The AASM Manual for the Scoring of Sleep and Associated Events

The 2007 AASM Scoring Manual vs. the AASM Scoring Manual v2.0

October 2012

The American Academy of Sleep Medicine (AASM) is committed to ensuring that *The AASM Manual for the Scoring of Sleep and Associated Events* reflects the best and most current evidence in sleep medicine. The online format of the manual makes it particularly amendable to periodic updates based on new evidence in the literature and feedback from users and beneficiaries. A Scoring Manual Committee oversees the content and makes recommendations when content changes are indicated, need for clarification exists, there is new technology or the literature suggests that updates are needed.

The AASM Board of Directors has approved the changes described below. The updated manual was released in October 2012 as Version 2.0. All AASM-accredited sleep facilities are required to implement the new rules in Version 2.0 by October 1, 2013.

The following summary provides an overview of the changes that have been incorporated in Version 2.0.

I. User Guide (formerly the "Key")

- The term 'ALTERNATIVE' has now been replaced with 'ACCEPTABLE'

II. Parameters to be Reported for Polysomnography

A. General Parameters

- 'Airflow parameters' was revised to 'Airflow signals'
- 'Effort parameters' was revised to 'Respiratory effort signals'
- A new RECOMMENDED parameter was added (*9. Electrocardiogram (ECG)*).

B. Sleep Scoring Data

- Scoring data calculations were revised to spell out individual parameters used in the calculations (See #7, 8, 10)
- Note 1 was revised to include: "*Time with patient disconnected from the recording equipment should be scored as Stage W. Brief episodes of sleep during this time, if they occur, are not considered significant for the Stage Scoring Summary.*"

C. Arousal Events

- Scoring data calculations were revised to spell out individual parameters used in the calculations (See #2)

D. Cardiac Events

- No Revisions

E. Movement Events
    - Scoring data calculations were revised to spell out individual parameters used in the calculations (See #3, 4)

F. Respiratory Events
    - Scoring data calculations were revised to spell out individual parameters used in the calculations (See #8-12, 14, 15)

    - OPTIONAL reporting of number of obstructive hypopneas was added.

    - OPTIONAL reporting of number of central hypopneas was added.

    - OPTIONAL reporting of the obstructive apnea hypopnea index (OAHI: (number of obstructive apneas + number of mixed apneas + number of obstructive hypopneas) X 60 / TST) was added.

    - OPTIONAL reporting of the central hypopnea index (CAHI: (number of central apneas + central hypopneas) X 60 / TST) was added.

    - OPTIONAL reporting of respiratory disturbance index (RDI; AHI + RERA index) was added.

    - Oxygen desaturation reporting was revised from ≥3% or ≥4% to just ≥3%.

    - Oxygen desaturation index reporting was revised from ≥3% or ≥4% to just ≥3%.

    - 'Continuous oxygen saturation' was revised to 'Arterial oxygen saturation.'

    - Occurrence of hypoventilation was split into 'during diagnostic study' and 'during PAP titration.' Occurrence of hypoventilation in adults in either case continues to be OPTIONAL. Reporting of occurrence of hypoventilation during a diagnostic study in children continues to be RECOMMENDED and was added to the Parameters to be Reported for Polysomnography. Reporting of occurrence of hypoventilation during a PAP titration study in children was not described in the 2007 Scoring Manual but is currently listed as OPTIONAL.

    - Reporting of periodic breathing in children continues to be RECOMMENDED and was added to the Parameters to be Reported for Polysomnography.

    - Occurrence of snoring was added as an OPTIONAL parameter to be reported.

