = output
- \( C_3 = 85 \) and noise = 15
- \( M_2 = 10 \) and noise = 15
- \((85 + 15) - (10 + 15) = \)
- \((85 + 15) - (10 + 15) = 85 - 10 = 75 \mu V\)
- \((C4 - C4) = 0\), flat line
Filters

• Low Frequency (LFF) High Pass
  – Less than

• High Frequency (HFF) Low Pass
  – Greater Than

• Notch filter (60 cycle)
Adjusted filter settings

Stage 2

HIGH FREQUENCY FILTER 35  LOW FREQ. 3

NO HIGH FREQUENCY FILTER

LOW FREQUENCY FILTER 5
AC Amplifier

- AC means alternating current and is capable of producing more complex wave forms.
- To ensure proper polarity
  - Input one is the active electrode (i.e. C₃ or LOC)
  - Input two is the reference electrode (i.e. A₁)
- Due to time constant, signal will always return to baseline
- AC amplifiers are used to produce tracings like EEG, EKG and EMG.
DC Amplifier

- Time constant is set to infinity so signal does not decay
- DC amplifiers are typically used to record slower moving signals such as pulse oximetry, CPAP pressures, esophageal pressure, or NPT
Nothing works

• Computer problem
• Communication issues
• Software problem
• Amplifier issue
Computer

• No power
  – Possible causes?
  – Solutions?

• No display
  – Causes?
  – Solutions?

• Software hangs
  – Causes?
  – Solutions?
Straight Power

Power backup
Communication errors

• Disconnected cable
• Device is not powered
  – May need to reset card
• Connection
  – Firewall
  – Bad Port or computer card
Software problem

- Software hung up
  - Reboot
- Virus or adware
- Corrupted files
Equipment problems?

• Power down and reset
• Check connections
• If possible switch working amplifier with poor communicating
Multiple lead failure

- All leads
  - Amplifier may not be communicating
    - Check connections
    - Reset amp
    - Amp failure
  - Software hung
    - Reboot computer
- Ground Electrode
- Referential Electrode
- Electrical Interference
- Some but not all leads.
  - Headbox or connecting cable partially disconnected
  - Bad cable or headbox
Ground Electrode

• Safety
• Provides electrical zero
• Poor ground
  – Exploring electrode pairs will not have zero point
  – May lead to artifact
Referential

• Assists in the cancellation of noise
• Chin₁-Chin₂
• Chin₁-Chin₂ = output
  – Chin₁--R
    R--Chin₂
    =Chin₁-Chin₂
  – Chin₁--R
    R--Chin₃
    =Chin₁-Chin₃
So what happens if referential is bad?
Referential Electrode

- Single most important electrode
- Low impedance
- Is most effective equidistant to all exploring electrodes
  - Cz good site
- Some systems have inputs for two referential inputs
- Some systems allow user to manually assign reference electrode
Single tracing

• Bad signal
  – Is it lead or equipment?

• If M1 is bad and M2 is good
  – Switch leads within head box
    • If bad signal moves to M2
      – Most likely bad electrode or poor electrode application
    • If bad signal remains in M1
      – Problem with equipment
        » Headbox
        » Cable
        » Amplifier
Poor tracings

• High resistance
  – Electrode cups inadequately filled with conductive paste
  – Electrode damage
  – Electrode wire damage
  – Poor patient skin preparation
  – Electrode Mismatch

• Artifacts
Artifacts

- Physiological
  - Movement
  - Muscle
  - Sweat
  - Respiratory
  - ECG
  - Pacemaker

- Mechanical
  - Electrode Pop
  - 60 cycle interference
  - Snoring
  - Miscellaneous equipment problems
    - Cable disconnect
    - Faulty equipment
Movement

• Appearance
  – Very high muscle activity
    • Small movements
  – Squared off slow waves
    • Large body movements
    • Repositioning of body
Movement (cont)

• Differentiate
  – Movement artifact is typically associated with or following a body movement

• Causes
  – Loose or high impedance electrode
  – Temporary large amplitude muscle activity

• Correction
  – Allow patient to settle after movement
  – Replace or reapply electrode
Muscle

• Appearance
  – High frequency, fast duration
  – Varying amplitude
  – Often appears in EEG and EOG signals
  – May be unilateral
  – Most commonly seen in the waking patient
    • Immediately following wake
    • Disappears with or shortly after sleep onset
Muscle (cont)

• Differentiate
  – Difficult to distinguish from 60 cycle interference

• Cause
  – Muscle tension
  – Patient clenching jaw

• Correction
  – Have patient relax jaw or slightly open mouth
  – May need to replace or reapply electrode after rescrubbing electrode site
Sweat

