Polysomnography Artifacts and Updates on AASM Scoring Rules

Robin Lloyd, MD, FAASM, FAAP

2017 Utah Sleep Society Conference
Conflict of Interest Disclosures for Speakers

1. I do not have any relationships with any entities producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients, OR

2. I have the following relationships with entities producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients.

<table>
<thead>
<tr>
<th>Type of Potential Conflict</th>
<th>Details of Potential Conflict</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant/Research Support</td>
<td></td>
</tr>
<tr>
<td>Consultant</td>
<td></td>
</tr>
<tr>
<td>Speakers’ Bureaus</td>
<td></td>
</tr>
<tr>
<td>Financial support</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

3. The material presented in this lecture has no relationship with any of these potential conflicts, OR

4. This talk presents material that is related to one or more of these potential conflicts, and the following objective references are provided as support for this lecture:

1.
2.
3.
Objectives

• Recognize common artifacts and ways to eradicate them
• Describe normal polysomnography variants that may be confusing
• Summarize the most recent changes to the AASM scoring rules
• Identify resources for reviewing common scoring questions
Artifacts
Special Thanks

• James Wyatt, PhD
• Richard Berry, MD
• Kelly Carden, MD
• Erik St. Louis, MD
• Elaine Wirrell, MD
• Dan Herold, RPSGT
Artifact Overview

• Extraneous signals interfering with the desired signal from a given PSG channel.
  – May be Extrinsic (non-physiologic) or Intrinsic (physiologic)
  – May be low frequency or high frequency
  – May use filters to attenuate but only as a last choice
Artifact Sources

- Extrinsic/nonphysiologic
  - Equipment
    - Lead impedance/60 HZ
    - Electrode pop
    - Pulse oximetry
    - Over amplification
    - Unhooked amplifier
    - Loose respiratory belt
  - Environment
    - Phones
    - Alarms

- Intrinsic/physiologic
  - Heart
  - Muscle
  - Movement
  - Bruxism
  - Eye
  - Sweat
  - Respirations
Artifact Classification

- **Slow frequency:**
  - Sweat
  - Respiratory

- **Fast frequency:**
  - Muscle
  - 60 Hz

- **Heart:**
  - ECG
  - Pulse

- **Miscellaneous:**
  - Movement
  - Electrode pop
Extrinsic (Non-physiologic) Artifacts
Lead Impedence/60 Hz

• High frequency, highly regular
• May be seen in EEG, ECG, EOG, EMG
• Usually from poor electrode contact, defective lead wire, inadequate grounding, or nearby electrical equipment
• Correction:
  – Reprep and reattach electrode and ground
  – Turn off unnecessary electrical equipment
60 Hz Artifact

Rich Berry, MD
Electrode Pop

• Abrupt vertical deflections confined to a single electrode

• Correction:
  – Re-apply offending lead
  – Re-apply conducting gel to improve conductance
  – Replace lead
Electrode popping is seen in the channels containing electrode M2. This demonstrates that M2 is the problem electrode. Note that the artifact is synchronous with airflow suggesting that electrode M2 is moving with each respiration. From Berry RB, Wagner MH Sleep Medicine Pearls, 3rd edition
Electrode Pop Artifact
Pulse Oximetry

• Unusual or unexpected readings
  – Oxygen reading 0% or lower than expected
  – Frequent large vacillations

• Correction:
  – Reapply or change out oximeter
  – Remove nail polish
  – Avoid acrylic nails
  – Try a different location (ie, ear lobe, toe)
Oximetry Artifact

Kelly Carden, MD
Over Amplification

- Most commonly happens in pediatrics with high amplitude slow waves
- EEGs are saturating channels
- Correction:
  - Decrease channel gains
Over Amplification

Kelly Carden, MD
Unhooked Amplifier

• All signals flat
• Most commonly seen when patient uses restroom
• Correction:
  – Check all connections between patient and amplifier
Unhooked Amplifier

Kelly Carden, MD
Loose Respiratory Belt

- Flattened effort channels despite good respiratory effort
- May also appear to have notches
- Occurs when belt is loose or malpositioned
- Correction:
  - Tighten or reposition the belt
Loose Respiratory Belt

Kelly Carden, MD
Intrinsic (Physiologic) Artifacts
Heart (ECG)

• ECG artifact throughout
• Correction:
  – Reposition ECG electrodes higher up on the chest
  – Reposition the reference leads (ie M1 and/or M2)
  – Link M1 and M2 (bridging)
  – Reference to non-offending reference
ECG Artifact

An example of severe ECG artifact reduced by using an average of M1 and M2 as the reference

Rich Berry, MD
Heart (Pulse)

• ECG artifact in one lead
  – Pulsations of nearby artery resulting in electrode movement
  – Small-amplitude, low frequency waveform that corresponds to the pulse rate

