OLIVE VIEW-UCLA MEDICAL CENTER
RESPIRATORY CARE SERVICES – SLEEP MEDICINE
POLICY & PROCEDURE

NUMBER: 8910
VERSION: 2

SUBJECT/TITLE: SCORING OF SLEEP STUDIES

POLICY: All sleep records will be scored using established definitions and criteria. All sleep recordings on patients > 6 months of age will be scored for sleep stages using criteria published in the most current version of the **AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications.**

Diagnostic and PAP-titration studies also will be scored for arousals, periodic limb movements, apneas (central, obstructive and mixed), hypopneas, respiratory-effort-related arousals, and EEG and EKG irregularities.

PURPOSE: The use of an established scoring system for sleep stages, respiration, arousals and periodic limb movements ensures reliability of scoring and contributes to the accuracy of the diagnosis from all sleep tests.

DEPARTMENTS: RESPIRATORY CARE SERVICES

PROCEDURE: **1.0 Scoring of Sleep Stages**

1.1 The following terminology should be used for the stages of sleep (Adults)
- 1.1.1 Stage W (wakefulness)
- 1.1.2 Stage N1 (NREM 1)
- 1.1.3 Stage N2 (NREM 2)
- 1.1.4 Stage N3 (NREM 3)
- 1.1.5 Stage R (REM)

1.2 Scoring of Epochs
- 1.2.1 Score sleep stages in 30-second, sequential epochs commencing at the start of the study.
- 1.2.2 Assign a stage to each epoch
- 1.2.3 If 2 or more stages coexist during a single epoch, assign the stage comprising the greatest portion of the epoch. (excluding wake if it 15 seconds or less)

1.3 Scoring Stage W
- 1.3.1 Score in accordance with the following definitions:
  - 1.3.1.1 Alpha rhythm: trains of sinusoidal 8-13 Hz activity recorded over the occipital region with eye closure, attenuating with eye

opening.
1.3.1.2 Eye blinks: Conjugate vertical eye movements at a frequency of 0.5 Hz present in wakefulness with the eyes open or closed.
1.3.1.3 Reading eye movements: Trains of conjugate eye movements consisting of a slow phase followed by a rapid phase in the opposite direction as the subject reads.
1.3.1.4 Rapid eye movements (REM): Conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec.
1.3.1.5 Slow eye movements (SEM): conjugate, reasonably regular, sinusoidal eye movements with an initial deflection usually lasting >500 msec.
1.3.2 Score epochs as stage W when more than 50% of the epoch has alpha rhythm over the occipital region.
1.3.3 Score epochs without visually discernible alpha rhythm as stage W if ANY of the following are present:
1.3.3.1 Eye blinks at a frequency of 0.5-2 Hz
1.3.3.2 Reading eye movements
1.3.3.3 Irregular, conjugate rapid eye movements associated with normal or high chin muscle tone.

1.4 Scoring Stage N1
1.4.1 Score in accordance with the following definitions:
1.4.1.1 Slow eye movements (SEM): Conjugate, reasonably regular, sinusoidal eye movements with an initial deflection usually lasting > 500 msec.
1.4.1.2 Low-amplitude, mixed-frequency EEG activity: Low-amplitude, predominantly 4-7 Hz activity.
1.4.1.3 Vertex sharp waves (V waves): Sharply contoured waves with duration < 0.5 seconds maximal over the central region and distinguishable from the background activity.
1.4.1.4 Sleep onset: The start of the first epoch scored as any stage other than stage W. (In most subjects this will usually be the first epoch of stage N1).
1.4.2 In subjects who generate alpha rhythm, score stage N1 if the alpha rhythm is attenuated and replaced by low-amplitude, mixed-frequency activity for more than 50% of the epoch.
1.4.3 In subjects who do not generate alpha rhythm, score stage N1 commencing with the earliest of ANY of the following phenomena:
1.4.3.1 EEG activity in range of 4-7 Hz with slowing of background frequencies by > Hz from those of stage W
1.4.3.2 Vertex sharp waves
1.4.3.3 Slow eye movements

1.5 Scoring Stage N2
1.5.1 Score in accordance with the following definitions:
1.5.1.1 K complex: A well-delineated, negative, sharp wave

immediately followed by a positive component standing out from the background EEG, with total duration > 0.5 seconds, usually maximal in amplitude when recorded using frontal derivations. For an arousal to be associated with a K complex, the arousal must either be concurrent with the K complex or commence no more than 1 second after termination of the K complex.

