SCORING SLEEP RELATED EVENTS: PEDIATRIC

Audience: All personnel in the Sleep Disorder Center.

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

Policy: Standard definitions will be used for all sleep-related events. Sleep-related definitions will conform to the Clinical Practice Parameters set by the American Academy of Sleep Medicine (AASM) where they exist. The scoring of all sleep related events shall conform to the latest edition of the AASM Manual for the Scoring of Sleep and Associated Events version 2.0.

Criteria for respiratory events during sleep children can be used for children <18 years, but an individual sleep specialist can choose to score children ≥13 years using adult criteria.

Diagnostic and PAP-titration studies will be scored for arousals, periodic limb movements, apneas (central, obstructive and mixed), hypopneas and EEG and EKG irregularities. The scoring of Respiratory-effort-related arousals will be at the discretion of the clinical director.

Procedure: Scoring EEG Arousal

- Score arousals 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.
- Arousal scoring should incorporate the information from both the occipital and central derivations.
- Arousal scoring can be improved by the use of additional information in the recording such as respiratory events and/or additional EEG channels. Scoring of arousals, however, cannot be based on this additional information alone and such information does not modify any of the arousal scoring rules.
- Arousals meeting all scoring criteria but occurring during an awake epoch in the recorded time between “lights out” and “lights on” should be scored and used for computation of the arousal index.
- Artifacts or K-complexes are not scored as arousals unless they are accompanied by an EEG frequency shift lasting 3 seconds of greater.
- Delta waves may accompany an arousal when scoring pediatric arousals.
- Arousals that occur without any explanation are scored as spontaneous.

- Arousals that occur due to a respiratory event are scored as a respiratory arousal.
- Arousals that occur due to a PLM event are scored as a PLM arousal.

Scoring Respiratory Events: Technical Specifications

- For identification of an apnea during a diagnostic study, use an oronasal thermal airflow sensor to monitor airflow.
- 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, a) nasal pressure transducer (with or without square root transformation), b) RIPsum (calibrated or uncalibrated), c) RIPflow (calibrated or uncalibrated), d) end-tidal PCO2.
- For identification of a hypopnea during a diagnostic study, use a nasal pressure transducer to monitor air flow.
- 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 sensors: a) oronasal thermal airflow b) RIPsum (calibrated or uncalibrated), c) RIPflow (calibrated or uncalibrated) d) dual thoracoabdominal RIP belts (calibrated or uncalibrated.
- During PAP titration, use the PAP device flow signal to identify apneas or hypopneas.
- For monitoring respiratory effort, use one of the following: a) esophageal manometry, b) dual thoracoabdominal RIP belts (calibrated or uncalibrated).
- For monitoring oxygen saturation, use pulse oximetry with a maximum acceptable signal averaging time of $\leq$ 3 seconds at a heart rate of 80 bpm.
- For monitoring snoring, use a piezoelectric sensor or nasal pressure transducer or an acoustic sensor (microphone).
- For detection of hypoventilation during a diagnostic study, use arterial PCO2, transcutaneous PCO2 or end-tidal PCO2.
- For detection of hypoventilation during PAP titration, use arterial PCO2 or use transcutaneous PCO2.
- For further information see the AASM Manual for the Scoring of Sleep and Associated Events, Version 2, P. 45.

Scoring Respiratory Events: Measuring Event Duration (same as adult)

- 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.

- 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. See the AASM Manual for the Scoring of Sleep and Associated Events, Version 2, Technical specifications for adults, P. 39, A.2 and A.4
- 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%.