- Two new notes were added to this section:
  Note 2. *If electing to measure the arterial PCO_2 or surrogate during sleep in cases where it is optional to do so, the occurrence/absence of hypoventilation must be included in the PSG report.*

  Note 3. *Reporting the occurrence of Cheyne-Stokes breathing in the PSG report is required only if central apneas are present.*

G. Summary Statements
   - No revisions

III. Technical and Digital Specifications

A. Digital Specifications for Routine PSG Recordings
   - A new note was added:
     Note 10. *The body position channel is exempt from the digital resolution standard. However, the recommended sampling rate of 1 Hz remains in effect.*

   - Sampling Rates were specified for Transcutaneous PCO_2, End-Tidal PCO_2, and PAP Device Flow.

   - For Routinely Recorded Filter Settings, the 2007 manual grouped respiration and suggested a low frequency filter of 0.1 Hz and high frequency filter of 15 Hz. In V2.0, these were separated as follows:
     1) Oronasal Thermal Flow, Thoracoabdominal Belt Signals - still recommended at 0.1 Hz low-frequency filter and 15 Hz high-frequency filter. [RECOMMENDED]
     2) Nasal Pressure - either direct current (DC) or a low-frequency filter of ≤0.03 Hz or a high-frequency filter of 100 Hz. [RECOMMENDED]
     3) PAP Device Flow – DC for both the low and high-frequency filter. [RECOMMENDED]

B. PSG Recording Features
   - No revisions

C. Use Systems with the Following PSG Display and Display Manipulation Features
   - Display requirements have been changed from being at least 1600 x 1200 to a recommended display for scoring and review of sleep study data which must meet or exceed the following criteria: 15-inch screen size, 1600 pixels horizontal and 1050 pixels vertical. [RECOMMENDED]

D. Perform the Following Digital Analyses of PSG
   - No revisions

IV. Visual Rules

Part 1: Visual Rules for Adults

A. Technical Specifications for Electroencephalogram (EEG)
   - A new note has been added.
     Note 3. *Fz-Cz is not appropriate for measuring the amplitude of frontal activity for determination of slow wave activity. When using the* acceptable *EEG derivations and the* acceptable *EOG derivations, the E1-Fpz derivation should be used to measure frontal slow wave amplitude. Used in this way, Fpz will be the active electrode recording frontal activity and E1 the reference electrode in a referential derivation. When using the* acceptable *EEG derivations and the* recommended *EOG derivations, EEG amplitude to determine slow wave activity should be measured using the C4-M1 derivation. When using the recommended EEG derivations, the EEG amplitude is measured using the derivation F4-M1.*

B. Technical Specifications for Electrooculogram (EOG)
   - Addition of "*When using the recommended electrode derivations, conjugate eye movements result in out-of-phase deflections.*" to Note 1.

C. Technical Specifications for Electromyogram (EMG)
   - No revisions

D. General Scoring of Sleep Stages
   - No revisions

E. Scoring Stage W
   - A definition for slow eye movements (SEM) was added.

   - A new note has been added:
     Note 5. *Time with the patient disconnected from the recording equipment should be scored as stage W. Brief episodes of sleep during this time, if they occur, are not considered significant for the stage scoring summary.)*

F. Scoring Stage N1
   - No revisions

G. Scoring Stage N2
   - Note 2 was modified from "Continue to score stage N1 for epochs with arousal-associated K complexes but no spontaneous K complexes or sleep spindles." To "*Continue to score stage N1 for epochs with arousal-associated K complexes unless they contain sleep spindles or K complexes not associated with arousals.*"

   - Two new notes have been added:
     Note 1. *An epoch of stage N2 meeting criteria in rule G.2 is termed* ***definite stage N2***.

Note 4. *Although sleep spindles and frequency changes associated with arousals are more typically noted in the central and occipital derivations respectively, these events should be used to score sleep even if they are only noted in the frontal derivations.*).

