INTERPRETATION OF POLYSOMNOGRAPHY

DR ANKAN BANDYOPADHYAY

SR PULMONARY MEDICINE
Polysomnography is a comprehensive recording of biophysiological changes that occur during sleep.

PSG includes -

1. Identification of sleep stage
2. Analysis of patterns of respiration
3. Analysis of movement patterns
What are various types of sleep studies?

• Type 1: Fully attended polysomnography (≥ 7 channels) in a laboratory setting

• Type 2: Unattended polysomnography (≥ 7 channels)

• Type 3: Limited channel study (using 4–7 channels)

• Type 4: One or two channels usually using oximetry as one of the parameters
<table>
<thead>
<tr>
<th></th>
<th>level1</th>
<th>level2</th>
<th>level3</th>
<th>level4</th>
</tr>
</thead>
<tbody>
<tr>
<td>attended</td>
<td></td>
<td></td>
<td>unattended</td>
<td>Cardiorespiratory monitoring</td>
</tr>
<tr>
<td>unattended</td>
<td></td>
<td></td>
<td></td>
<td>Continuous single or dual bio parameter recording</td>
</tr>
<tr>
<td>channels</td>
<td>Minimum of 7 channels including EEG, EOG, chin EMG, ECG, airflow, respiratory effort, oxygen saturation</td>
<td>Minimum of 7 channels including EEG, EOG, chin EMG, ECG, airflow, respiratory effort, oxygen saturation</td>
<td>Minimum of 4, including ventilation (at least 2 channels of respiratory movement or respiratory movement and airflow), heart rate or ECG, and oxygen saturation</td>
<td>Minimum of one including oxygen saturation, flow or chest movement</td>
</tr>
<tr>
<td>Body position</td>
<td>Objectively measured</td>
<td>Possible</td>
<td>Possible</td>
<td>No</td>
</tr>
<tr>
<td>Leg movement</td>
<td>EMG or motion sensor desirable but optional</td>
<td>optional</td>
<td>optional</td>
<td>No</td>
</tr>
</tbody>
</table>
• Level 1 study or in-hospital, in-laboratory, technician-attended, overnight polysomnography (PSG) is the “Gold standard” for evaluation of sleep-disordered breathing (Evidence Quality A, Strong Recommendation).

• Level 1 polysomnography remains the cornerstone for the diagnosis in patients of comorbid sleep disorders, unstable medical conditions or complex sleep-disordered breathing.

INOSA GUIDELINE 2014
Laboratory attended PSG (level 1) is not necessary in all patients suspected to have OSA.

Portable monitoring with devices (which should at least include airflow, oxygen saturation and respiratory effort) is adequate for diagnosis if

- Used in conjunction with comprehensive sleep evaluation
- In patients with high pre-test probability of moderate to severe OSA
- Without co-morbid sleep disorders or medical disorders like pulmonary disease, neuromuscular disease, or congestive heart failure *(Evidence Quality A, Strong Recommendation)*.

Mohamed El Shayeb MD MSc, Leigh-Ann Topfer MLS, Tania Stafinski PhD, Lawrence Pawluk MD, Devidas Menon PhD

*CMAJ, January 7, 2014, 186(1)*
Other indications for unattended portable sleep study:

a. Severe clinical symptoms indicate OSA and initiation of treatment is urgent and PSG is not readily available

b. Patients are unable to be studied in the sleep laboratory (safety or immobility)

c. As a follow-up study when the diagnosis of OSA was previously established by PSG and the intent of testing is to evaluate the response to therapy (weight loss, surgery, oral appliance)
INTERPRETATION AND MONITORING OF RESPIRATORY EVENTS
RESPIRATORY SENSORS

• The sensor to detect absence of airflow in apnea is oronasal thermal sensor.

• The sensor for detection of air flow for identification of hypopnea is a nasal air pressure transducer.

• The sensor for detection of respiratory effort is either esophageal manometry or calibrated or uncalibrated inductance plethysmography.

• The sensor for detection of blood oxygen is pulse oxymetry.
## COMPARING 2007 AND 2012 AASM RULES

<table>
<thead>
<tr>
<th></th>
<th>2007 rule</th>
<th>2012 rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>APNOEA</td>
<td>Drop in peak thermal sensor excursion by &gt; 90% of baseline</td>
<td>Drop in peak thermal sensor excursion by &gt; 90% of pre-event baseline</td>
</tr>
<tr>
<td></td>
<td>Duration of event lasts &gt; 10 seconds</td>
<td>Duration of event lasts &gt; 10 seconds</td>
</tr>
<tr>
<td></td>
<td>At least 90% of event’s duration meets amplitude reduction criteria for apnea</td>
<td><strong>NOTE: Removed</strong>: 90% of event duration must meet amplitude reduction criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Added</strong>: 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</td>
</tr>
</tbody>
</table>
Types of apneas

- **Obstructive apnea:** If the event meets apnea criteria and associated with continued or increased inspiratory effort throughout the entire period of absent airflow.

- **Central apnea:** If the event meets the apnea criteria and associated with absent inspiratory effort through the entire period of absent airflow.

- **Mixed apnea:** If the event meets apnea criteria and is associated with absent inspiratory effort in the initial portion of event followed by resumption of inspiratory effort in second portion of event.

  - AASM GUIDELINE OF SCORING SLEEP 2012
Blood oxygen levels reduce to \( \geq 3\% \) of baseline value.
HYPOPNOEA RULES- 2007

Criteria 1: When all of the following criteria are made-
• Nasal pressure signal excursions drop by ≥30% of baseline.
• Duration of drop occur for a period lasting at least 10 seconds.
• ≥ 4% desaturation from pre event baseline
• At least 90% of event duration must meet amplitude reduction criteria for hypopnea.