Scoring Apneas

- Score a respiratory event as an apnea when ALL of the following criteria are met:
    - There is a drop in the peak signal excursion by ≥90% of the pre-event baseline using an oronasal thermal sensor (diagnostic), PAP device flow (titration), or an alternative apnea sensor (diagnostic).
    - The duration of the ≥90% drop in sensor signal lasts at least the minimum duration as specified by obstructive, mixed or central apnea duration criteria outlined below.
    - The event meets respiratory effort criteria for obstructive, central or mixed apnea.
- Score a respiratory event as an *obstructive apnea* if it meets apnea criteria for at least the duration of 2 breaths during baseline breathing AND is associated with the presence of respiratory effort throughout the entire period of absent airflow.
- Score a respiratory event as a *central apnea* if it meets apnea criteria, is associated with absent inspiratory effort throughout the entire duration of the event AND at least one of the following is met:
    - The event lasts ≥20 seconds
    - The event lasts at least the duration of two breaths during baseline breathing and is associated with an arousal or a ≥3% arterial oxygen desaturation.
    - The event is associated with a decreased heart rate to less than 50 beats/min for at least 5 seconds or less than 60 beats/min for 15 second (infants under 1 year of age only).
- Score a respiratory event as a *mixed apnea* if it meets apnea criteria for at least the duration of 2 breaths during baseline breathing AND is associated with absent respiratory during one portion of the event AND the presence

of inspiratory effort in another portion, regardless of which portion comes first.

Scoring Hypopneas

- Score a respiratory event as a hypopnea if ALL of the following criteria are met:
    - The peak signal excursions drop by ≥30% of pre-event baseline using nasal pressure (diagnostic), PAP device flow (titration) or an alternative hypopnea sensor (diagnostic).
    - The duration of the ≥30% drop in signal excursion lasts for ≥2 breaths.
    - There is a ≥3% oxygen desaturation from pre-event baseline or the event is associated with an arousal.
- If electing to score obstructed hypopneas, score a hypopnea as obstructive if ANY of the following criteria are met:
    - Snoring during the event.
    - Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing.
    - Associated thoracoabdominal paradox occurs during the event but not during pre-event breathing.
- If electing to score central hypopneas, score a hypopnea as central if NONE of the following criteria are met:
    - Snoring during the event.
    - Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing.
    - Associated thoracoabdominal paradox occurs during the event but not during pre-event breathing.

Scoring Respiratory Effort-Related Arousal (RERA)

- If electing to score RERAs, score a RERA if there is a sequence of breaths lasting ≥2 (or the duration of two breaths during baseline breathing) when the breathing sequence is characterized by increasing respiratory effort, flattening of the inspiratory portion of the nasal pressure (diagnostic) or PAP device flow (titration) waveform, snoring, or an elevation in the end-tidal PCO2 leading to arousal from sleep when the sequence of breaths does not meet criteria for an apnea or hypopnea.

Scoring Hypoventilation

- Monitoring hypoventilation in children is recommended during a diagnostic study and optional during a PAP titration study.

- Score hypoventilation during sleep when >25% of the total sleep time is measured by either the arterial PCO2 or surrogate is spent with a PCO2 >50 mmHg.

Scoring of Periodic Breathing

- Score a respiratory event as periodic breathing if there are ≥3 episodes of central apnea lasting >3 seconds separated by ≤20 seconds of normal breathing.
- Central apneas that occur within a run of periodic breathin should be scored as individual apneas as well.

Apnea/hypopnea Index (AHI)

- AHI equals the total number of apneas and hypopneas divided by total sleep time (TST) in hours.
- Apnea index equal the total number of apneas divided by TST in hours.
- Hypopnea index equals the total number of hypopneas divided by TST in hours.

Respiratory Disturbance Index (RDI)

- RDI equal the total number of apneas and RERAs divided by the total sleep time (TST) in hours.
- RERA index equals the total number of RERAs divided by TST in hours.

Scoring Periodic Limb Movements

- Leg movement (LM) is 0.5 seconds to 10 seconds in duration.
- A LM event is at least an 8 μV increase in EMG voltage above resting EMG.
- Periodic Limb Movement (PLM) episode is 4 or more LMs separated by more than 5 seconds but less than 90 seconds from the onset of each LM.
- LMs on 2 different legs separated by less than 5 seconds between movement onsets are counted as a single LM.
- A LM should not be scored if it occurs during a period from 0.5 seconds preceding an apnea, hypopnea, RERA or other sleep-disordered-breathing event to 0.5 seconds following.
- An arousal and a PLM should be considered associated with each other when there is <0.5 seconds between the end of one event and the onset of the other event regardless of which is first.
- When two periodic limb movements occur with an interval of less than 10 seconds and each is associated with a 3 second arousal, only the first arousal should be scored although both limb movements may be scored. In this scenario, the arousal index and PLMS arousal index, but not the PLMS index, would be influenced by not scoring the second “arousal”.