H. Scoring Stage N3
- A new note has been added:
  Note 1. *K complexes would be considered slow waves if they meet the definition of slow wave activity.*

I. Scoring Stage R
- There is a clarification regarding chin EMG tone in **Rule 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 as defined in rule I.2 above, IF the EEG continues to show low-amplitude, mixed-frequency activity without K complexes or sleep spindles AND the chin EMG tone remains low ***for the majority of the epoch***. [RECOMMENDED]

- Three new notes have been added:
  Note 1. *Epochs defined by rule I.2 are called epochs of* ***definite stage R****. Such epochs usually do not contain K complexes or sleep spindles. However, especially in the first REM sleep period of the night, K complexes or sleep spindles may be interspersed among epochs of what otherwise appears to be stage R sleep. Epochs defined by rule I.2 are scored as stage R even in the presence of K complexes or sleep spindles. In the absence of rapid eye movements, epochs containing sleep spindles or K complexes are not scored as stage R even if they contain low chin EMG tone.*

  Note 2. ***Definite stage N2*** *refers to epochs defined by G.2. The epoch contains one or both of the following: one or more sleep spindles or one or more K complexes in the first half of the epoch, and the epoch does not meet criteria for stage N3.*

  Note 5. *There are no rules specifically dealing with stage N1-R transitions. Stage R sleep will only commence when rapid eye movements are seen in association with low muscle tone and the typical EEG.*

J. Scoring Epochs with Major Body Movements
- No revisions

Part 2: Visual Rules for Children

A. Ages for Which Pediatric Visual Scoring Rules Apply
- No revisions

B. Technical Specifications
- The note regarding EEG sensitivity was removed.

C. General Scoring of Sleep Stages

- Note 1 has been revised from "Sleep spindles usually are present in NREM sleep of infants 2 to 3 months post-term or older." To "*Sleep spindles may be seen by age 4-6 weeks post-term and are present in all normal infants by age 2-3 months post-term. At this age the spindles are asynchronous between the hemispheres but become more synchronous over the first year of life.*"

D. Scoring Stage W
   - The term 'dominant posterior rhythm' has been replaced with 'posterior dominant rhythm.'

E. Scoring Stage N1
   - The term 'dominant posterior rhythm' has been replaced with 'posterior dominant rhythm.'

F. Scoring Stage N2
   - No revisions

G. Scoring Stage N3
   - No revisions

H. Scoring Stage R
   - No revisions

V. Arousal Rules

- A new note has been added to address a FAQ to the 2007 Scoring Manual regarding scoring arousals in wake:
  Note 3. *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.*

VI. Cardiac Rules

A. Technical Specifications
   - No revisions

B. Scoring Cardiac Events
   - A new note was added:

     Note 4. Sustained sinus bradycardia or tachycardia is defined by more than 30 seconds of a stable rhythm to distinguish it from transient responses, associated sleep disordered breathing events or arousals.

   - The reference referred to in Note 3 was added:
     Caples SM, Rosen CL, Shen WK, Gami AS, Cotts W, Adams M, Dorostkar P, Shivkumar K, Somers VK, Morgenthaler TI, Stepanski EJ, Iber C. The scoring of cardiac events during sleep. *J Clin Sleep Med* 2007;3:147-54.

VII. Movement Rules

A. Scoring Periodic Limb Movements in Sleep (PLMS)

- Note 1 was revised from "An LM should not be scored if it occurs during a period from 0.5 seconds preceding an apnea or hypopnea to 0.5 seconds following an apnea or hypopnea." To "*An LM should not be scored if it occurs during a period from 0.5 seconds preceding an apnea, hypopnea, RERA or sleep-disordered-breathing event to 0.5 seconds following*."

