Recognizing, Evaluating, and Minimizing Artifacts

Robertson Chapter 10

Introduction

- Webster's Medical definition = ECG and EEG wave that arises from sources other than heart or brain
  - Too basic of a definition for PSG
- Early recognition and evaluation is essential
  - Must be corrected in timely and accurate fashion
  - Also must determine when artifacts can't be eliminated without jeopardizing data
- Artifact-free recording starts with proper electrode prep and placement

Introduction

- Ensure accurate signal processing through using a quality system and optimal amplifier settings
- Vigilant watch of the recording integrity is important

Electrode and Sensor Application

- Typically, the tech applies:
  - EEG, EOG, ECG and EMG electrodes
  - RIP belts
  - Airflow pressure sensor
  - Thermal airflow sensor
  - Snore sensor
  - Oximeter probe

Electrode Application Methods

- Collodion
  - Pros:
    - Very stable application
    - Fewer artifacts
  - Cons:
    - Highly flammable
    - Irritating to upper respiratory tract and mucous membranes
      - Should be applied in well ventilated area
  - Must be stored in cool, dry area
    - Often in a vented fireproof container

Electrode Application Methods

- Conductive paste
  - Pros:
    - Nontoxic
    - Requires no special storage or air-handling procedures
  - Cons:
    - Not as stable as collodion
    - Increased likelihood for artifacts
  - Use gauze to hold head electrodes in place
  - Use hypoallergenic tape for face and body

Electrode Removal

- Acetone is used to remove collodion
  - Must be stored in cool, dry location
  - May need to be kept in vented, fireproof cabinet
  - Be careful around patient's eyes, nose, and mouth
  - Be careful if patient has respiratory disease because of the fumes
- Paste removal requires no special chemicals
  - Best for patient to take a hot shower after study, let hot water run over them for a few minutes before applying shampoo

Gloving

- Gloves should always be used during direct patient contact
  - Use during electrode site prep, electrode application, and electrode removal
- If latex gloves are used, check with patient regarding allergies
  - Should have non-latex alternatives
- May have to wear multiple layers of gloves when using acetone and collodion as they can break down gloves
- Use new gloves for each patient

Electrode Site Preparation

- Assess patient's skin
  - Is the patient sensitive to adhesives?
  - Does the patient have a skin condition?
- Prepare skin using skin prep lotion with abrasive material
  - Helps remove oils, skin care products, and dead skin cells
  - Only prep contact area for electrode
    - Prepping larger area can lead to signal contamination and salt bridge artifact
      - Salt bridging = Excessive conductive material and electrodes in close proximity communicating
  - Be careful not to be too excessive with abrasion

Electrode Composition

- Electrodes should be composed of gold, silver, or silver-silver chloride
- Gold cup electrodes are gold-plated silver
  - Be careful not to scratch or crack as this causes artifact
- Avoid mixing electrode materials within a derivation
  - Will lead to distortion of recorded data
  - Leads to electrical potential differences

Electrode Impedance

- Check prior to and during acquisition
- Should be under 5,000 Ohms
- If impedances are imbalanced, CMR becomes ineffective
- Low impedance value
  - Very low = May be contact with another electrode due to excess gel, paste, or skin prep, sweat, or another electrolyte liquid
  - Check if impedance less than 1,000 Ohms

Electrode Impedance

- High impedance value
  - Need more conductive material between electrode and skin
  - Electrode needs cleaned
  - Bad electrode wire
  - Electrode popping
  - Makes recording more prone to 60 Hz interference
- Make sure connections are secure in head box

Differential Amplifier

- Amplifies difference between 2 input signals
  - Electrical difference between its 2 inputs
- Typically housed in head box
- CMRR = Ability of an amplifier to reject in-phase potentials and amplify out-of-phase potentials
  - Defining feature of differential amplifier
  - Input 1 = Exploring electrode
  - Input 2 = Reference electrode

Filters

- Allow manipulation of signals to attenuate artifacts
  - Should only be used as a final option as they change appearance of data
- LFF
  - Attenuates frequencies approaching, at, and below cut-off frequency
    - If at 1 Hz, a 1 Hz input will show 80% of original amplitude
      - Faster signals will show > 80% but < 100% of original amplitude
      - Less than 1 Hz will show < 80% of original amplitude
  - Changes time for amplitude to decay back to baseline

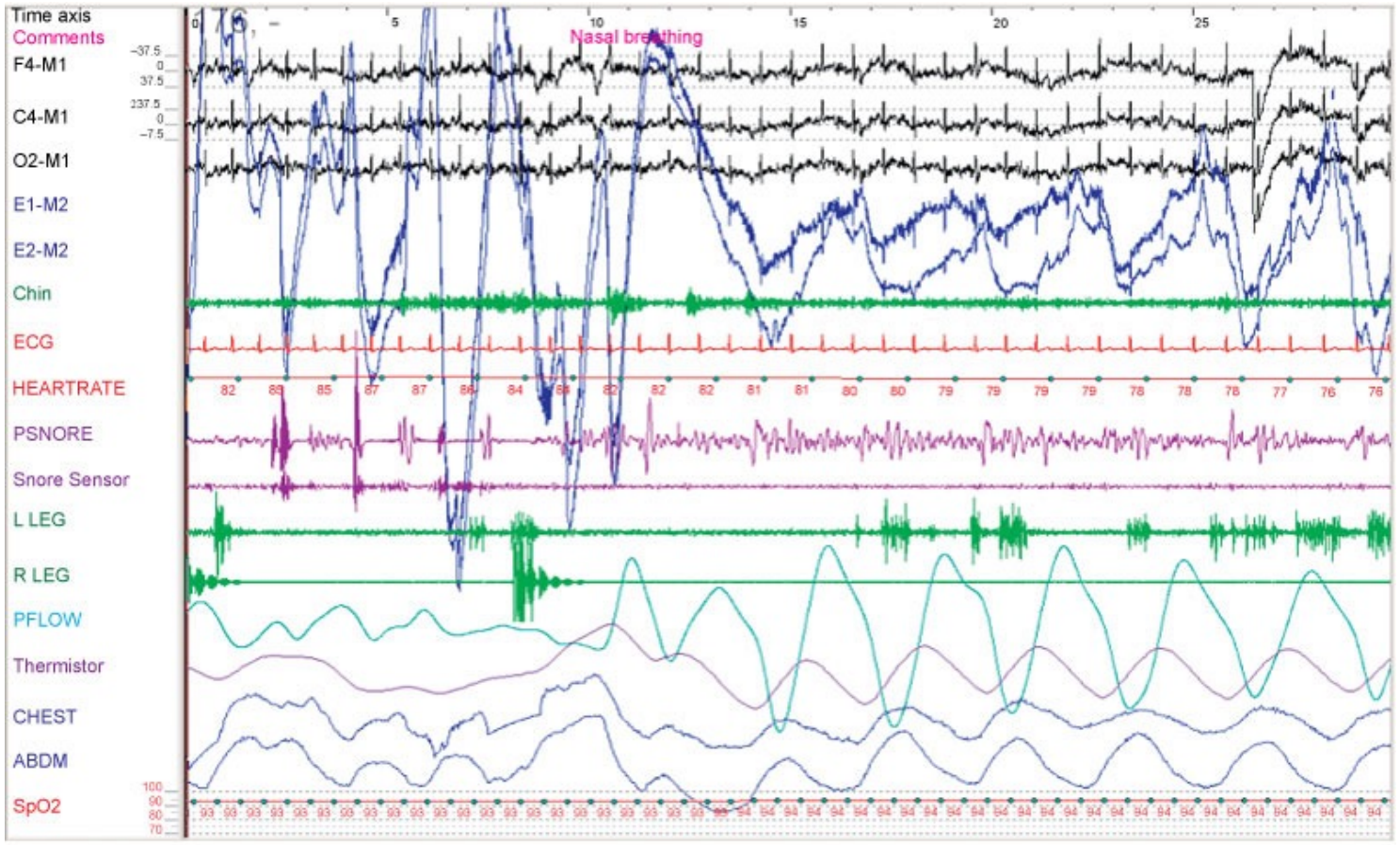
Filters

- HFF
  - Attenuates frequencies approaching, at, or above cut-off frequency
  - Effect mirrors LFF
- 50/60 Hz Filter
  - Designed to minimize data associated with electrical current interference
  - Also known as “line filter” or “notch filter” as it is designed to “notch out” frequencies surrounding line noise

Artifact Isolation

- Determine if issue is in more than 1 channel
- Is the artifact mechanical or physiological?
- Is the electrode loose?
- Is the lead wire intact?
- Is there enough conductive material?
- Is there a short circuit?

What is the Source of the Artifact?



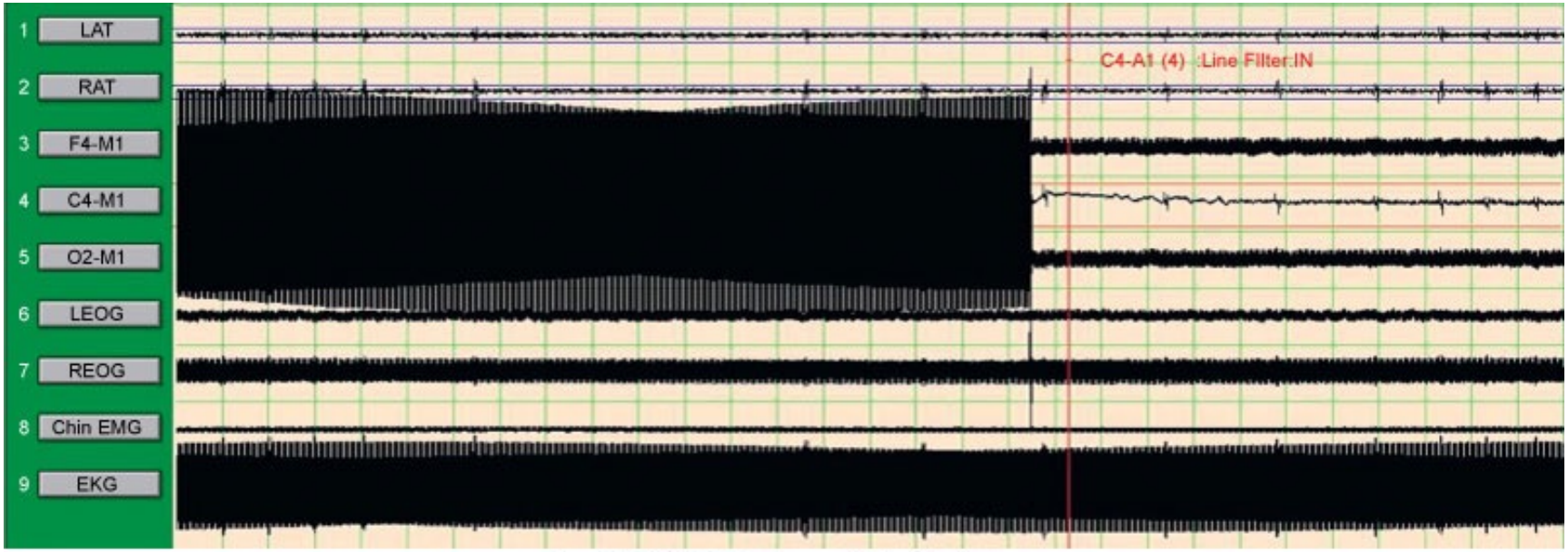
Line Frequency Artifact

- Electrical current noise
- Common artifact
  - May be unavoidable if current is strong
  - Usually seen in bioelectric channels but sometimes seen in transduced channels
    - If seen in all bioelectric channels, typically is a bad ground electrode
- May appear in 1 channel or all channels
  - Uniform in appearance
- Activating 60 Hz filter will make this artifact disappear but should be last resort