• Appearance
  – Very low frequency sway or rolling in baseline
  – Usually generalized over the EEG
  – May appear unilaterally

• Differentiate
  – Does not correlate with respiration
Sweat (cont)

• Cause
  – Electrode paste is diluted
  – Possibility of salt bridge

• Correction
  – Control the environment
  – Cool the patient
  – Wipe area between electrodes with alcohol or antiperspirant
Respiratory

• Appearance
  – Rhythmic slow wave
  – In phase and time synced to respiratory rate
  – May be localized to the side of the head that the patient is lying on

• Differentiate
  – Distinguish between sweat artifact
Respiratory (cont)

• Cause
  – Loose electrode
  – Movement artifact due to electrode moving in association with patient’s breathing

• Correction
  – If only on one side, reference to electrode on contralateral side
  – May need to replace or reapply electrode after rescrubbing electrode site
ECG

- **Appearance**
  - High voltage, rhythmic spike in sync with ECG R wave
- **Cause**
  - Electrode placed over fatty tissue that conducts ECG signal
ECG (cont)

• Correction
  – Reposition affected mastoid electrode onto mastoid bone.
  – If still persists reapply electrode to ear lobe
  – Still persists and ECG is in both mastoids, may link the mastoids
    • Note: This will result in an attenuation of the referenced pair amplitude
      – Also eliminates the back up capabilities of having two mastoids.
        » If one goes bad, it will be reflected in both mastoids.
    • It is better to link by software verses by physically jumping the electrodes.
Pulse

• Appearance
  – Low amplitude, rhythmic rounded alteration in normal baseline activity
  – Seen in EEG and EOG
  – Same frequency as heart rate

• Cause
  – Electrode is placed directly over a blood vessel

• Correction
  – Reposition electrode off a blood vessel
Pacemaker

• Appearance
  – Very high amplitude spike seen on several unrelated recording channels
    • Seen in EEG, EOG and EMG
  – Same frequency as heart rate if continuously on or sporadically if an on demand pacemaker

• Cause
  – Electrical interference from pacemaker

• Correction
  – This type of artifact can not be eliminated
Snore Artifact

- Snores can cause artifact in EMG channels
60 cycle Interference

• Appearance
  – Fast regular sinusoidal waves resulting in a thick dark signal which can obscure an EEG tracing
  – Caused by high or unequal impedances, poor connection, broken lead, or current leakage in the room

• Differentiate
  – Speed up tracing to 60mm/sec
    • Cycles are occurring at 1 per mm or 60 per second
  – Distinguish from muscle artifact

• Causes
  – Loose or high impedance electrode
  – Lack of ground electrode on patient
  – Electrical interference from electrical appliances
60 cycle (cont)

• Correction
  – Replace or reapply electrode after rescrubbing electrode site
  – Verify that a ground electrode is in place with an acceptable impedance
  – Turn off or unplug, any unnecessary equipment or lights
  – If artifact can not be eliminated may be necessary to use the 60 Hz filter to obtain a usable recording
• Heated CPAP hose
• Heating pad
Electrode Popping

- Appearance
  - Sharp, high amplitude deflection, that usually boxes off
Electrode Pop

• Cause
  – Loose electrode
  – Poor electrode impedance
  – Insufficient or dried out conductive paste
  – Pulling on wire
  – Something touching electrode

• Correction
  – Replace or reapply electrode after rescrubbing electrode site
Oximeter artifact
Electrode Bridge

• Appearance
  – Significantly reduced amplitude, may even be a flat line
  – Slowly drifting baseline
• Differentiate
  – Distinguish from sweat
• Cause
  – Sweat
  – Excess electrolyte connecting two electrodes
• Correction
  – Clean the area between electrodes
Loss of CPAP flow

• Connection to CPAP?
  – NO
    • Check power on AOM
    • Check connection to computer
    • Check connection from AOM to CPAP
    • Check Connection to CPAP in patient’s room

• DC inputs working correctly?
  – Send cal signal through PC direct
If receiving this signal then hardware working, pt may be mouth breathing
Bipolar deep brain stimulation permits routine EKG, EEG, and polysomnography

Abstract—As the population of patients treated with deep brain stimulation (DBS) grows and the patients age, more will require routine or emergent electrophysiologic tests. DBS artifact may render these uninterpretable, whereas stopping DBS may release symptoms that confound evaluation. The authors find that monopolar, but not bipolar, stimulation produces significant artifact during EKG, EEG, and polysomnography.

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Robert C. Frylinger, PhD; Mark Quigg, MD, MSc; and W. Jeffrey Elias, MD
• What is the difference between monopolar and bipolar?
• From our own recording montage, what are examples of each?