1.5.1.2 Sleep spindle: A train of distinct waves with frequency 11-16 Hz (most commonly 12-14 Hz) with a duration > 0.5 seconds, usually maximal in amplitude in the central derivations.

1.5.2 Begin scoring stage N2 (in absence of criteria for N3) if EITHER OR BOTH of the following occur during the first half of that epoch or the last half of the previous epoch:

1.5.2.1 One or more K complexes unassociated with arousals

1.5.2.2 One or more trains of sleep spindles

1.5.3 Continue to score epochs with low-amplitude, mixed-frequency EEG activity without K complexes or sleep spindles as stage N2 if they are preceded by epochs containing EITHER of the following:

1.5.3.1 K complexes unassociated with arousals

1.5.3.2 Sleep spindles

1.5.4 End stage N2 sleep when ONE of the following events occurs:

1.5.4.1 Transition to stage W

1.5.4.2 An arousal (change to stage N1 until a K complex unassociated with an arousal, or a sleep spindle occurs)

1.5.4.3 A major body movement followed by slow eye movements and low-amplitude, mixed-frequency EEG without non-arousal associated K complexes or sleep spindles

1.5.4.4 Transition to stage N3

1.5.4.5 Transition to stage R

1.6 Scoring Stage N3

1.6.1 Score in accordance with the following definition:

1.6.1.1 Slow wave activity: Wave of frequency 0.5 Hz-2 Hz and peak-to-peak amplitude > 75uV, measured over the frontal regions

1.6.2 Score stage N3 when > 20% of an epoch consists of slow wave activity, irrespective of age.

1.7 Scoring Stage R

1.7.1 Score in accordance with the following definitions:

1.7.1.1 Rapid eye movements (REM): Conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec.

1.7.1.2 Low chin EMG tone: Baseline EMG activity in the chin derivation no higher than in any other sleep stage and usually at the lowest level of the entire recording.

1.7.1.3 Sawtooth waves: Trains of sharply contoured or triangular,

often serrated, 2-6 Hz waves maxima in amplitude over the central head regions and often, but not always, preceding a burst of rapid eye movements.

1.7.1.4 Transient muscle activity: Short irregular bursts of EMG activity usually with duration <0.25 seconds superimposed on low EMG tone. The activity may be seen in the chin or anterior tibial EMG derivations, as well as in EEG or EOG deviations, the latter indicating activity of cranial nerve innervated muscles (facial muscles and scalp). The activity is maximal in association with rapid eye movements.

1.7.2 Score stage R sleep in epochs with ALL of the following phenomena:

1.7.2.1 Low amplitude, mixed-frequency EEG

1.7.2.2 Low chin EMG tone

1.7.2.3 Rapid eye movements

1.7.3 Continue to score stage R sleep, even in the absence of rapid eye movements, for epochs following one or more epochs of stage R.

1.7.4 Stop scoring stage R sleep when ONE OR MORE of the following occur:

1.7.4.1 There is a transition to stage W or N3

1.7.4.2 An increase in chin EMG tone above the level of stage R is seen for the majority of the epoch and criteria for stage N1 are met.

1.7.4.3 An arousal occurs followed by low-amplitude, mixed-frequency EEG and slow eye movements (Score the epoch as stage N1; if there are no slow eye movements and chin EMG tone remains low, continue to score as stage R).

1.7.4.4 A major body movement followed by slow eye movements and low-amplitude, mixed-frequency EEG without non-arousal associated K complexes or sleep spindles (Score the epoch following the major body movement as stage N1; if no slow eye movements and the EMG tone remains low, continue to score as stage R; the epoch containing the body movement is scored using criteria for Scoring Body Movements).

1.7.4.5 One or more non-arousal associated K complexes or sleep spindles are present in the first half of the epoch in the absence of rapid eye movements, even if chin EMG tone remains low (Score the epoch as stage N2).