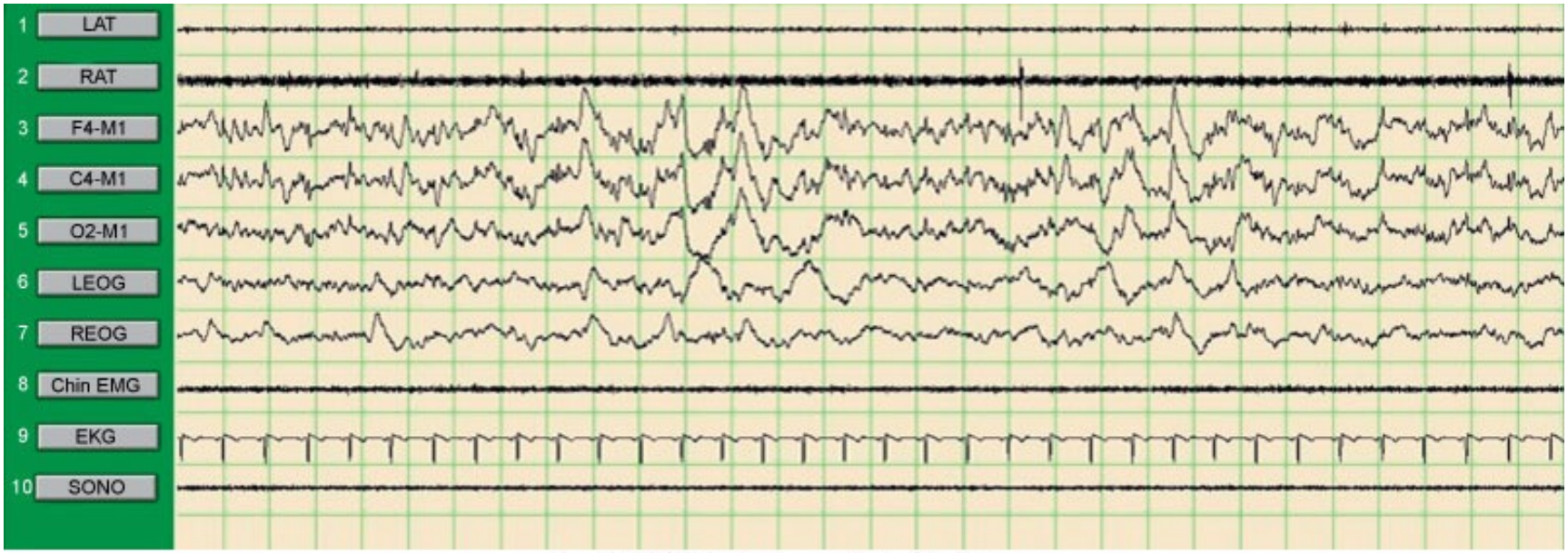
Line Frequency Artifact

- If impedance good, amplifier may be picking up ambient leakage from nearby sources
  - Typically this affects all channels
- AASM recommends that line filter not be used on EMG
- Not all fast artifacts are 60-Hz line noise

Ambient Signals with Head Box Disconnected



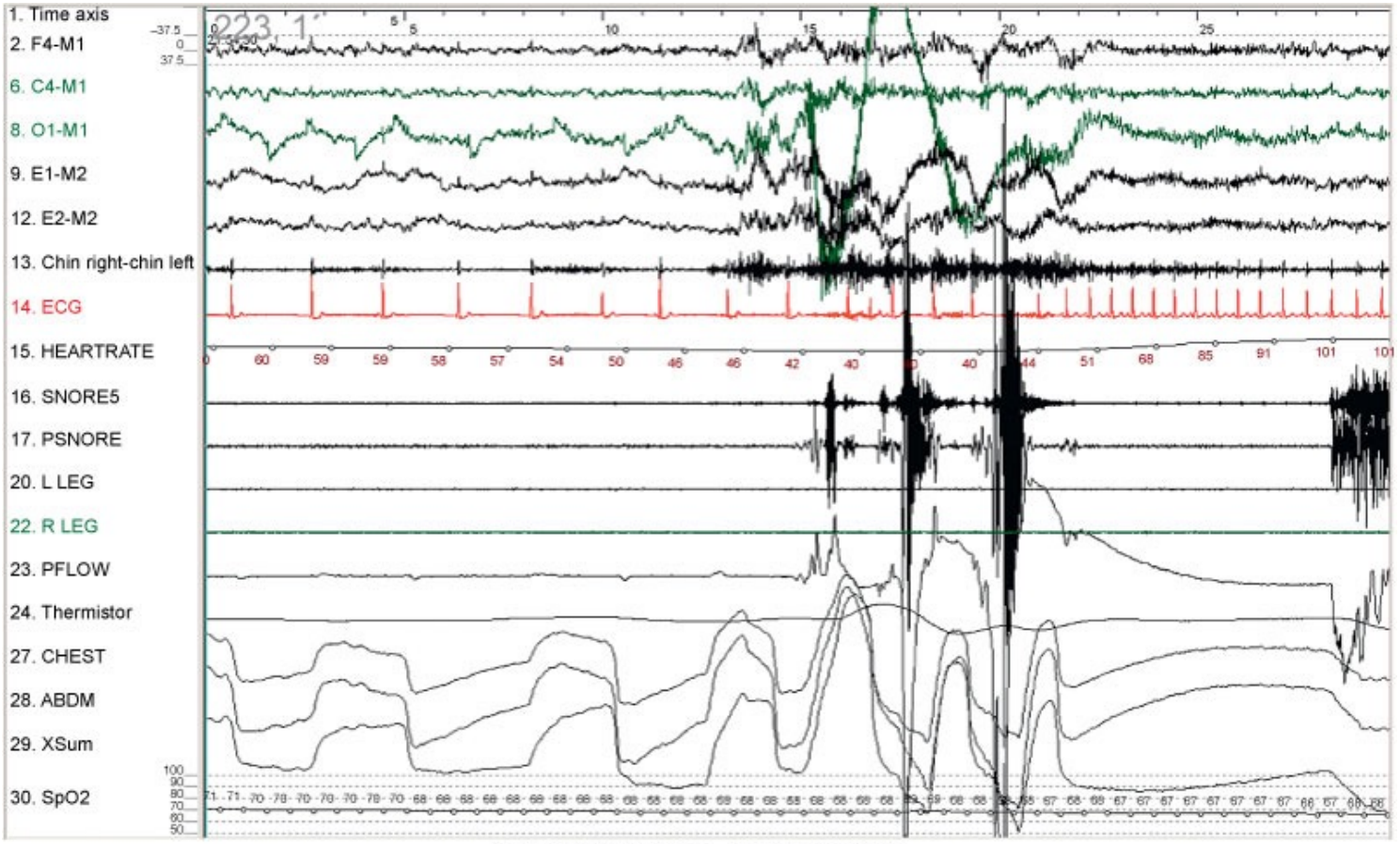
High Frequency Artifact on RAT



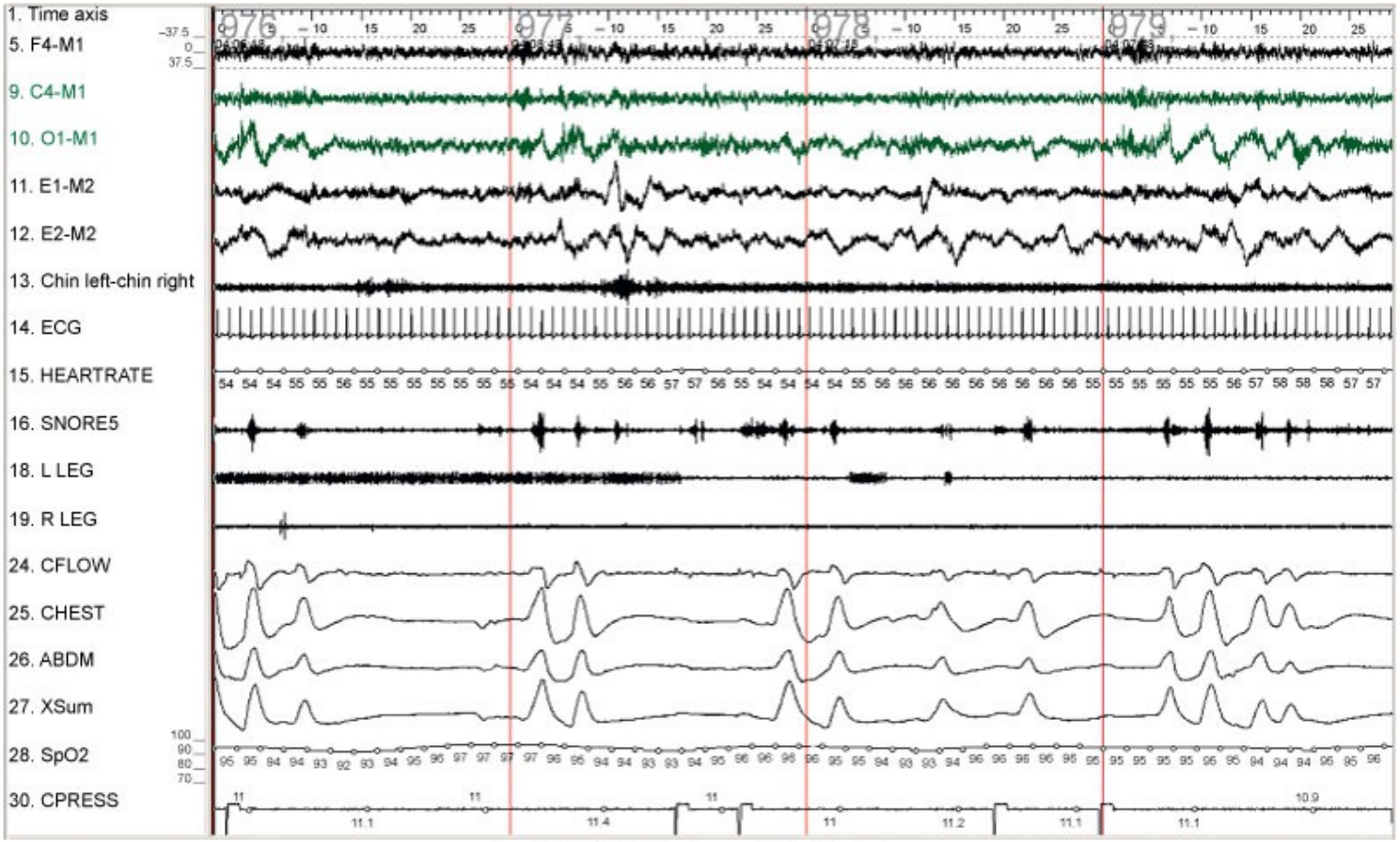
Muscle Artifact

- Typically appears in EEG, EOG, and occasionally ECG
- Generated by localized muscle activity/ tension
  - Has frequency of 20-200 Hz
  - May look a lot like 60 Hz artifact
  - May disappear at sleep onset
- Abdominal effort
  - Reduce gain/sensitivity so signals are not overlapping