Periodic Limb Movement Index (PLMI)

- PLM index equals the total number of periodic limb movements divided by TST in hours.
- PLM arousal index equals the total number of periodic limb movements associated with an arousal divided by the TST in hours.

Scoring Bruxism

- Bruxism may consist of brief (phasic) or sustained (tonic) elevation of chin EMG activity that are at least twice the amplitude of background EMG.
- 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.
- Sustained elevations of chin EMG activity are scored as bruxism if the duration is more than 2 seconds.
- A period of at least 3 seconds of stable background chin EMG must occur before a new episode of bruxism can be scored.
- 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.

Scoring REM Behavior Disorder (RBD)

- 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.
- 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 - 5.0 seconds in duration and at least 4 times as high in amplitude as the background EMG activity.
- The polysomnographic characteristics of RBD are characterized by **either** or **both** of the following: a) Sustained muscle activity in REM sleep in the chin EMG, b) Excessive transient muscle activity during REM in the chin or limb EMG.
- Time-synchronized, audio-equipped video PSG demonstrating dream enactment or a characteristic clinical history are necessary to make the diagnosis of RBD in addition to polysomnographic evidence of REM sleep without atonia or excessive transient muscle activity in REM sleep.

- Transient muscle activity and occasional accompanying visible twitching of small muscle groups are a normal phenomenon seen in REM sleep. When larger muscle groups are involved, this activity is not associated with large, overt muscular activity acting across large joints. When smaller muscle groups are involved, the movement often involves the distal muscles of the hands and face or the corner of the mouth. Transient muscle activity may be excessive in RBD.
- The sustained muscle activity or the excessive transient muscle activity observed in REM sleep may be interrupted by superimposed (usually dream-enacting) behaviors of RBD.
- In normal individuals there is an atonis seen in REM sleep in the chin and anterior tibialis EMG. In this state the baseline amplitude of the EMG signal decreases markedly. This atonia of REM sleep is lost to a considerable extent in RBD, with variable frequency, and as a result, the EMG baseline amplitude is often higher. In this situation, the EMG can be said to be in a tonic rather that atonic state.

Scoring Other Movements

- For scoring Alternating Leg Muscle Activation (ALMA), Hypnagogic Foot Tremor (HFT), Excessive Fragmentary Myoclonus (EFM) and Rhythmic Movement Disorder see the AASM Manual for the Scoring of Sleep and Associated Events, Version 2, P. 37, 38.

Scoring Cardiac Events

- Use modified EKG Lead II and torso electrode placement. While classically Lead II is derived from electrodes placed on the right arm and left leg, the electrodes may be placed on the torso aligned in parallel to the right shoulder and left hip.
- Standard EKG electrode applications are superior to EEG electrodes in minimizing artifact.
- Score sinus tachycardia during sleep for sustained sinus heart rate of greater than 90 bpm for adults.
- Score bradycardia during sleep for a sustained heart rate of less than 40 bpm for ages 6 years through adult.
- Sustained sinus tachycardia or bradycardia is defined by more than 30 seconds of a stable rhythm to distinguish it from transient responses, associated sleep disordered breathing events or arousals.
- Score asystole for cardiac pauses greater than 3 seconds for ages 6 years through adult.
- Score wide complex tachycardia for a rhythm lasting more than 3 cardiac cylces with QRS duration of $\geq$120 ms at a rate of >100 bpm.
- Wide complex tachycardia rhythms include PVCs, bigimeny, trigeminy, quadgeminy, bradycardia and nonsustained VT (NSVT).

- A narrow complex tachycardia is a sustained rhythm lasting more than 3 cardiac cycles with a QRS duration <120 ms and a rate >100 bpm.
- Narrow complex tachycardia rhythms include atrial tachycardia, atrial flutter, A-fib, Atopic atrial tachycardia, sinus tachycardia and sustained VT (SVT).
- Atrial fibrillation is an irregularly irregular ventricular rhythm associated with the replacement of P waves with rapid oscillations or waves that vary in size, shape and timing.

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