1.7.5 Score epochs at the transition between stage N2 and stage R as follows:

1.7.5.1 In between epochs of definite stage N2 and definite stage R, score an epoch with a distinct drop in chin EMG in the first half of the epoch to the level seen in stage R as stage R even in the absence of rapid eye movements. If ALL the following are met:

1.7.5.1.1 Absence of non-arousal associated K complexes

1.7.5.1.2 Absence of sleep spindles

1.7.5.2 In between epochs of definite stage N2 and definite stage R,

score an epoch with a distinct drop in chin EMG in the first half of the epoch to the level seen in stage R as stage N2 if all the following criteria are met:

1.7.5.2.1 Presence of non-arousal associated K complexes or sleep spindles

1.7.5.2.2 Absence of rapid eye movements

1.7.5.3 In between epochs of definite stage N2 with minimal chin EMG tone and definite stage R without further drop in chin EMG tone, score epochs as stage R even in the absence of rapid eye movements, if all of the following are met:

1.7.5.3.1 Absence of non-arousal associated K complexes

1.7.5.3.2 Absence of sleep spindles

2.0 Scoring Body Movements:

2.1 Score in accordance with the following definitions:

2.1.1 Major body movement: Movement and muscle artifact obscuring the EEG for more than half an epoch to the extent that the sleep stage cannot be determined

2.2 If alpha rhythm is present for part of the epoch (even < 15 seconds duration), score as stage W

2.3 If no alpha rhythm is discernible, but an epoch scorable as stage W either precedes or follows the epoch with a major body movement, score as stage W

2.4 Otherwise, score the epoch as the same stage as the epoch that follows it

3.0 Scoring of Arousals

3.1 Score arousal during sleep stages N1, N2, N3 or R if there is an abrupt shift of EEG frequency including 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. Scoring of arousal during REM requires a concurrent increase in submental EMG lasting at least 1 second

4.0 Scoring of EKG:

4.1 Use a single modified EKG lead II and torso electrode placement.

4.2 Score cardiac events:

4.2.1 Score sinus tachycardia during sleep for a sustained sinus heart rate of greater than 90 bpm. (Adult)

4.2.2 Score bradycardia during sleep for a sustained heart rate of less than 40/min for ages 6 through adult.

4.2.3 Score wide complex tachycardia for a rhythm lasting a minimum of 3 consecutive beats at a rate greater than 100 per minute with QRS duration of less than 120 msec.

4.2.4 Score atrial fibrillation if there is an irregularly irregular ventricular rhythm associated with replacement of consistent P waves by rapid oscillations that vary in size, shape, and timing.

5.0 Scoring Periodic Limb Movements (PLMS):

5.1 Significant leg movement (LM) events:

5.1.1 Minimum duration of a LM event is 0.5 seconds

5.1.2 Maximum duration of a LM event is 10 seconds

5.1.3 Minimum amplitude of a LM event is an 8 μV increase in EMG voltage above resting EMG.

5.1.4 The timing of the ending of a LM event is defined as the start of a period lasting at least 0.5 seconds during which the EMG does not exceed 2 μV above resting EMG.

5.2 Definitions of a PLM series:

5.2.1 Minimum number of consecutive LM events needed to define a PLM series is 4 LMs.

5.2.2 Minimum period length between LMs (defined as the time between onsets of consecutive LMs) to include them as part of a PLM series is 5 seconds.

5.2.3 Maximum period length between LMs (defined as the time between onsets of consecutive LMs) to include them as part of a PLM series is 90 sec.

5.2.4 Leg movements on 2 different legs separated by less than 5 seconds between movement onsets are counted as a single leg movement.

6.0 Scoring Alternating Leg Muscle Activation (ALMA):

6.1 Minimum number of discrete and alternating EMG bursts of leg muscle activity needed to score an ALMA series is 4 ALMAs

6.2 Minimum frequency of the alternating EMG bursts in ALMA is 0.5 Hz.

6.3 Maximum frequency of the alternating EMG bursts in ALMA is 3.0 Hz

7.0 Scoring Hypnagogic Foot Tremor (HFT):

7.1 Minimum number of EMG bursts needed to make a train of bursts in a HFT series is 4 HFT bursts.

7.2 Minimum frequency of the EMG bursts in a HFT is 0.3 Hz

7.3 Maximum frequency of the EMG bursts in a HFT is 4.0 Hz.

8.0 Scoring Excessive Fragmentary Myclonus (EFM):

8.1 Usual maximum EMG burst duration seen in fragmentary myclonus is 150 msec.

8.2 At least 20 minutes of NREM sleep with EFM must be recorded

8.3 At least 5 EMG potentials per minute must be recorded.

9.0 Scoring Bruxism:

9.1 Bruxism may consist of brief (phasic) or sustained (tonic) elevations of chin EMG activity that are at least twice the amplitude of background EMG.