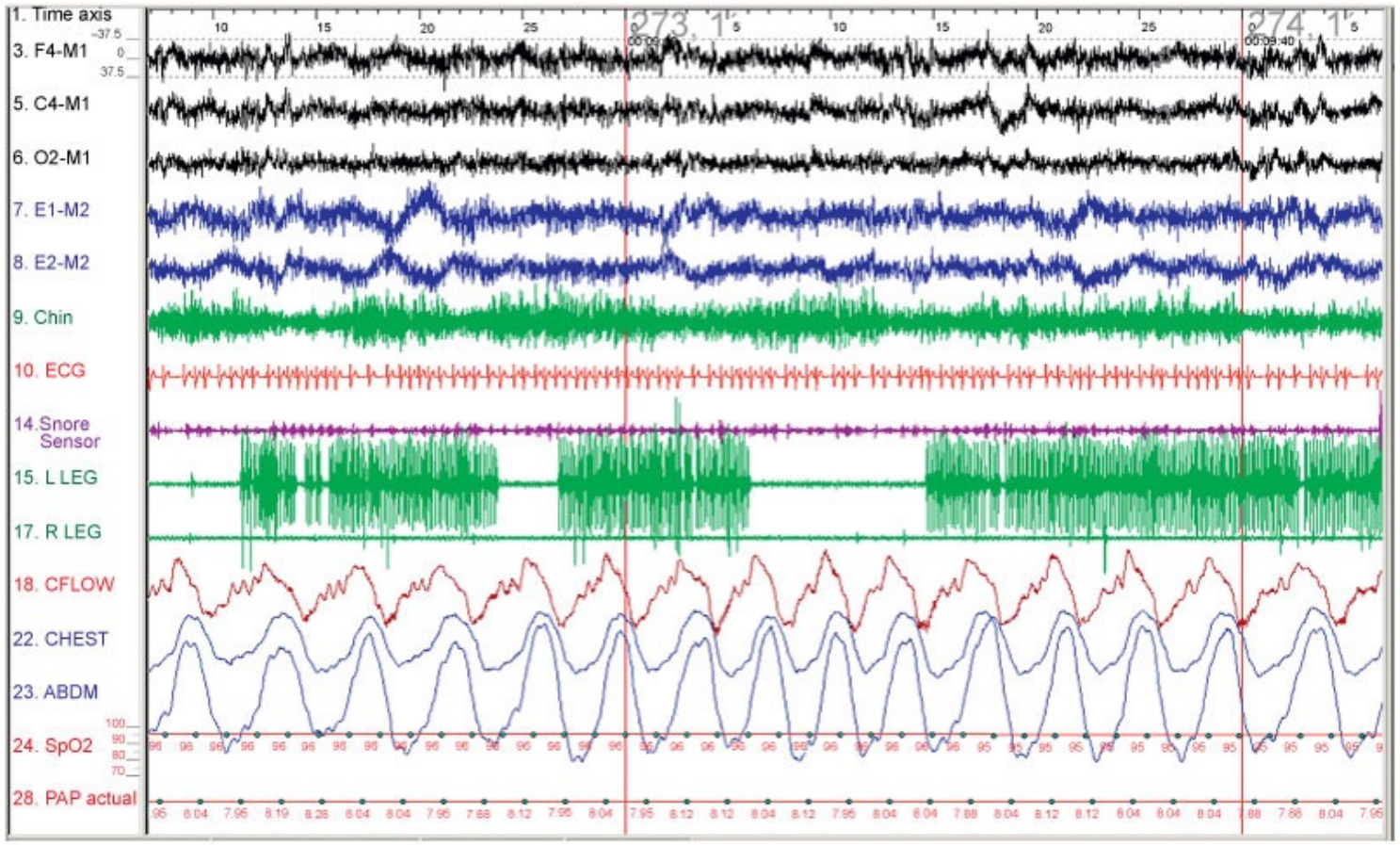
Respiratory Event with Muscle Artifact



Leg Cramps

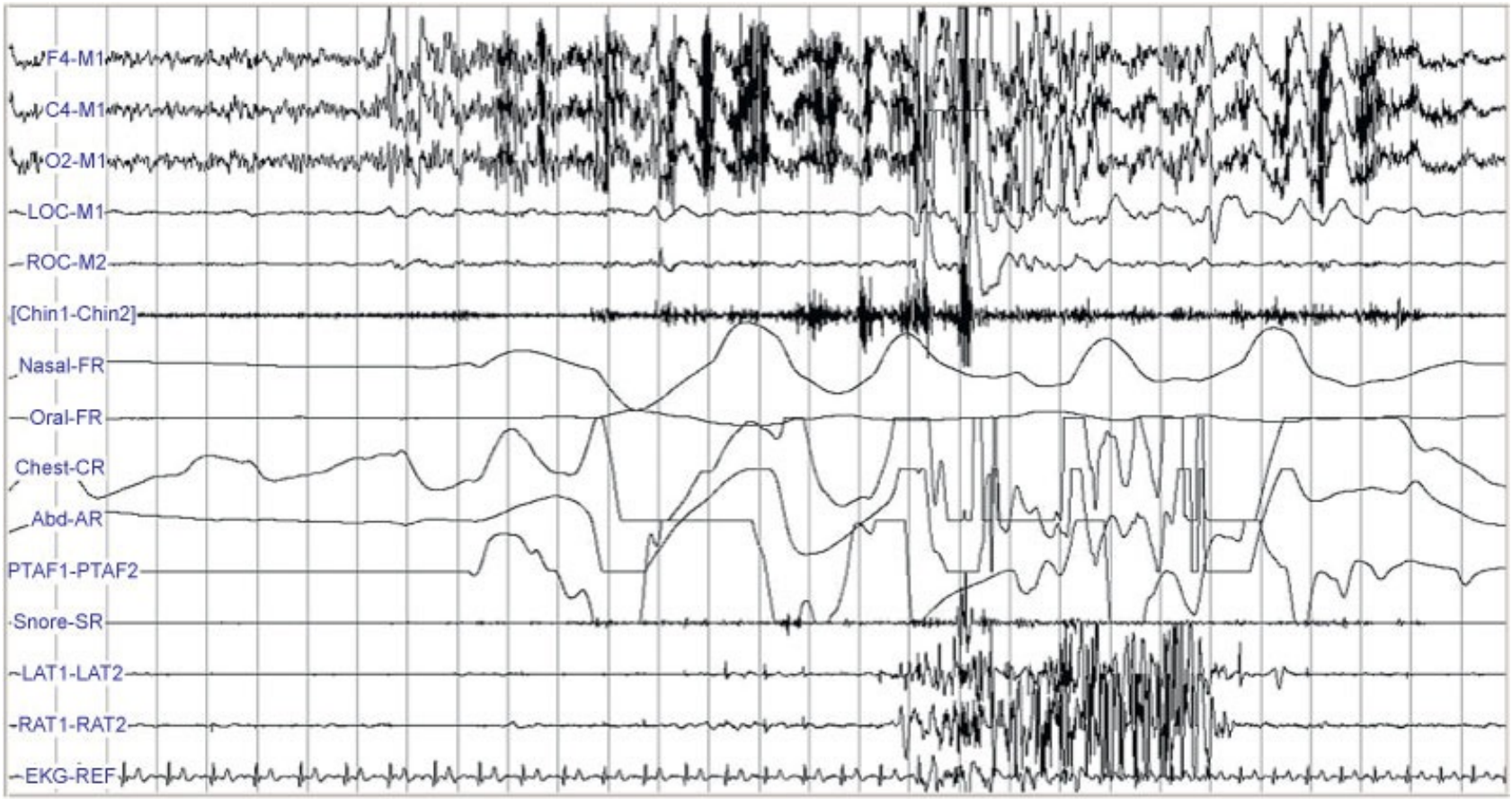


Leg Cramps

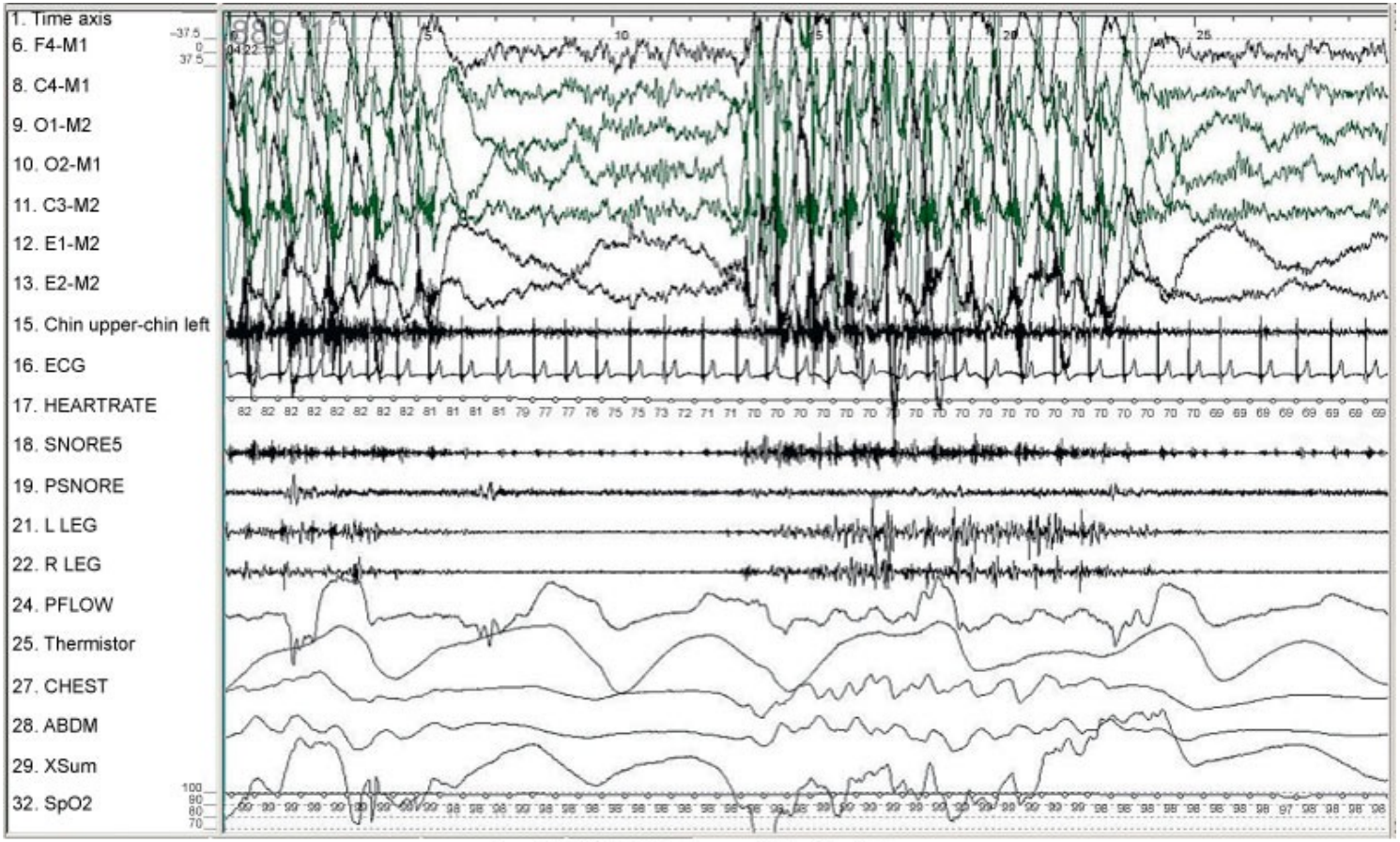


Bruxism

EEG Arousal



Body Rocking



ECG Artifact

- Common artifact
- Typically seen in EEG, EOG, and EMG
- Amplitude may be increased due to impedance imbalance between inputs 1 and 2
- This will present often in obese patients because adipose tissue is much better conductor than muscle
  - Take care to not place M1, M2 on soft, fatty tissue
    - But still ECG artifact may not be avoidable
- Can link or “double reference” the 2 reference electrodes to minimize ECG artifact

ECG Artifact

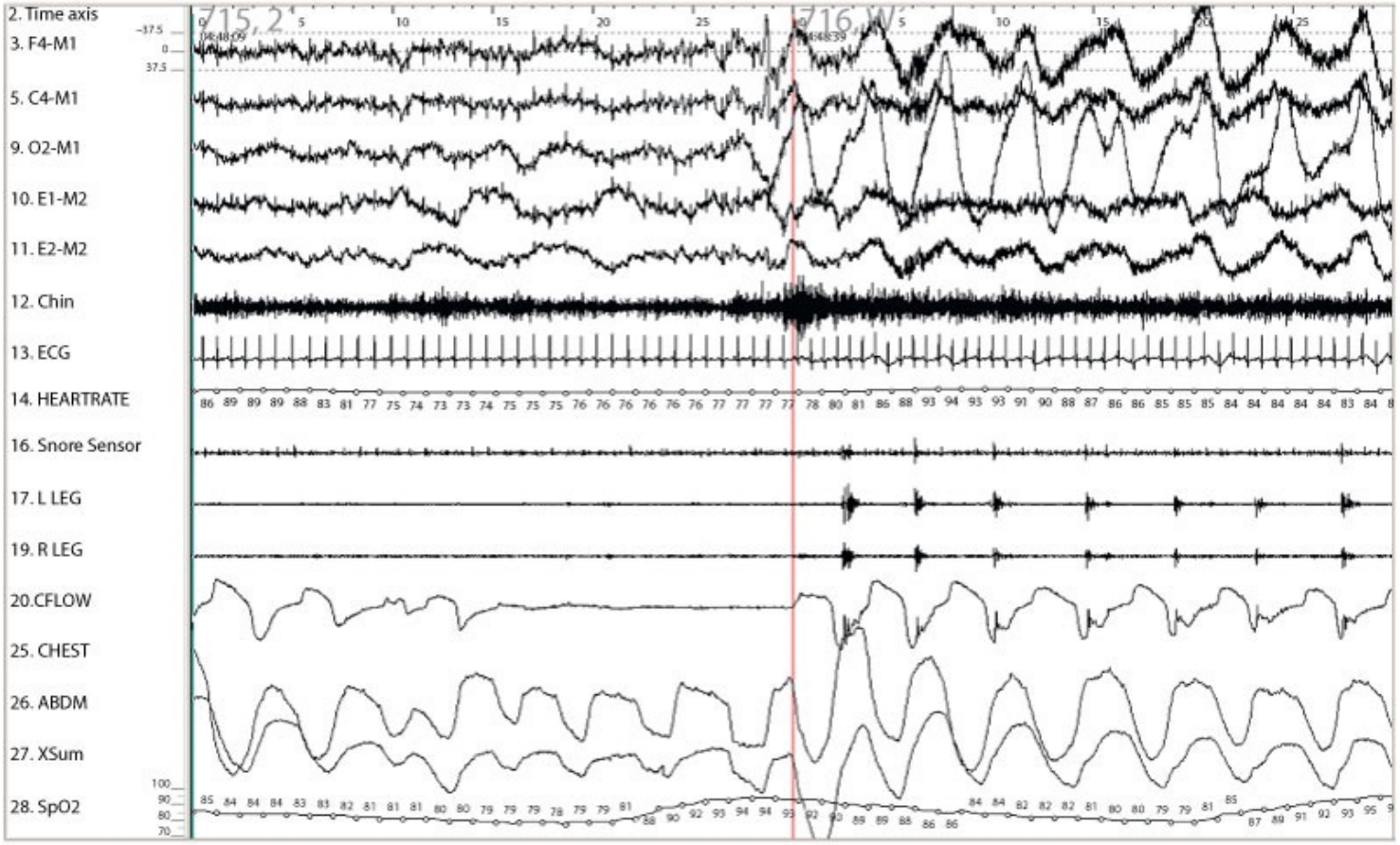
Slow-Frequency Artifacts

- Usually result of perspiration or body movements associated with breathing
- Typically seen in EEG or EOG
- Very high amplitude, 1-2 Hz or slower in frequency
  - May look like N3 sleep
- Sweat artifact
  - Perspiration can loosen electrodes and dilute conductive gel/paste between electrode and skin
  - May need to reaffix electrodes and cool patient down
    - Cooling patient down may take several minutes
  - Salt bridge occurs when sweat communicates between 2 electrodes