- A new note was added:
  Note 6. *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."*

B. Scoring Alternating Leg Muscle Activation (ALMA)

- No revisions

C. Scoring Hypnagogic Foot Tremor (HFT)

- No revisions

D. Scoring Excessive Fragmentary Myoclonus (EFM)

- No revisions

E. Scoring Bruxism

- No revisions

F. Scoring PSG Features of REM Sleep Behavior Disorder (RBD)

- No revisions

G. Scoring the PSG Features of Rhythmic Movement Disorder

- No revisions

VIII. Respiratory Rules

Part 1: Respiratory Rules for Adults

A. Technical Specifications

- **Rule 7** was clarified by revising the maximum acceptable signal averaging time from 3 seconds to ≤3 seconds at a heart rate of 80 beats per minute. [RECOMMENDED]

- Rules in this section were revised for clarification as follows:

  Regarding identifying apneas and hypopneas:
  Rule 1. *For identification of an apnea during a diagnostic study, use an oronasal thermal airflow sensor to monitor airflow.*[N1] *[RECOMMENDED]*

Rule 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):*[N2]

a. *Nasal pressure transducer (with or without square root transformation) [RECOMMENDED]*
b. *RIPsum (calibrated or uncalibrated) [RECOMMENDED]*
c. *RIPflow (calibrated or uncalibrated) [RECOMMENDED]*
d. *PVDFsum [ACCEPTABLE]*

Rule 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.*[N3] *[RECOMMENDED]*

Rule 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 apnea sensors):* [N2]

a. *Oronasal thermal airflow [RECOMMENDED]*
b. *RIPsum (calibrated or uncalibrated) [RECOMMENDED]*
c. *RIPflow (calibrated or uncalibrated) [RECOMMENDED]*
d. *Dual thoracoabdominal RIP belts (calibrated or uncalibrated) [RECOMMENDED]*
e. *PVDFsum [ACCEPTABLE]*

Rule 5. *During positive airway pressure (PAP) titration, use the PAP device flow signal to identify apneas or hypopneas. [RECOMMENDED]*

Regarding monitoring respiratory effort:
Rule 6. *For monitoring respiratory effort, use one of the following:*

a. *Esophageal manometry [RECOMMENDED]*
b. *Dual thoracoabdominal RIP belts (calibrated or uncalibrated) [RECOMMENDED]*
c. *Dual thoracoabdominal PVDF belts [ACCEPTABLE]*

- The following new rules were added:
  Rule 8. *For monitoring snoring, use an acoustic sensor (e.g. microphone), piezoelectric sensor or nasal pressure transducer.* [N4] *[RECOMMENDED]*

  Rule 9. *For detection of hypoventilation during a diagnostic study, use arterial PCO_2, transcutaneous PCO_2 or end-tidal PCO_2.*[N5,N6] *[RECOMMENDED]*

  Rule 10. *For detection of hypoventilation during PAP titration, use arterial PCO_2, or use transcutaneous PCO_2.*[N5,N6] *[RECOMMENDED]*

- The previous notes in this section were either incorporated into the rules or removed. The following new notes were added:

Note 1. *Thermal sensors include thermistors, thermocouples, or polyvinylidene fluoride (PVDF) airflow sensors.*

Note 2. *RIP stands for respiratory inductance plethysmography. The RIPsum is the sum of the signals from thoracic and abdominal RIP sensors (belts) and excursions in the signal are an estimate of tidal volume. The RIPflow is the time derivative of the RIPsum and excursions in the signal are an estimate of airflow. The PVDFsum is the sum of signals from thoracic and abdominal PVDF sensors (belts). Recording of RIPsum, RIPflow, or PVDFsum is optional.*

Note 3. *Using the nasal pressure signal without square root transformation for scoring hypopneas will result in a slightly higher hypopnea index than scoring using a square root transformation of the signal. This difference is not clinically significant in most patients.*

Note 4. *Monitoring snoring is optional as noted in Parameters to be Reported II.F.*

Note 5. *Monitoring hypoventilation is optional as noted in Parameters to be Reported II.F.*

Note 6.
a. Clinical judgment is essential when assessing the accuracy of end-tidal PCO_2 and transcutaneous PCO_2 readings. The values should not be assumed to be accurate surrogates of the arterial PCO_2 when the values do not fit the clinical picture.
b. The transcutaneous PCO_2 sensor should be calibrated with a reference gas according to the manufacturer's recommendations and when the accuracy of the reading is doubtful. Of note, the value of the transcutaneous PCO_2 typically lags behind changes in the arterial PCO_2 by two minutes or more.
c. The end-tidal PCO_2 often malfunctions or provides falsely low values in patients who have marked nasal obstruction, profuse nasal secretions, are obligate mouth breathers, or who are receiving supplemental oxygen It is crucial to obtain a plateau in the end-tidal waveform for the signal to be considered valid.