9.2 Brief elevations of chin EMG activity are scored as bruxism if they are 0.25-2 seconds in duration and if at least 3 such elevations occur in a regular sequence.

9.3 Sustained elevations of chin EMG activity are scored as bruxism if the duration is more than 2 seconds.

9.4 A period of at least 3 seconds of stable background chin EMG must occur before a new episode of bruxism can be scored.

9.5 Bruxism can be scored reliably by audio in combination with polysomnography by a minimum of 2 audible tooth grinding episodes per night of polysomnography in the absence of epilepsy.

10.0 Scoring PSG Features of REM Sleep Behavior Disorder (RBD):

10.1 Score in accordance with the following definitions:

10.1.1 Sustained muscle activity (tonic activity) in REM sleep: an epoch of REM sleep with at least 50% of the duration of the epoch having a chin EMG amplitude greater than the minimum amplitude demonstrated in NREM

sleep.

10.1.2 Excessive transient muscle activity (phasic activity) in REM sleep: In a 30-second epoch of REM sleep divided into 10 sequential, 3-second mini-epochs, at least 5 (50%) of the mini-epochs contain bursts of transient muscle activity. In RBD, excessive transient muscle activity bursts are 0.1-5 seconds in duration and at least 4 times as high in amplitude as the background EMG activity.

10.2 The polysomnographic characteristics of RBD are characterized by EITHER or BOTH of the following features:

10.2.1 Sustained muscle activity in REM sleep in the chin EMG

10.2.2 Excessive transient muscle activity during REM in the chin or limb EMG

11.0 Scoring the PSG Features of Rhythmic Movement Disorder:

11.1 The following define the polysomnographic characteristics of rhythmic movement disorder:

11.1.1 The minimum frequency for scoring rhythmic movements is 0.5 Hz.

11.1.2 The maximum frequency for scoring rhythmic movements is 2.0 Hz

11.1.3 The minimum number of individual movements required to make a cluster of rhythmic movements is 4 movements.

11.1.4 The minimum amplitude of an individual rhythmic burst is 2 times the background EMG activity.

12.0 Respiratory Rules for Adults and Peds:

12.1 Technical Specifications

12.1.1 For identification of an apnea during a diagnostic study, use an oronasal thermal airflow sensor to monitor airflow

12.1.2 For identification of an apnea during a diagnostic study when the oronasal thermal airflow sensor is not functioning or the signal is not reliable, use one of the following alternative apnea sensors:

12.1.2.1 RIPsum (calibrated or uncalibrated)

12.1.2.2 RIPflow (calibrated or uncalibrated)

12.1.2.3 PVDFsum

12.1.3 For identification of a hypopnea during a diagnostic study, use a nasal pressure transducer (with or without square root transformation of the signal to monitor airflow)

12.1.4 For identification of a hypopnea during a diagnostic study when the nasal pressure transducer is not functioning or the signal is not reliable, use one of the following alternative hypopnea sensors:

12.1.4.1 RIPsum (calibrated or uncalibrated)

12.1.4.2 RIPflow (calibrated or uncalibrated)

12.1.4.3 PVDFsum

12.1.5 During positive airway pressure (PAP) titration, use the PAP device flow signal to identify apneas or hypopneas.

12.1.6 For monitoring respiratory effort, use one of the following:

12.1.6.1 Esophageal manometry

12.1.6.2 Dual thoracoabdominal RIP belts (calibrated or uncalibrated)

12.1.6.3 Dual thoracoabdominal PVDF belts

12.1.7 For monitoring oxygen saturation, use pulse oximetry with a maximum acceptable signal averaging time of ≤ 3 seconds at a heart rate of 80 beats per minute.

12.1.8 For monitoring snoring, use an acoustic sensor (e.g. microphone), piezoelectric sensor or nasal pressure transducer.

12.1.9 For detection of hypoventilation during a diagnostic study, use arterial PCO 2, transcutaneous PCO 2 or end-tidal PCO 2.

12.1.10 For detection of hypoventilation during PAP titration, use arterial PCO 2, or use transcutaneous PCO 2 or end-tidal PCO2 .