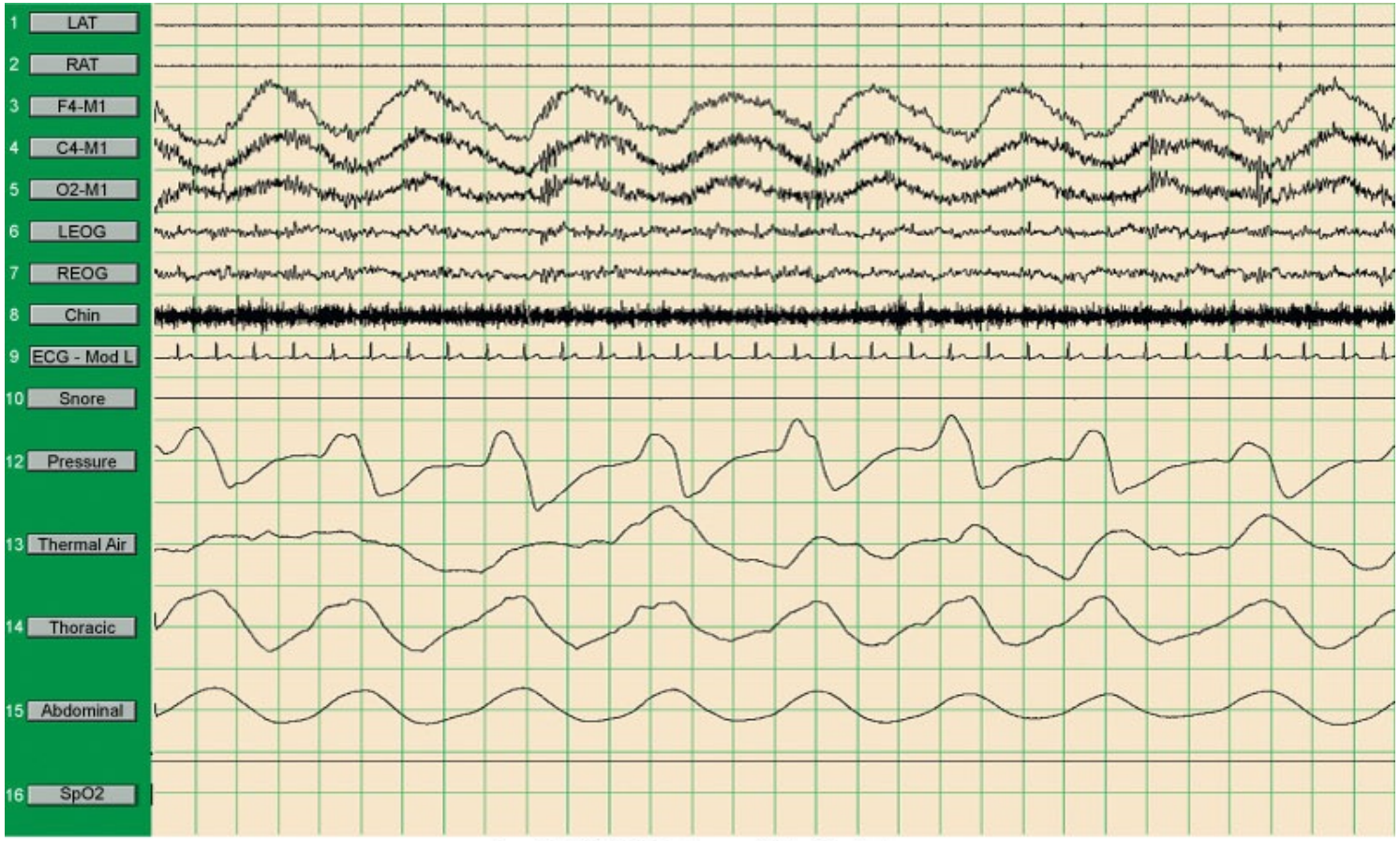
Respiratory Artifact

- Typically recorded from electrodes around scalp and face
- Synchronous with patient's breathing rate and rhythm
- May be caused by:
  - Bed moving along with patient breathing
  - Unstable input board moving in sync with breathing
  - Electrode wires next to patient moving with each breath
  - Often patient is lying on the affected electrode
- May resolve with patient repositioning or replacing electrodes

Slow-Frequency Artifact



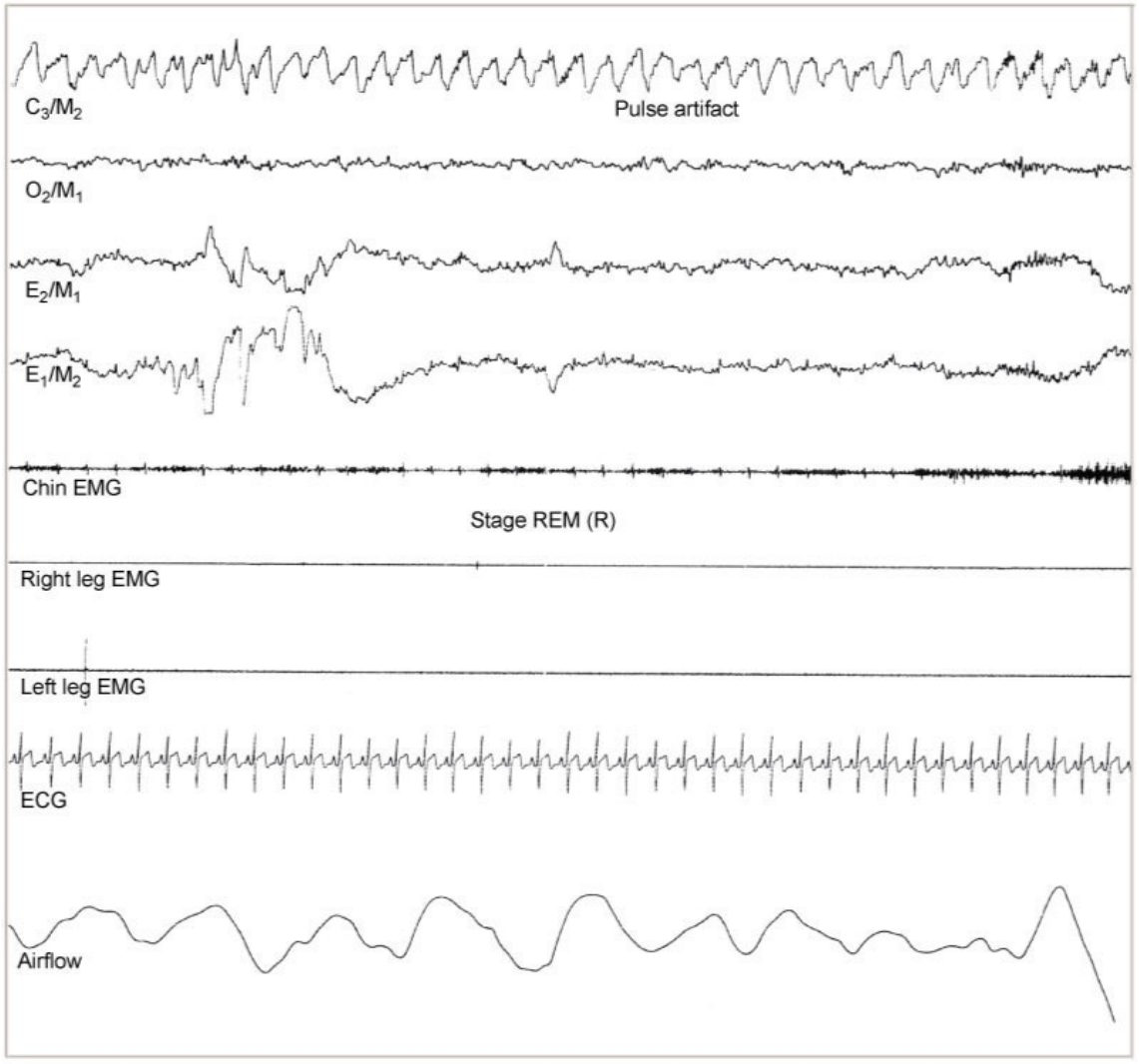
Slow-Frequency Artifact



Pulse Artifact

- May occur in one or more EEG or EOG channels
- Occurs when electrode is placed over a pulsating blood vessel
- Will line up with QRS but produces sinusoidal slow wave rather than spike
- Need to relocate electrode

Pulse Artifact



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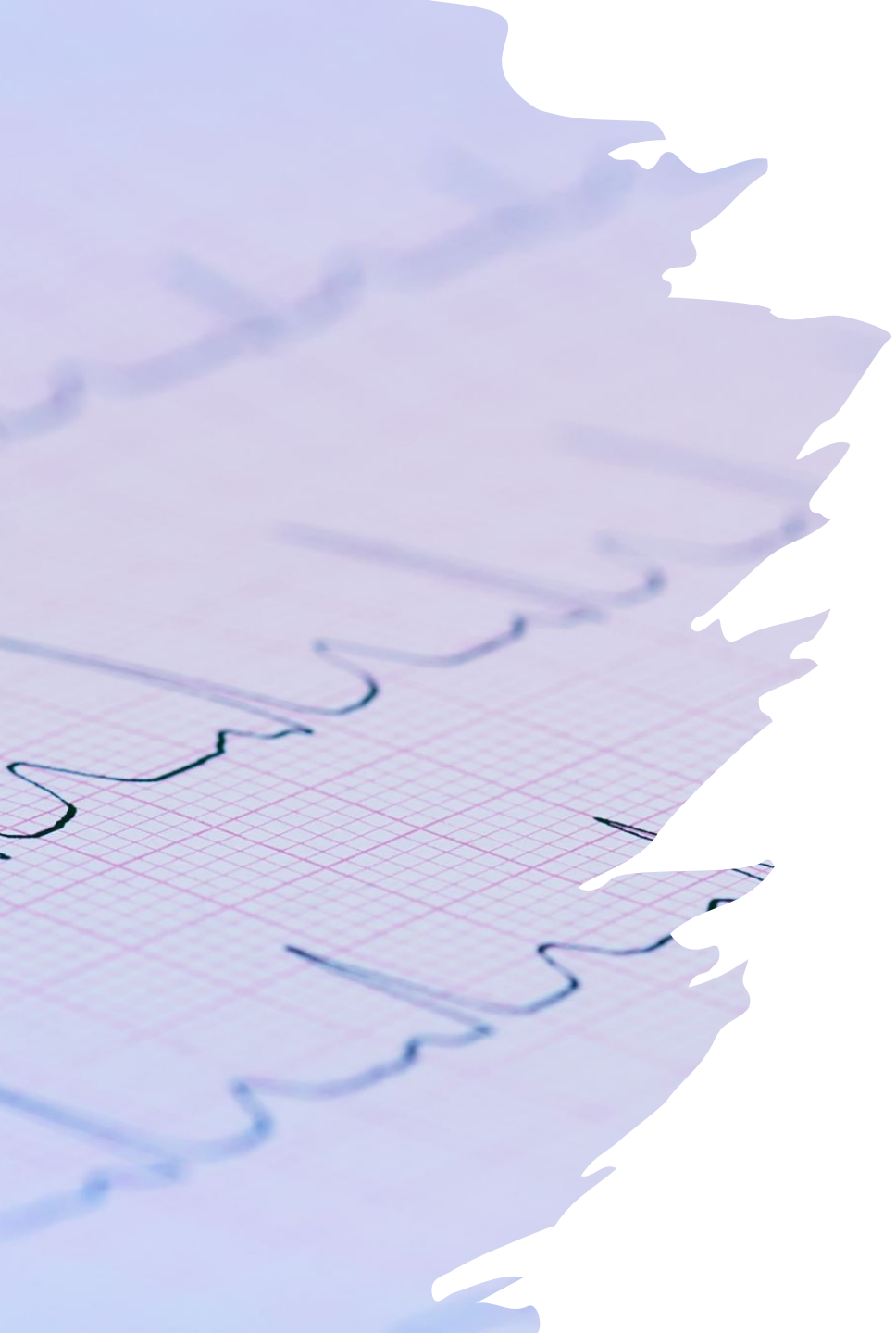
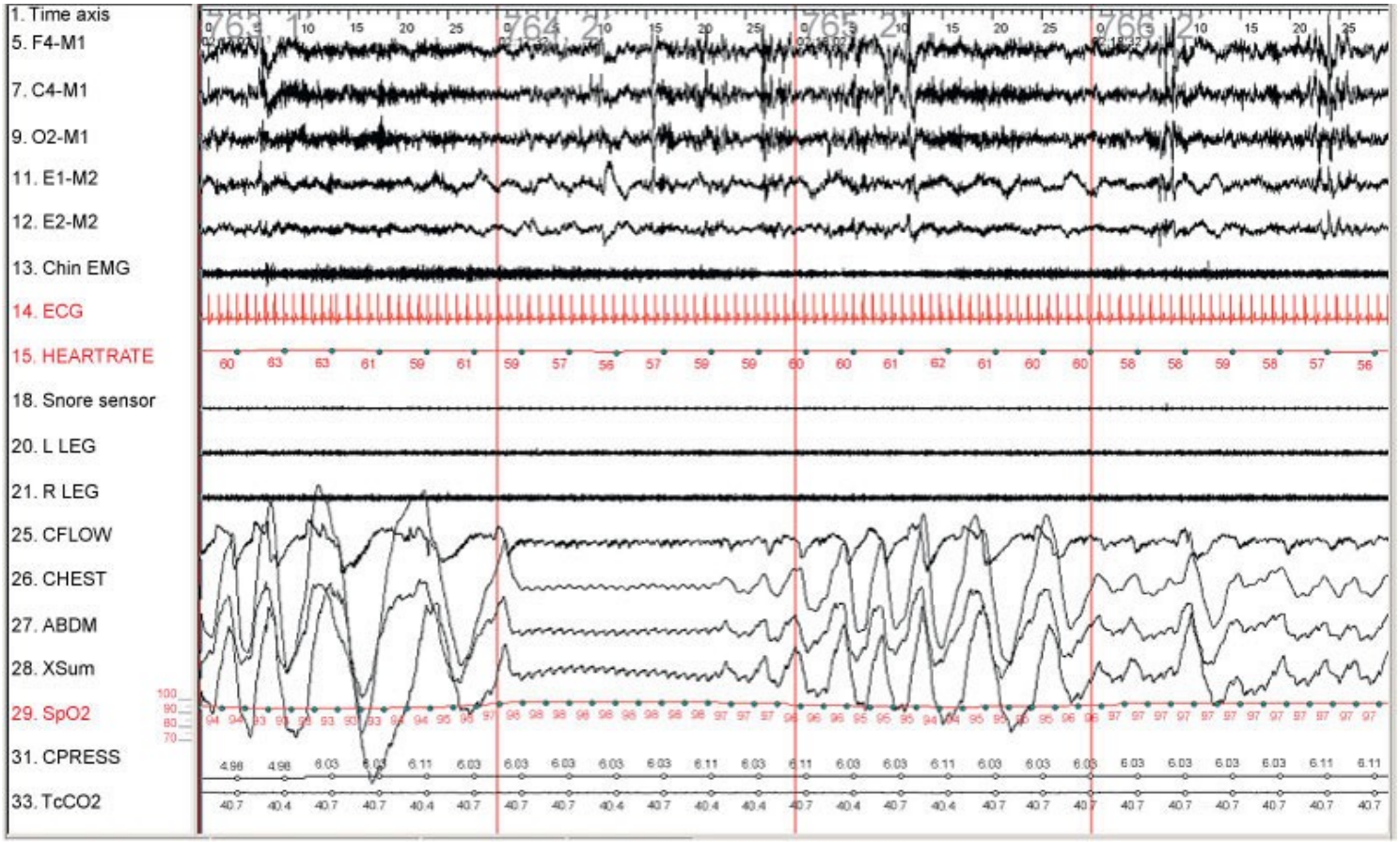