B. Measuring Event Duration
- A new rule was added:
  Rule 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. (see Technical Specifications for adults A.2 and A.4) [RECOMMENDED]*

C. Scoring of Apneas

- The rule about when to score a respiratory event as an apnea was revised to the following:
  Rule 1. *Score a respiratory event as an apnea when BOTH of the following criteria are met:*[N1, N2, N3, N4] *(see Figure 1) [RECOMMENDED]*
  a. *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).*
  b. *The duration of the ≥90% drop in sensor signal is ≥10 seconds.*

- The following new notes were added:
  Note 2. *If a portion of a respiratory event that would otherwise meet criteria for a hypopnea meets criteria for apnea, the entire event should be scored as an apnea.*

  Note 3. *If the apnea or hypopnea event begins or ends during an epoch that is scored as sleep, then the corresponding respiratory event can be scored and included in the computation of the apnea hypopnea index (AHI). This situation usually occurs when an individual has a high AHI with events occurring so frequently that sleep is severely disrupted and epochs may end up being scored as wake even though <15 seconds of sleep is present during the epoch containing that portion of the respiratory event. However, if the apnea or hypopnea occurs entirely during an epoch scored as wake, it should not be scored or counted towards the apnea hypopnea index because of the difficulty of defining a denominator in this situation. If these occurrences are a prominent feature of the polysomnogram and/or interfere with sleep onset, their presence should be mentioned in the narrative summary of the study.*

  Note 4. *For* alternative *apnea sensors* *see Technical Specifications for adults A.2*.

  Note 5. *There is not sufficient evidence to support a specific duration of the central and obstructive components of a mixed apnea; thus, specific durations of these components are not recommended.*

D. Scoring of Hypopneas

- The prior distinction between the RECOMMENDED hypopnea criteria (≥30% signal drop + ≥4% oxygen desaturation) vs. the ALTERNATIVE hypopnea criteria (≥50% signal drop + ≥3% oxygen desaturation) has been revised to be a single rule:
  Rule 1. *Score a respiratory event as a hypopnea if ALL of the following criteria are met:*[N1, N2, N3] *(see Figure 2) [RECOMMENDED]*
  a. *The peak signal excursion drops by ≥30% of pre-event baseline using nasal pressure (diagnostic study), PAP device flow (titration study), or an alternative hypopnea sensor (diagnostic study).*
  b. *The duration of the ≥30% drop in signal excursion is ≥10 seconds.*

c. *There is a ≥3% oxygen desaturation from pre-event baseline or the event is associated with an arousal.*

- Rules 2 and 3 are new RECOMMENDED rules for scoring obstructive or central hypopneas if electing to score them.
  Rule 2. *If electing to score obstructive hypopneas, score a hypopnea as obstructive if ANY of the following criteria are met: [RECOMMENDED]*
  a. *Snoring during the event*
  b. *Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing*
  c. *Associated thoracoabdominal paradox occurs during the event but not during pre-event breathing*

  Rule 3. *If electing to score central hypopneas, score a hypopnea as central if NONE of the following criteria are met: [RECOMMENDED]*
  a. *Snoring during the event*
  b. *Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing*
  c. *Associated thoracoabdominal paradox occurs during the event but not during pre-event breathing*

- The following new notes have been added:
  Note 1. *If necessary, the number of hypopneas using a definition requiring a ≥30% drop in flow for ≥10 seconds that is associated with ≥4% desaturation may* additionally *be reported to qualify a patient for PAP reimbursement (eg. Medicaid or Medicare patients).*

  Note 2. For *alternative* hypopnea sensors see Technical Specifications for adults A.4.