12.2 **Measuring Event Duration**

12.2.1 For scoring either an apnea or a hypopnea, the event duration is measured from the nadir preceding the first breath that is clearly reduced to the beginning of the first breath that approximates the baseline breathing amplitude.

12.2.2 For apnea duration, the oronasal thermal sensor signal (diagnostic study) or PAP device flow signal (PAP titration study) should be used to determine the event duration. For hypopnea event duration, the nasal pressure signal (diagnostic study) or PAP device flow signal (PAP titration study) should be utilized. When the diagnostic study sensors fail or are inaccurate, alternative sensors may be used.

12.2.3 When baseline breathing amplitude cannot be easily determined and when underlying breathing variability is large, events can also be terminated when either there is a clear and sustained increase in breathing amplitude, or in the case where a desaturation has occurred, there is event-associated resaturation of at least 2%.

12.3 **Scoring of Apneas:**

12.3.1 Score a respiratory event as an apnea when BOTH of the following criteria are met:

12.3.1.1 There is a drop in the peak signal excursion by ≥ 90% of pre-event baseline using an oronasal thermal sensor (diagnostic study), PAP device flow (titration study) or an alternative apnea sensor (diagnostic study).

12.3.1.2 The duration of the ≥ 90% drop in sensor signal is ≥ 10 seconds.

12.3.1.3 **PEDS:** The duration of ≥ 90% drop in sensor signal lasts at least 2 breaths.

12.3.2 Score an apnea as obstructive if it meets apnea criteria and is associated with continued or increased inspiratory effort throughout the entire period of absent airflow.

12.3.3 Score an apnea as central if it meets apnea criteria and is associated with absent inspiratory effort throughout the entire period of absent airflow.

12.3.4 Score an apnea as mixed if it meets apnea criteria and is associated with absent inspiratory effort in the initial portion of the event, followed by resumption of inspiratory effort in the second portion of the event.

12.4 **Scoring of Hypopneas:**

12.4.1 Score a respiratory event as a hypopnea if ALL of the following criteria are

met:

12.4.1.1 The peak signal excursions drop by ≥ 30% of pre-event baseline using nasal pressure (diagnostic study), PAP device flow (titration study), or an alternative hypopnea sensor (diagnostic study).

12.4.1.2 The duration of the ≥ 30% drop in signal excursion is ≥10 seconds, or at least 2 breaths for Peds patients.

12.4.1.3 There is a ≥ 4%, (**3% for peds or event is followed by an arousal**), oxygen desaturation from pre-event baseline.

12.4.2 If electing to score obstructive hypopneas, score a hypopnea as obstructive if ANY of the following criteria are met:

12.4.2.1 Snoring during the event

12.4.2.2 Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing

12.4.2.3 Associated thoracoabdominal paradox occurs during the event but not during pre-event breathing.

12.4.3 If electing to score central hypopneas, score a hypopnea as central if NONE of the following criteria are met:

12.4.3.1 Snoring during the event

12.4.3.2 Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing

12.4.3.3 Associated thoracoabdominal paradox occurs during the event but not during pre-event breathing.

12.5 **Scoring Respiratory Effort-Related Arousal:**

12.5.1 If electing to score respiratory effort-related arousals, score a respiratory event as a respiratory effort-related arousal (RERA) if there is a sequence of breaths lasting ≥ 10 seconds characterized by increasing respiratory effort or by flattening of the inspiratory portion of the nasal pressure (diagnostic study) or PAP device flow (titration study) waveform leading to arousal from sleep when the sequence of breaths does not meet criteria for an apnea or hypopnea.

12.6 **Scoring Hypoventilation:**

12.6.1 If electing to score hypoventilation, score a respiratory event as hypoventilation during sleep if EITHER of the below occur:

12.6.1.1 There is an increase in the arterial PCO 2 (or surrogate) to a value >55 mmHg for ≥10 minutes.

12.6.1.2 There is ≥ 10 mmHg increase in arterial PCO 2 (surrogate) during sleep (in comparison to an awake supine value) to a value exceeding 50 mmHg for ≥ 10 minutes.

12.7 **Scoring Cheyne-Stokes Breathinghh**

12.7.1 Score a respiratory event as Cheyne-Stokes breathing if BOTH of the following are met:

12.7.1.1 There are ≥ 5 central apneas and/or central hypopneas per hour of sleep associated with the crescendo/decrescendo breathing pattern recorded over ≥ 2 hours of monitoring.

References:	
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