Cardioballistic Artifact

- Generated by cardiogenic oscillations, resulting in movement from intrathoracic pressure changes caused by contraction and relaxation of heart within thorax
- Not electrical artifact but lines up with QRS
- Typically on pressure and respiratory channels during central SDB event

Cardioballistic Artifact

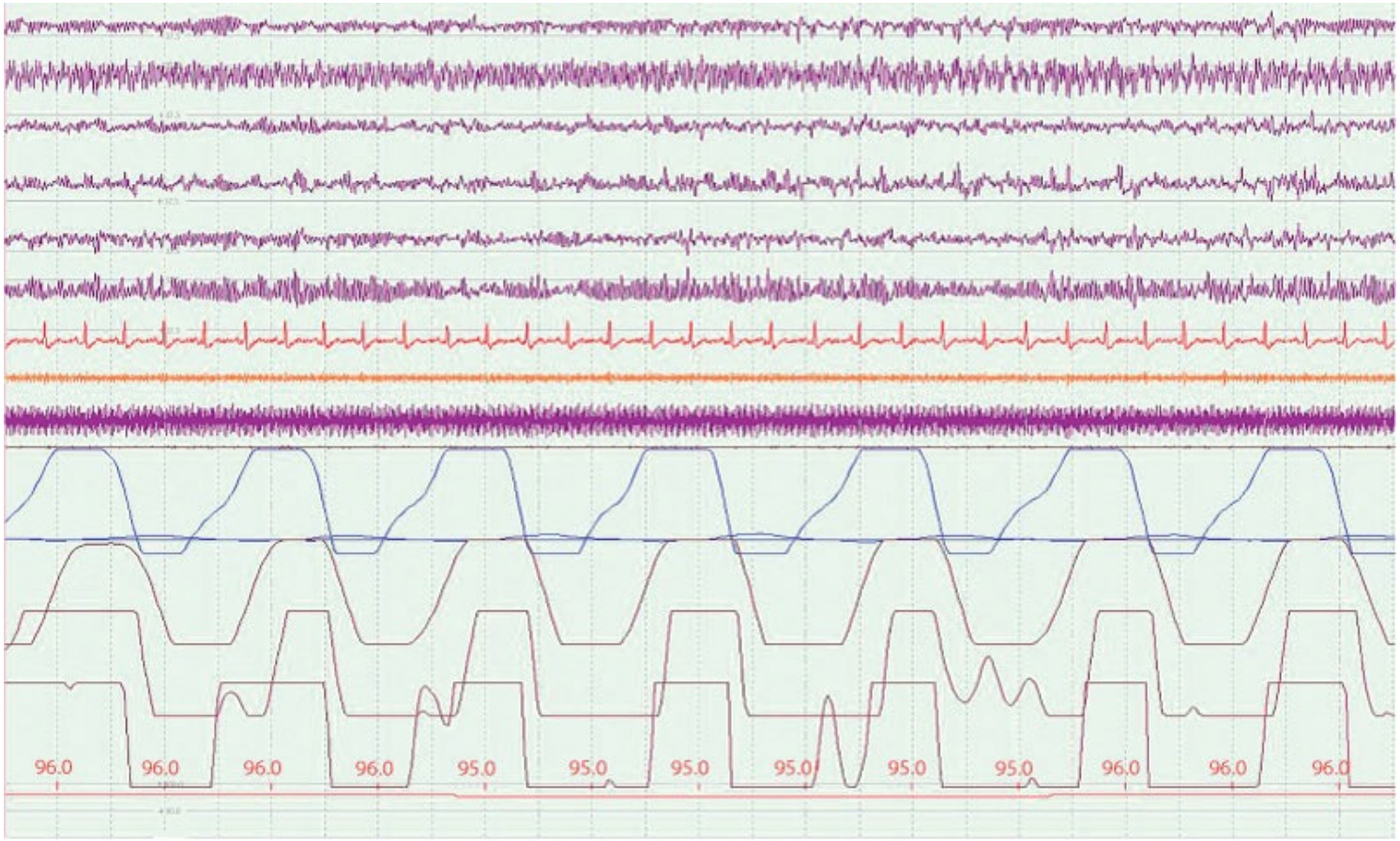


Cardioballistic Artifact

Channel-Blocking Artifact

- Occurs when amplitude of signal is higher than can be recorded within physical limitations of channel
- Often the result of faulty wire, popping electrode, or too high gain/sensitivity
- Creates a “flat” or “chopped off” appearance to the wave or signal may intrude into other channels
- If caused by profuse sweating, cool patient
  - If not caused by sweating, replace electrode or adjust gain/sensitivity
  - Last resort = Adjust LFF to 1 Hz

Channel-Blocking Artifact



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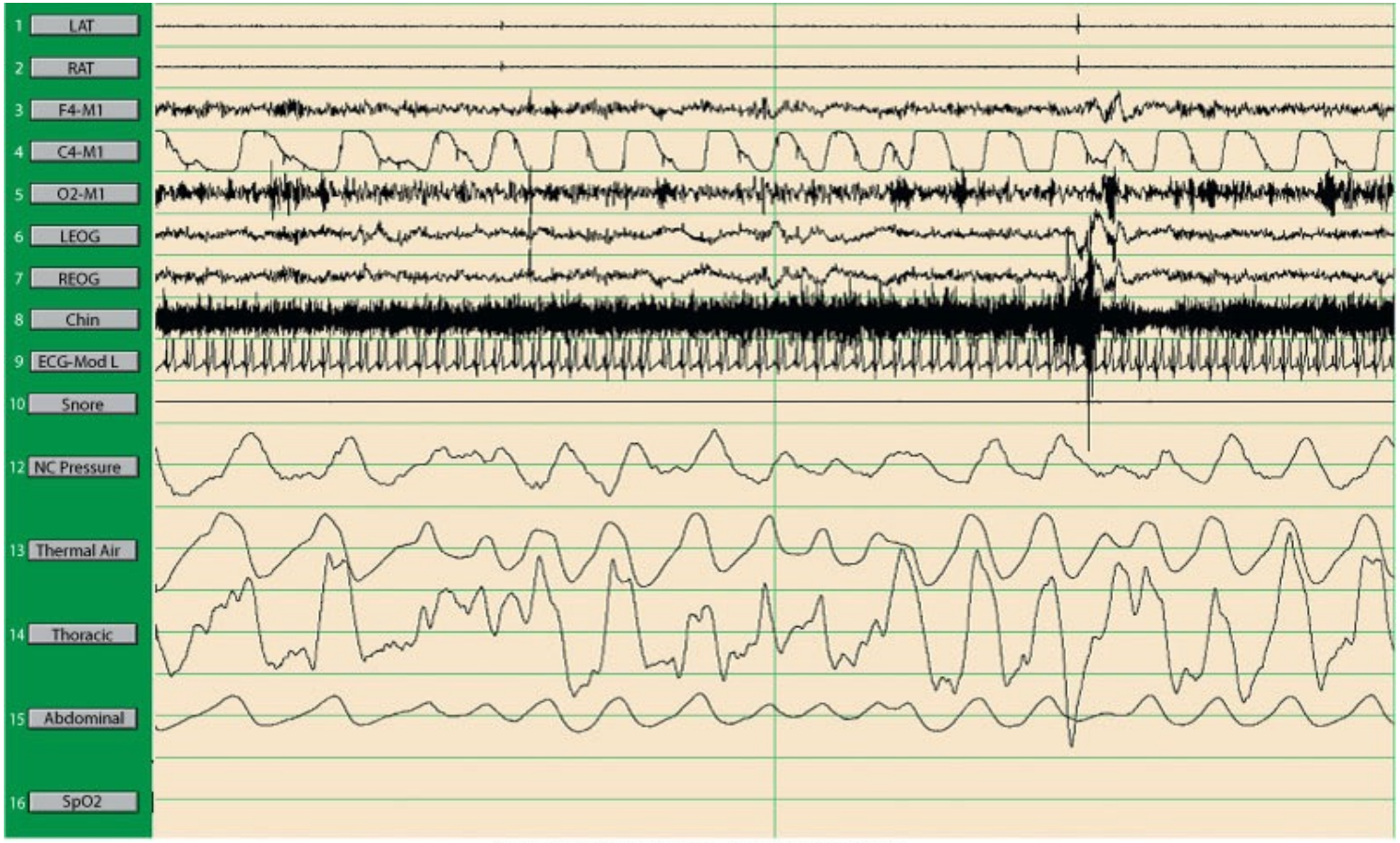