• Correction:
  – Reposition the electrode
Pulse Artifact
Heart (Pacemaker)

- Spikes occurring in the ECG typically but may be seen in EEG and EOG
- Typically will not see heart rate variability with respiratory event
- Correction:
  - None
Pacemaker Artifact

Dan Herold
Muscle

• High frequency artifact typically seen in EEG and EOG channels
• Typically easy to distinguish from the background
• From increased muscle activity
• Generally resolves when muscle relaxes so no correction needed
Muscle Artifact
Movement

• Sudden brief bursts of high amplitude, high frequency activity seen across multiple channels

• Correction:
  – None
Movement Artifact

Kelly Carden, MD
Rhythmic Movement

Kelly Carden, MD
Scratch

Head scratching by vid

Kelly Carden, MD
Foot Movement

Dan Herold
Bruxism

• High frequency rhythmic pattern in EEG, EOG, and chin leads
• Video and tech notes helpful
• Correction:
  – None
Eye Movement Artifacts

• Most notable in eye and frontal leads
• Correction: None
• Reading eye movements
• Blinks
• “Prozac eyes”
• Glass eye
Reading Eye Movements

- Occur during wakefulness
- Slow component followed by fast

E. St. Louis, MD
Blink Artifact

- Rapid upward rotation of the globe (Bell’s phenomenon)
- Cornea is positive relative to retina

Kelly Carden, MD
“Prozac Eyes”

-Slow rolling eye movements persisting into N1 and sometimes N2 in patients on fluoxetine

E. St. Louis, MD
Glass Right Eye

- Unilateral movement of one eye

Dan Herold
Sweat Artifact ("Sway")

- Very slow frequency waveforms seen in EEG and EOG channels, may be asymmetric
- Changes in salt content of sweat can alter the ionic composition of the conducting gel
- Correction:
  - Decrease room temperature
  - Turn on fan and remove blankets
  - Caution...use of filtering may dampen slow waves
An example of sweat artifact -- the frequency of oscillations is much lower than the respiratory rate and all channels are involved. Turning on a ceiling fan eliminated the problem.
Respiratory Artifact

• Slow frequency waveform corresponding to respirations
• Most often due to an electrode wire in contact with the chest and abdomen
• Correction:
  – Usually don’t need to do anything
  – May resolve with change in body position
  – Reposition or re-reference affected electrode wires
Respiratory Artifact

Dan Herold
Snoring

• Increased activity in the chin EMG correlating with respirations
• Correction:
  – None during diagnostic study
Increased chin EMG activity synchronous with snoring (snore sensor) and vibration in nasal pressure signal (here high filter is 100 Hz).

Rich Berry, MD
Normal Variants
Hypnagogic Hypersynchrony

Elaine Wirrell, MD
V Waves

Elaine Wirrell, MD
Alpha-Intrusion

Erik St. Louis, MD
Excessive Spindling

Erik St. Louis, MD
• **Recording phase**
  – Detect artifacts
  – Document
  – Which to fix/ignore

• **Analysis phase**
  – Detect artifacts
  – Which to fix/ignore
  – Report if clinically important
  – Feedback to technicians
This patient is having a seizure:

- A. True
- B. False
Answer

• False...Hypnagogic Hypersynchrony
Question

- Choose all that apply:
  A. Patient has spikes in the EEG.
  B. There is an ECG artifact.
  C. There is a respiratory artifact.
  D. A and C
  E. B and C
Answer: E
Update on AASM Scoring Rules

The AASM Manual for the Scoring of Sleep and Associated Events
RULES, TERMINOLOGY AND TECHNICAL SPECIFICATIONS

VERSION 2.3
Richard B. Berry, MD (Chair); Rita Brooks, MEd, RST, RPSGT; Charlene E. Qamalado, MD; Susan M. Harding, MD; Robin M. Lloyd, MD; Carole L. Marcus, MBBCh; and Bradley V. Vaughn, MD for the American Academy of Sleep Medicine
History

• **2007 AASM manual (1.0)**
  – Represented a restructuring of “R and K” rules
  – AASM commissioned steering committee in 2004 with 8 task forces

• **2012 revision (2.0)**-First online edition, SAD task force for new respiratory chapter

• **2014 revision (2.1)**-Sleep staging rules

• **2015 revision (2.2)**-Sleep staging rules for infants and home sleep apnea testing (HSAT) rules for adults
2016 Revision, 2.3

- Movement Rules
  - Technical specifications
  - Video monitoring for RMD and RBD
- Bruxism: Masseter EMG
- PLMS: Rules, figures and clarifications
- Sleep stages when 3 or more segments meet criteria for different stages
Movement Rules

• Technical Specifications
  – New rules and figures for electrode placement for monitoring or detecting movements
RBD