  Note 3. *Supplemental oxygen may blunt desaturation. There are currently no scoring guidelines for when a patient is on supplemental oxygen and no desaturation is noted. If the diagnostic study is performed while the subject is on supplemental oxygen, its presence should be mentioned in the narrative summary of the study.*

E. Scoring of Respiratory Effort-Related Arousal
- Electing to score RERAs is still OPTIONAL; however, *if* you do elect to score a RERA, then it is RECOMMENDED that the following revised rule be followed:
  Rule 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. (see Figure 3) [RECOMMENDED]*

- The note associated with this section regarding esophageal pressure has been removed.

F. Scoring Hypoventilation
   - Electing to score hypoventilation is still OPTIONAL; however, *if* you do elect to score hypoventilation, then there is a RECOMMENDED rule to follow for scoring this event.

   - The RECOMMENDED rule in this section has been clarified and duration criteria added:
     Rule 1. *If electing to score hypoventilation, score a respiratory event as hypoventilation during sleep if EITHER of the below occur:*[N1]
     a. *There is an increase in the arterial PCO_2 (or surrogate) to a value >55 mmHg for ≥10 minutes.*
     b. *There is ≥10 mmHg increase in arterial PCO_2 (or surrogate) during sleep (in comparison to an awake supine value) to a value exceeding 50 mmHg for ≥10 minutes.*

   - A new note was added:
     Note 1. *See Technical Specifications for adults A.9 and A.10 for information on surrogate signals for monitoring hypoventilation.*

G. Scoring Cheyne-Stokes Breathing
   - The RECOMMENDED rule in this section has been revised to the following:
     Rule 1. *Score a respiratory event as Cheyne-Stokes breathing if BOTH of the following are met (See Figure 4):*[N1,N2]
     a. *There are episodes of ≥3 consecutive central apneas and/or central hypopneas separated by a crescendo and decrescendo change in breathing amplitude with a cycle length of ≥40 seconds.*
     b. *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.*

   - The note on cycle length has been revised to the following:
     Note 1. *Cycle length is the time from the beginning of a central apnea to the end of the next crescendo-decrescendo respiratory phase (start of the next apnea).*

   - A new note was added:
     Note 2. *Central apneas that occur within a run of Cheyne-Stokes breathing should be scored as individual apneas as well.*

Part 2: Respiratory Rules for Children

A. Ages for Which Pediatric Respiratory Scoring Rules Apply
   - The note on adult vs. pediatric criteria has been revised to the following:
     Note 1. *Several studies suggest that the apnea hypopnea index (AHI) will be higher in adolescent patients when using pediatric compared to the adult rules presented in the*

2007 version of the AASM scoring manual. As adult and pediatric hypopnea rules are similar in the current rules except for the duration of the event, there may now be less difference in the AHI when using adult versus pediatric rules.

B. Technical Specifications

- The pediatric technical specifications have been revised to be more similar to those found in the Adult Respiratory rules.

- Rules in this section were revised for clarification as follows:

Regarding identifying apneas and hypopneas:
Rule 1. *For identification of an apnea during a diagnostic study, use an oronasal thermal airflow sensor to monitor airflow.* [N1] *[RECOMMENDED]*

Rule 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):[N2]

a. *Nasal pressure transducer (with or without square root transformation) [RECOMMENDED]*
b. *RIPsum (calibrated or uncalibrated) [RECOMMENDED]*
c. *RIPflow (calibrated or uncalibrated) [RECOMMENDED]*
d. *End-tidal PCO2 [ACCEPTABLE]*