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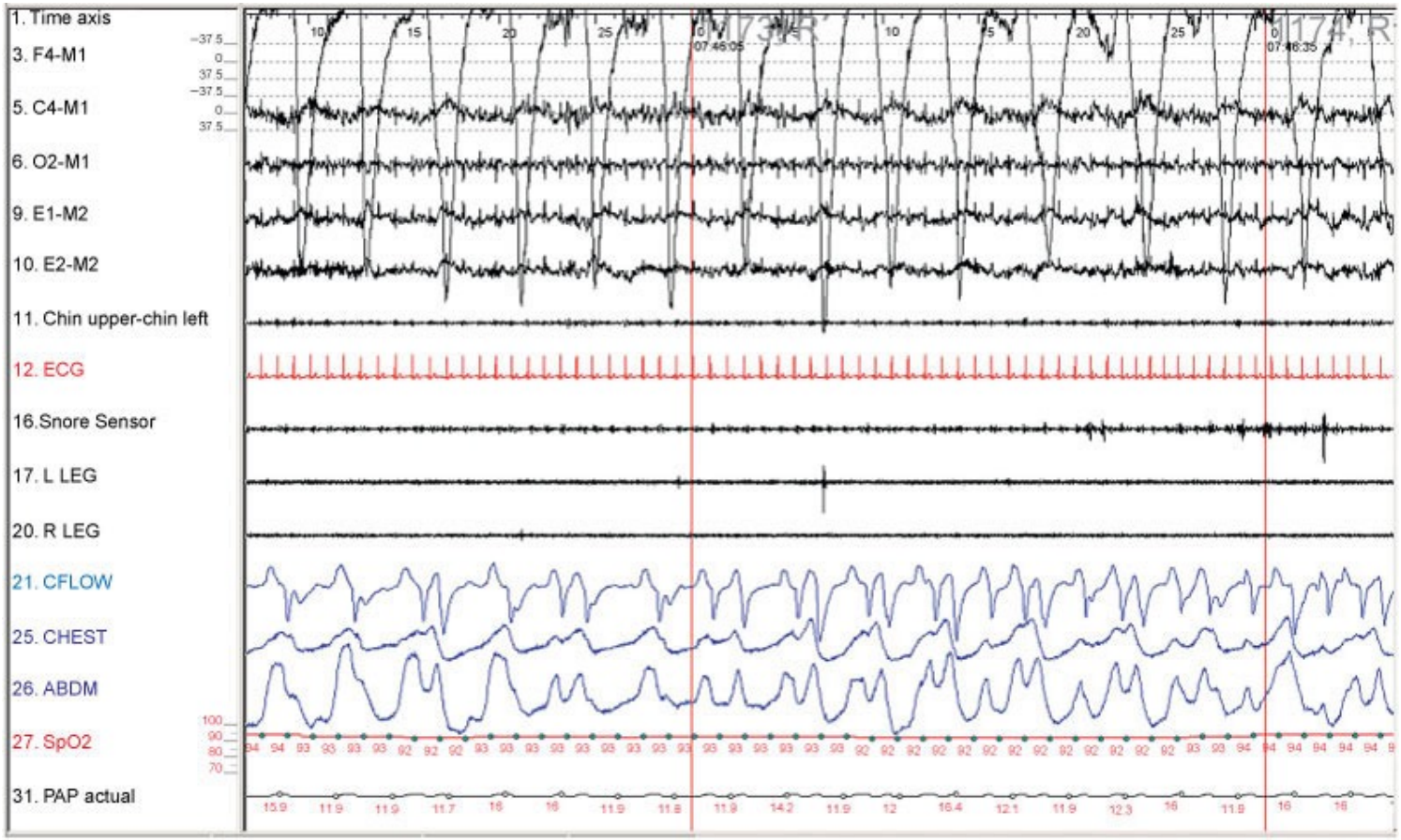
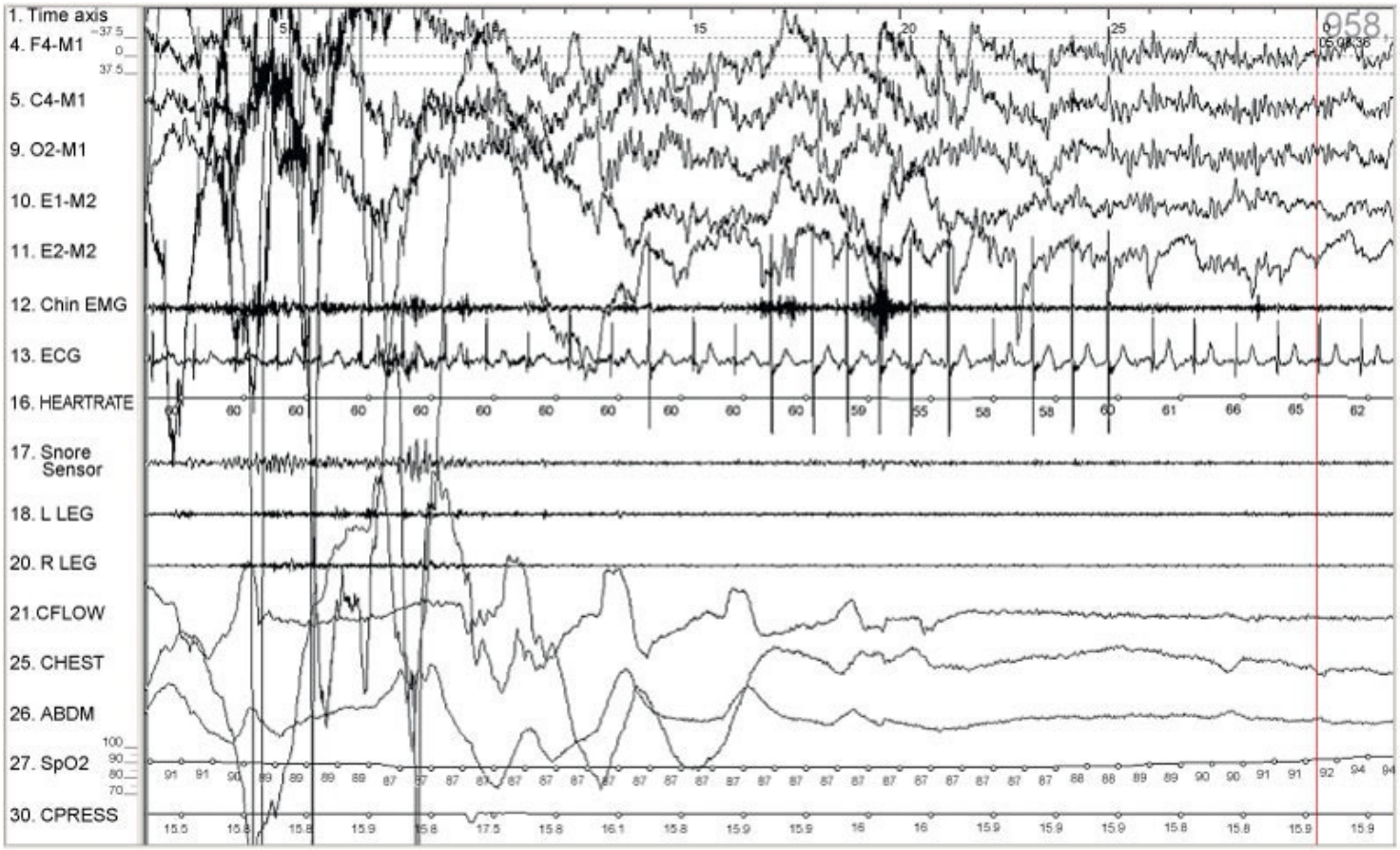


Electrode Popping Artifact

- Result of abrupt shift in electrode impedance
- Causes:
  - Mechanical instability of electrode
  - Intermittent short in electrode wire
  - Intermittently disconnected circuit
- Fixes:
  - Reaffix electrode
  - Secure circuit connection
  - Replace electrode
- LFF alters the duration of this type of artifact

Electrode Popping Artifact



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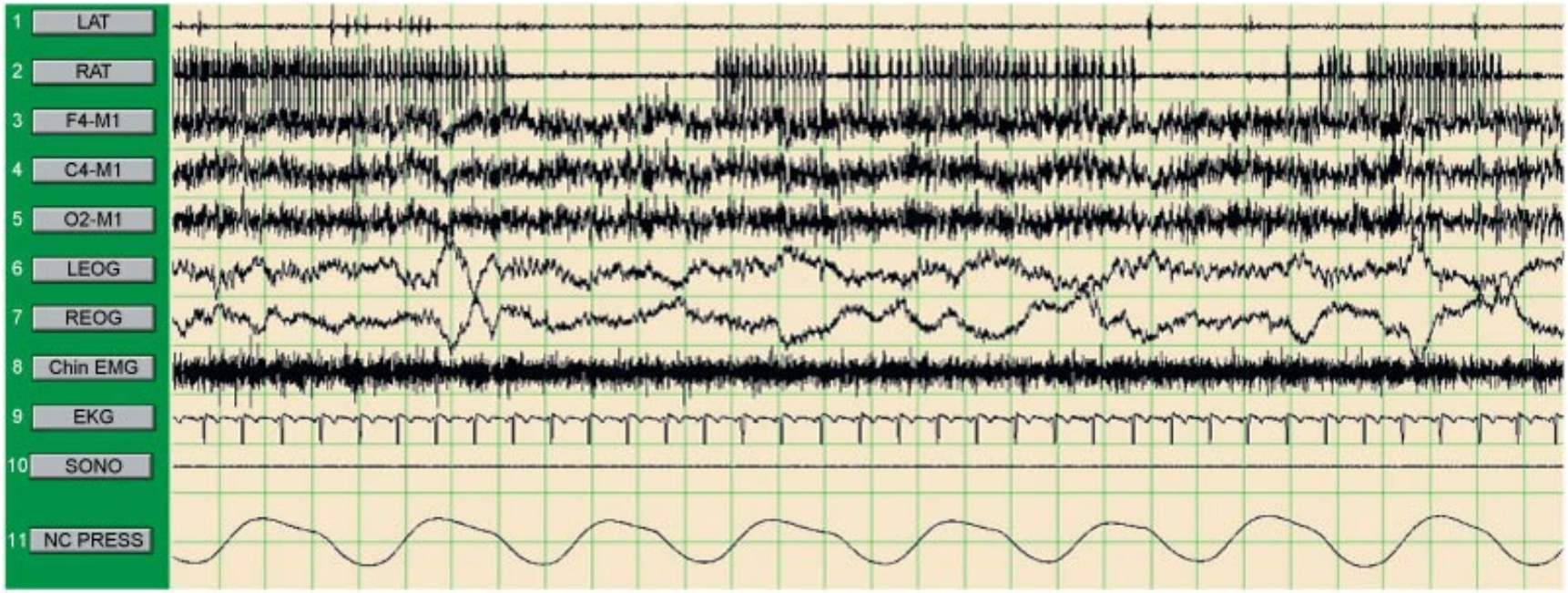
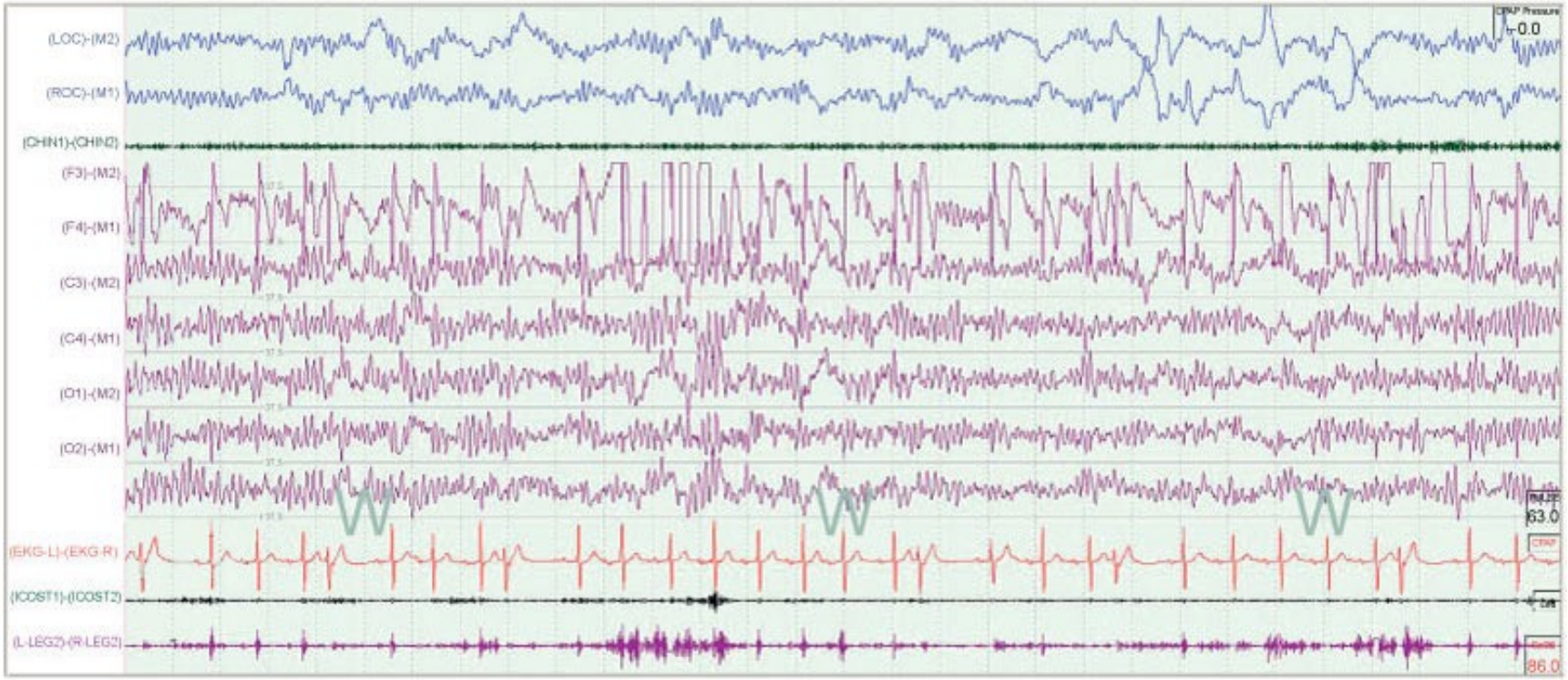