- Time-synchronized, audio-equipped video PSG
- Clinical history of dream enactment
- PSG evidence of REM sleep without atonia
Rhythmic Movement Disorder

- Time-synchronized video PSG (recommended)
- Bipolar surface electrodes should be placed to record electrical activity of the large muscle groups involved (optional)

Figure 5. Placement of electrodes on the neck paraspinal muscles for monitoring rhythmic movement disorder. Illustration may not be to scale.
Bruxism

Figure 4. Placement of electrodes on the masseter muscle for detecting bruxism. Illustration may not be to scale.
PLMS

• Technical Specifications

Figure 1. Placement of electrodes on the anterior tibialis muscle for monitoring leg movements. Illustration may not be to scale.
The event lasts 2.8 seconds – more than 0.5 and less than 10 seconds.

The amplitude is 8 µV above the baseline amplitude.

This is the baseline (resting) amplitude.

50 µV
PLMS series.

- The amplitude is $\geq 8 \, \mu V$, and the signal returns to $\leq 2 \, \mu V$ above baseline in $\geq 0.5$ seconds and $< 10$ seconds.
- There are $\geq 4$ LMs in this series. The period length varies somewhat, but is about 19 seconds long. This is $\geq 5$ seconds and $< 90$ seconds.
New Sleep Staging Rule

• When three or more segments of an epoch meet criteria for different stages (stage W, N1, N2, N3, R):
  – i. Score the epoch as sleep if the majority of the epoch meets criteria for stage N1, N2, N3, or R.
  – ii. Assign the sleep stage that occurs for the majority of sleep within the epoch.
Figure 4. In this epoch, there is an initial segment meeting criteria for stage W (12 seconds), a second segment meeting criteria for stage N1 (11 seconds) and a final segment meeting criteria for stage N2 (7 seconds). The epoch is scored as sleep as the majority of the epoch is sleep. The epoch is scored as stage N1 as the majority of sleep is stage N1. The following epoch would be scored as stage N2 unless there was evidence of a shift to another sleep stage. (See subsequent sections in this chapter for definitions of alpha rhythm, LAMF, and K complex.)
Question:
Scoring Periodic Limb Movements in Sleep (PLMS)

How many leg kicks would you count below?

A. 0
B. 1
C. 2
D. 3
E. 4

Duration: 10 seconds

© 2016 American Academy of Sleep Medicine. All rights reserved.
Scoring Periodic Limb Movements in Sleep (PLMS)

New for 2016

Duration: 10 seconds
Period Length

LAT

RAT

Figure 6. The first two LMs are counted as one leg movement since the time from onset to onset of the LMs in the left anterior tibial EMG channel (LAT) and right anterior tibial EMG channel (RAT) is less than 5 seconds. The period length to the next LM is measured from the onset of the first LM in the group considered to be a single LM.

Answer: 2
Question:
How would you score this PLM?

A. 2 PLM without arousal
B. 2 PLM with arousal
C. 1 PLM with arousal and 1 PLM without arousal
D. 1 LM
E. Not enough information
How would you score this PLM?

Answer: B.

2 PLM with arousal
Question: How would you score this PLM?

A. 2 PLM without arousal
B. 2 PLM with arousal
C. 1 PLM with arousal and 1 PLM without arousal
D. 1 LM
E. Not enough information
How would you score this PLM?

Answer: B
2 PLM with arousal
Question:
How would you score this PLM?

A. 2 PLM without arousal
B. 2 PLM with arousal
C. 1 PLM with arousal and 1 PLM without arousal
D. 1 LM
E. Not enough information
How would you score this PLM?

Answer: B

2 PLM with arousal

Figure 7. An arousal and LM occurring in a PLM series are considered to be associated if they occur simultaneously (epochs 50 and 51), overlap (epochs 52 and 53) or if the time from the end of one event to the start of the next is less than 0.5 seconds, regardless which event comes first (epoch 54).
Question: How many leg kicks would you score below?

A. 0
B. 1
C. 2
D. 3
E. 4

© 2016 American Academy of Sleep Medicine. All rights reserved.
Scoring Periodic Limb Movements in Sleep (PLMS)

Answer: 4

Figure 8. Five LMs are depicted. The fourth occurs in an epoch of wake and cannot be counted as a PLM in sleep. However, the other 4 LMs would be included in the same PLM series.
• New rules should have been implemented by Oct. 1, 2016
Resources for Scoring Questions

• AASM Scoring Manual
• AASM website
  – “Contact us”
  – Scoring FAQ’s coming soon!
Summary

• Reviewed common artifacts and ways to eradicate them
• Looked at some normal variants that may be confusing
• Summarized the most recent changes to the AASM scoring rules
• Identified resources for reviewing common scoring questions
Thank You

Lloyd.robin@mayo.edu