Rule 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.*[N3] *[RECOMMENDED]*

Rule 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 to monitor airflow (*alternative *hypopnea sensors):*[N2]

a. *Oronasal thermal airflow [RECOMMENDED]*
b. *RIPsum (calibrated or uncalibrated) [RECOMMENDED]*
c. *RIPflow (calibrated or uncalibrated) [RECOMMENDED]*
d. *Dual thoracoabdominal RIP belts (calibrated or uncalibrated) [RECOMMENDED]*

Rule 5. *During positive airway pressure (PAP) titration, use the PAP device flow signal to identify apneas or hypopneas. [RECOMMENDED]*

Regarding monitoring respiratory effort:
Rule 6. *For monitoring respiratory effort, use one of the following:*

a. *Esophageal manometry [RECOMMENDED]*
b. *Dual thoracoabdominal RIP belts (calibrated or uncalibrated) [RECOMMENDED]*

Regarding monitoring oxygen saturation:
Rule 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. [RECOMMENDED]*

Regarding detection of hypoventilation
Rule 9. *For detection of hypoventilation during a diagnostic study, use arterial PCO_2, transcutaneous PCO_2 or end-tidal PCO_2.[N5, N6] [RECOMMENDED]*

Rule 10. *For detection of hypoventilation during PAP titration, use arterial PCO_2, or use transcutaneous PCO_2.[N5, N6] [RECOMMENDED]*

- The following new rule was added:
  Rule 8. *For monitoring snoring, use an acoustic sensor (e.g. microphone), piezoelectric sensor or nasal pressure transducer.[N4] [RECOMMENDED]*

- The previous notes in this section were either incorporated into the rules or removed. The following new notes were added:

  Note 1. *Thermal sensors include thermistors, thermocouples, or polyvinylidene fluoride (PVDF) airflow sensors.*

  Note 2. *RIP stands for respiratory inductance plethysmography. The RIPsum is the sum of the signals from thoracic and abdominal RIP sensors (belts) and excursions in the signal are an estimate of tidal volume. The RIPflow is the time derivative of the RIPsum and excursions in the signal are an estimate of airflow. Recording of RIPsum, RIPflow, or PVDFsum is optional.*

  Note 3. *Using the nasal pressure signal without square root transformation for scoring hypopneas will result in a slightly higher hypopnea index than scoring using a square root transformation of the signal. This difference is not clinically significant in most patients.*

  Note 4. *Monitoring snoring is optional as noted in Parameters to be Reported II.F.*

  Note 5. *Monitoring hypoventilation during diagnostic study is recommended, as noted in Parameters to be Reported II.F. Monitoring hypoventilation during PAP titration is optional, as noted in Parameters to be Reported II.F.*

  Note 6.
  a. Clinical judgment is essential when assessing the accuracy of end-tidal PCO_2 and transcutaneous PCO_2 readings. The values should not be assumed to be accurate surrogates of the arterial PCO_2 when the values do not fit the clinical picture.
  b. The transcutaneous PCO_2 sensor should be calibrated with a reference gas according

to the manufacturer's recommendations and when the accuracy of the reading is doubtful. Of note, the value of the transcutaneous PCO_2 typically lags behind changes in the arterial PCO_2 by two minutes or more.
c. The end-tidal PCO_2 often malfunctions or provides falsely low values in patients who have marked nasal obstruction, profuse nasal secretions, are obligate mouth breathers, or who are receiving supplemental oxygen It is crucial to obtain a plateau in the end-tidal waveform for the signal to be considered valid.