Electrode Popping Artifact



Airflow Signal Artifacts

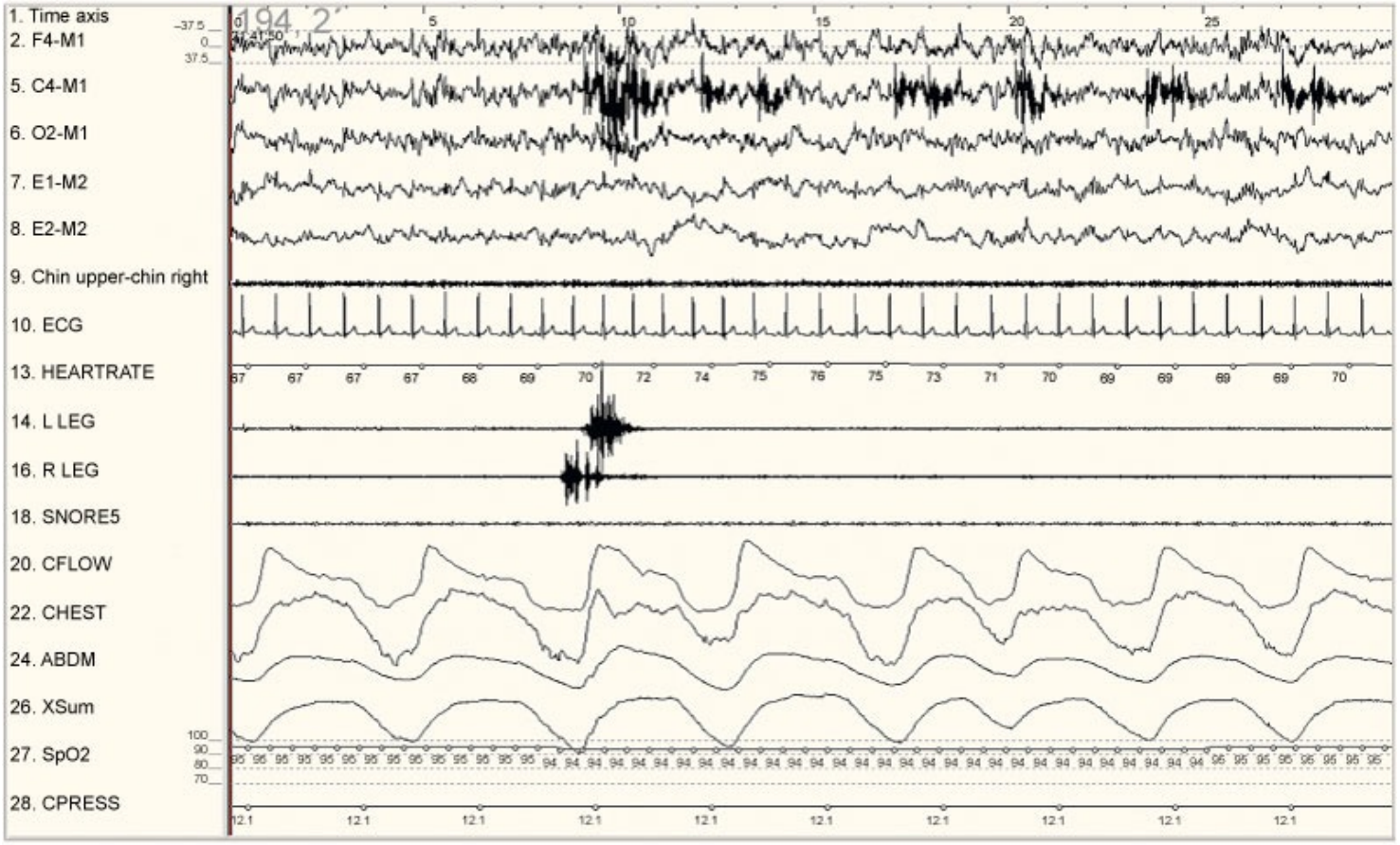
- Occurs when signal from thermistor or thermocouple degrades because of patient movement, sensor dislodged from path of airflow, oral breathing, or sensor contacting skin
- Must correct for malfunction as these channels imperative for respiratory event scoring and diagnosis of SDB

Airflow Signal Artifacts

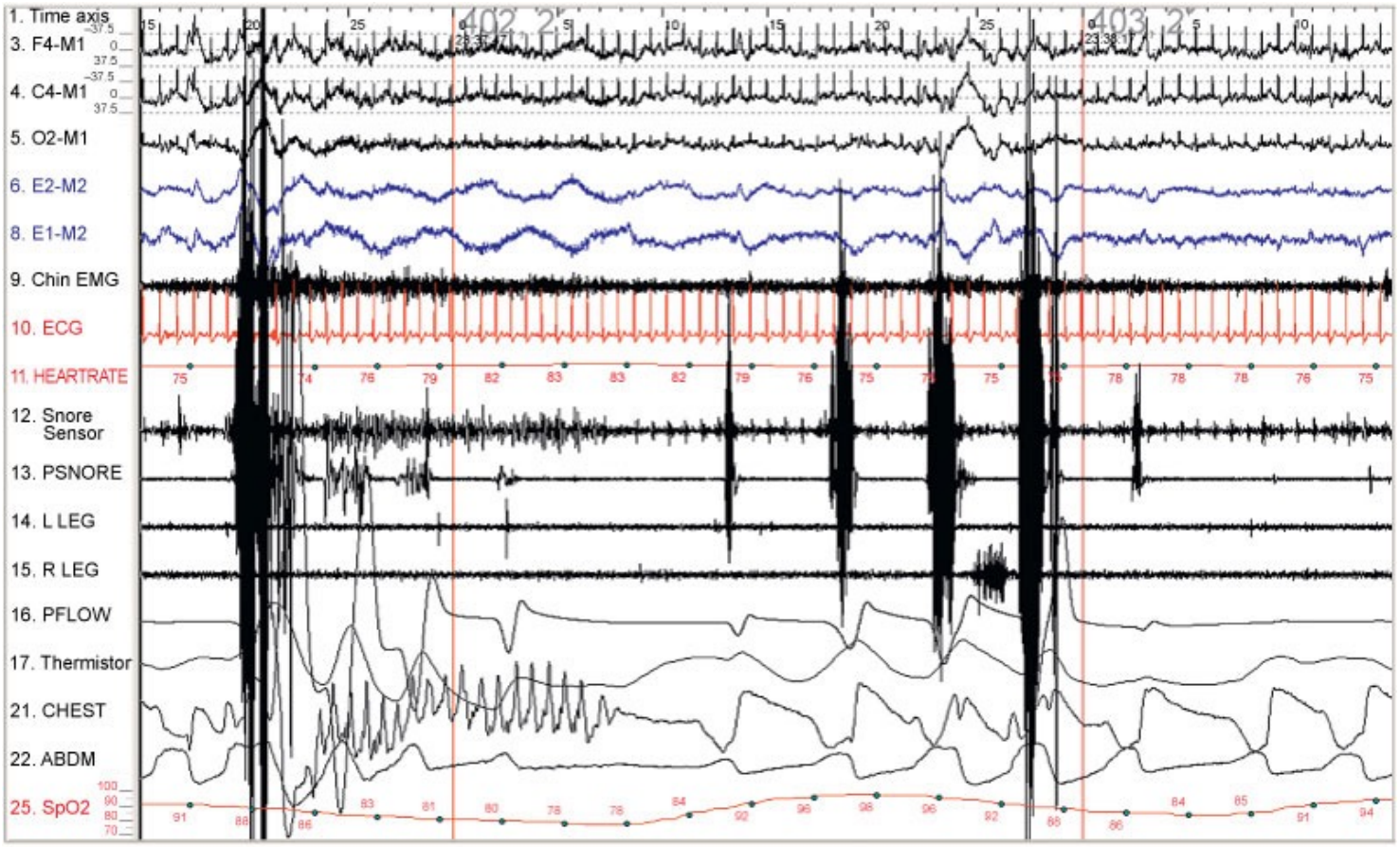
Respiratory Effort Sensor Artifact

- Causes:
  - Faulty sensor
  - Band displaced, over-tightened, or under-tightened
  - Connection unplugged or damaged
  - If external power, may be dead batteries
- Need to be efficient in isolating and correcting problem as these channels essential for scoring respiratory events and diagnosis SDB
  - Proper knowledge of equipment is essential

Respiratory Effort Sensor Artifact



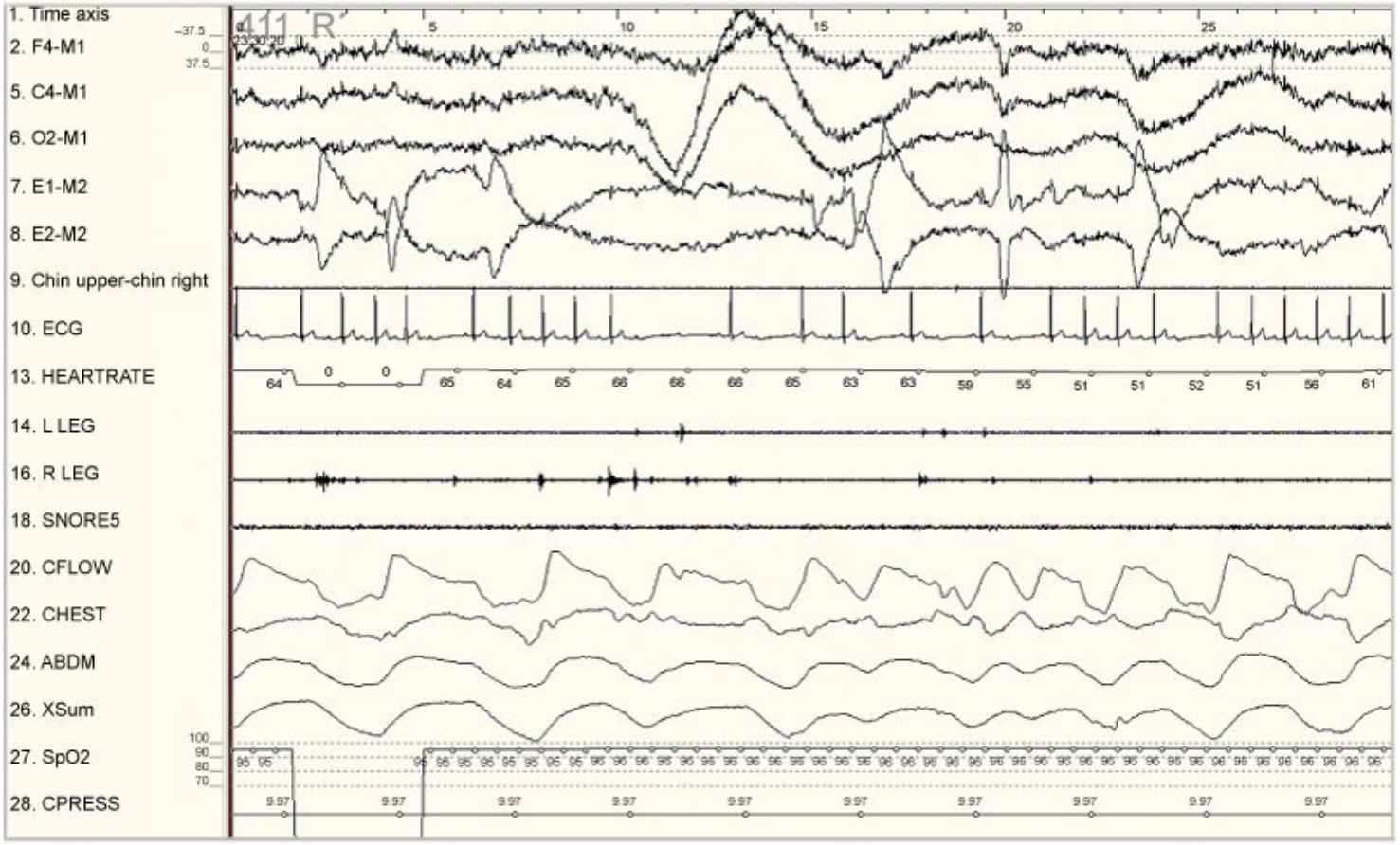
Respiratory Effort Sensor Artifact



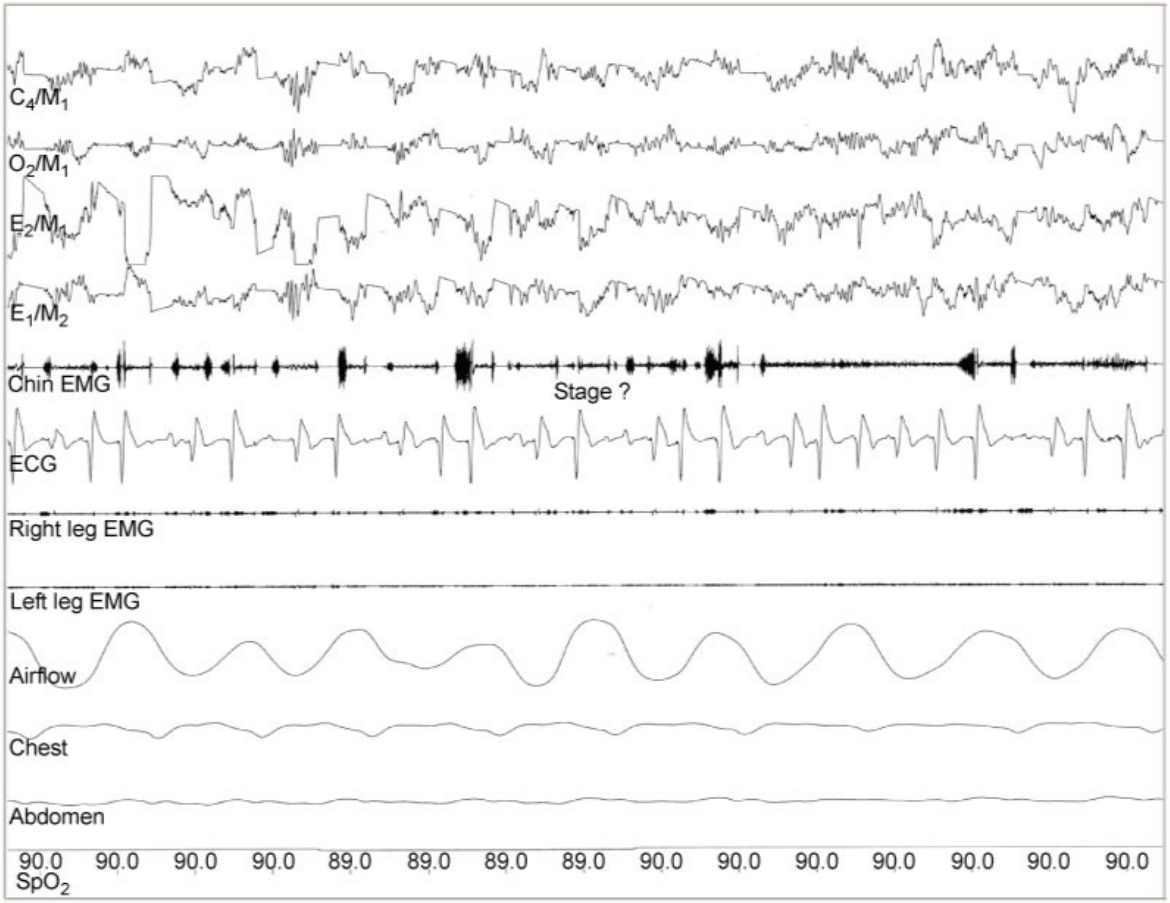
Oximetry Artifacts

- Caused by faulty or absent pulse oximeter or bad connection
  - Also affects display of HR
- Oximetry essential for identification of hypopneas
- Other causes:
  - Poor perfusion
  - Severe hypoxemia
  - Nail polish or nail coverings
  - Movement

Oximetry Artifacts



System Reference Artifact



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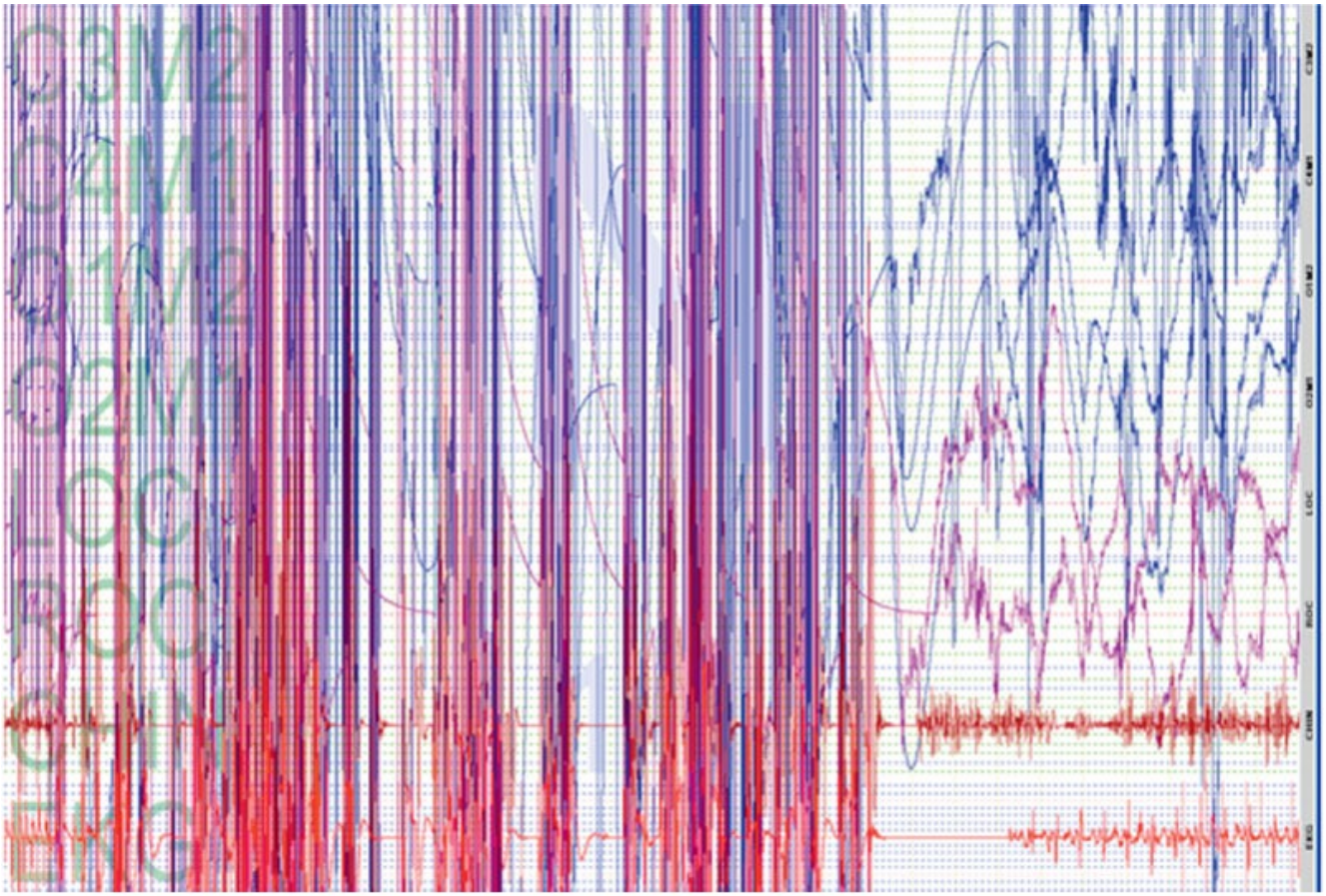
Disconnected Amplifier System/ Electrode Board

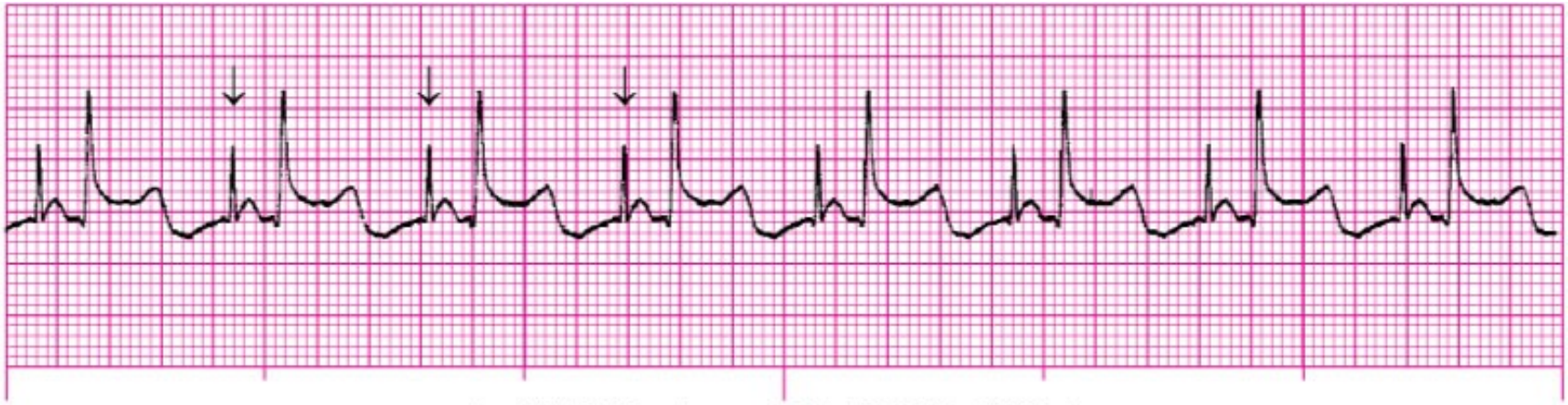


Disconnected Head Box

Implanted Electrical Devices

- Sometimes cranial implants and stimulators
  - May cause electrical interference
- Cardiac pacemakers
  - Ask patient if they have one
  - Small, battery-operated device typically implanted in chest just below right or left clavicle
- Atrial pacemaker
  - When SA node fails to consistently generate an impulse and circuitry to carry the signal is intact, patient only needs atrial pacemaker
  - Electrode rests in RA and stimulates atrium like SA node would

Atrial Pacemaker



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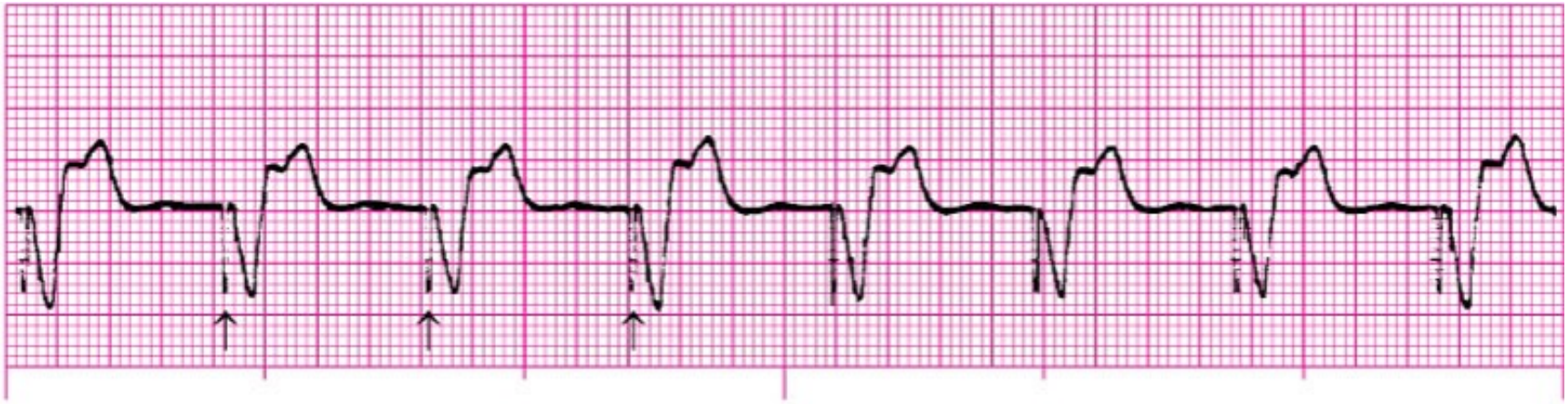
Ventricular Pacemaker



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AV Sequential Pacemaker

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Fixed-Rate and Demand Pacemakers

- Fixed-rate generate impulse at specified rate and do not wait to sense if heart spontaneously generates own rhythm
- Demand sense whether heart is generating impulse and only fire when rate drops below programmed settings

Artifact Response

- Tech must determine when it is essential to disrupt patient's sleep to correct artifacts
  - Consider sleep stage, how long patient has been asleep, initial sleep latency, TST, time remaining, and whether there are back-up electrodes
- Any time patient is awake, fix the artifact

Artifact Response