C. Measuring Event Duration
- This is a new section with a new rule:
  Rule 1. *Same as Measuring Event Duration in adults (B.1-3) [RECOMMENDED]*

D. Scoring of Apneas
- Scoring of apneas has been simplified and organized as general criteria for an apnea followed by specific criteria for obstructive, central, and mixed apneas. A new criteria regarding heart rate has also been added to the rule about scoring central apneas.
  Rule 1. *Score a respiratory event as an apnea when ALL of the following criteria are met:[N1] (see Figure 1) [RECOMMENDED]*
  a. *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).*
  b. *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.*
  c. *The event meets respiratory effort criteria for obstructive, central or mixed apnea.*

  Rule 2. *Score an apnea as <u>obstructive</u> 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. [RECOMMENDED]*

  Rule 3. *Score an apnea as <u>central</u> 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: [RECOMMENDED]*
  a. *The event lasts ≥20 seconds.*
  b. *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.*
  c. *The event is associated with a decrease in heart rate to less than 50 beats per minute for at least 5 seconds or less than 60 beats per minute for 15 seconds (infants under 1 year of age only).*

  Rule 4. *Score an apnea as <u>mixed</u> if it meets apnea criteria for at least the duration of 2 breaths during baseline breathing AND is associated with absent respiratory effort during one portion of the event AND the presence of inspiratory effort in another portion, regardless of which portion comes first. [RECOMMENDED]*

- A new note was added:
  Note 1. *For alternative apnea sensors see Technical Specifications for children B.2.*

E. Scoring of Hypopneas

- The scoring of hypopneas has been revised to be more similar to the adult rule:
  Rule 1. *Score a respiratory event as a hypopnea if ALL of the following criteria are met:*[N1] *[RECOMMENDED]*
  a. *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).*
  b. *The duration of the ≥30% drop in signal excursion lasts for ≥2 breaths*
  c. *There is a ≥3% oxygen desaturation from pre-event baseline or the event is associated with an arousal*

- Electing to score obstructive hypopneas is OPTIONAL; however, *if* you do elect to score obstructive hypopneas, then there is a RECOMMENDED rule to follow for scoring this event.
  Rule 2. *If electing to score obstructive hypopneas, score a hypopnea as* ***obstructive*** *if ANY of the following criteria are met: [RECOMMENDED]*
  a. *Snoring during the event*
  b. *Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing*
  c. *Associated thoracoabdominal paradox occurs during the event but not during the pre-event breathing.*

- Electing to score central hypopneas is OPTIONAL; however, *if* you do elect to score central hypopneas, then there is a RECOMMENDED rule to follow for scoring this event.
  Rule 3. *If electing to score central hypopneas, score a hypopnea as* ***central*** *if NONE of the following criteria are met: [RECOMMENDED]*
  d. *Snoring during the event*
  e. *Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing*
  f. *Associated thoracoabdominal paradox occurs during the event but not during the pre-event breathing.*

- A new note was added:
  Note 1. *For alternative hypopnea sensors see Technical Specifications for children B.4.*

F. Scoring of Respiratory Effort-Related Arousal

- RERA scoring has been simplified into one rule:

  Rule 1. *If electing to score respiratory effort-related arousals, score a respiratory event as a RERA if there is a sequence of breaths lasting ≥2 breaths (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 study) or PAP device flow (titration study) waveform, snoring, or an elevation in the end-tidal PCO_2 leading to arousal from sleep when the sequence of breaths does not meet criteria for an apnea or hypopnea. [RECOMMENDED]

- All previous notes were removed and no new notes have been added.

G. Scoring Hypoventilation

- The hypoventilation scoring rule only had some minor wording changes:

  Rule 1. *Score a respiratory event as hypoventilation during sleep when ≥25% of the total sleep time as measured by either the arterial PCO2 or surrogate is spent with a PCO2 >50 mm Hg.*[N1] *[RECOMMENDED]*

- All previous notes were removed and the following note on where to find information on surrogate signal was added:
  Note 1. *See Technical Specification for children B.9 and B.10 for information on surrogate signals for monitoring hypoventilation.*

H. Scoring of Periodic Breathing

- The rule for scoring periodic breathing has been slightly changed (from requiring > 3 episodes of central apnea to requiring ≥ 3 episodes of central apnea):
  Rule 1. *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.*[N1] *[RECOMMENDED]*

- A new note has been added:
  Note 1. *Central apneas that occur within a run of periodic breathing should be scored as individual apneas as well.*