Criteria 2: When all of the following criteria are met
• Nasal pressure signal excursion drop by ≥ 50% from baseline.
• Duration of drop for a period lasting at least 10 seconds
• ≥ 3% desaturation from pre event baseline or event is associated with arousal
• At least 90% of event duration must meet the amplitude reduction criteria for hypopnea.
HYPOPNEA RULE -2012

1. Nasal pressure signal excursions drop by > 30% in airflow from pre event baseline
2. Duration of this drop occurs for > 10 seconds
3. > 3% oxygen desaturation or event is associated with an arousal

**Removed**: 90% of event duration must meet amplitude reduction criteria.

No Alternative Rule

**Added**: Definitions for scoring obstructive and central hypopnea. Scoring hypopneas as obstructive or central is optional
CHEYNE STROKES RESPIRATION
<table>
<thead>
<tr>
<th>CHEYNE- STROKES RESPIRATION</th>
<th>2007 rule</th>
<th>2012 rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score CSR if there is:</td>
<td>a. &gt; 3 consecutive cycles of cyclical crescendo-decrescendo change in breathing amplitude AND at least one of the following: 1) &gt;5 central apneas and/or hypopneas per hour of sleep 2) The cyclical crescendo and decrescendo change in breathing amplitude has duration of &gt; 10 consecutive minutes</td>
<td>Score as CSR if BOTH the following are met: a. episodes of &gt; 3 consecutive central apneas and/or central hypopneas separated by crescendo-decrescendo change in breathing amplitude with a cycle length of &gt; 40 seconds AND b. There are &gt;5 central apneas and/or central hypopneas per hour of sleep associated with crescendo/decrescendo breathing pattern recorded over &gt; 2 hours of monitoring</td>
</tr>
<tr>
<td>NOTE: Central apneas occurring within a run of CSR should be scored as individual apneas as well</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Respiratory effort related arousal

• Sequence of breaths lasting at least 10 seconds characterized by increasing respiratory effort or flattening of the nasal pressure waveform leading to an arousal from sleep when sequence of breath does not meet criteria for apnea or hypopnea.

• Use of esophageal pressure is preferred method of assessing change of respiratory effort.

• AASM MANUAL OF SCORING SLEEP 2007
HYPOVENTILATION RULE
<table>
<thead>
<tr>
<th>hypoventilation</th>
<th>2007 rules</th>
<th>20 12 rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>During sleep, &gt; 10 mmHg increase in PaCO2 during sleep compared to wake supine value</td>
<td>Score a respiratory event as hypoventilation during sleep if EITHER of the below occur: a. There is an increase in the arterial PCO2 (or surrogate) to a value &gt;55 mmHg for ≥10 minutes. b. There is ≥10 mmHg increase in arterial PCO2 (or surrogate) during sleep (in comparison to an awake supine value) to a value exceeding 50 mmHg for ≥10 minutes.</td>
<td></td>
</tr>
<tr>
<td>CARDIAC EVENT PARAMETER</td>
<td>OLD 2007 RULES</td>
<td>NEW 2012 RULES</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Added:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average heart rate during sleep, highest heart rate during sleep, highest heart rate during recording</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occurrence of arrhythmia: Bradycardia (yes/no) [list lowest rate] Asystole (yes/no) [list longest pause] Sinus tachycardia (yes/no) [list highest rate] Narrow complex tachycardia (yes/no) [list highest rate] Wide complex tachycardia (yes/no) [list highest rate] Atrial fibrillation (yes/no) Other arrhythmias if present (yes/no)</td>
</tr>
<tr>
<td>General reporting, Sleep scoring and data parameter</td>
<td>Added ECG as recommended parameter</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td>Optional respiratory event report parameter</td>
<td><strong>Added the following optional reporting parameters:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstructive apnea hypopnea index (OAHI)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Central apnea hypopnea index (CAHI)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Respiratory disturbance index (RDI) index</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arterial oxygen saturation, mean value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Occurrence of hypoventilation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Occurrence of hypoventilation during PAP titration</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Removed or changed the following optional reporting parameters:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oxygen desaturations $\geq$3% total number</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oxygen desaturation index $\geq$3% (ODI)</td>
<td></td>
</tr>
</tbody>
</table>
DESCRIPTION AND METHODOLOGY OF MANUAL PAP TITRATION

(AASM clinical guideline for manual titration of PAP in OSA patients –update 2012) *Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008*

<table>
<thead>
<tr>
<th>CPAP TITRATION</th>
<th>PATIENTS&lt;12 YEARS</th>
<th>PATIENTS&gt;12 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPAP MINIMUM OF 4CM OF WATER AND MAXIMUM OF15 CM OF WATER</td>
<td>CPAP MINIMUM OF 4CM OF WATER AND MAXIMUM OF 20 CM OF WATER</td>
<td></td>
</tr>
</tbody>
</table>
Increase pressure by one cm of water at an interval of no less than five minutes in following cases-

<table>
<thead>
<tr>
<th>Patient&lt;12 yr</th>
<th>Patient&gt;12 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 obstructive apnoea</td>
<td>2 obstructive apnoeas</td>
</tr>
<tr>
<td>1 hypopnoea</td>
<td>3 hypopnoeas</td>
</tr>
<tr>
<td>3 RERAS</td>
<td>5 RERAS</td>
</tr>
<tr>
<td>1 min of loud unambiguous snoring</td>
<td>3 min of loud unambiguous snoring</td>
</tr>
</tbody>
</table>
Recommended maximum 20 cm H$_2$O

The patient may be transitioned to BPAP if there are continued breathing events at 15 cm H$_2$O**

"Exploration" of pressure

+5 cm H$_2$O

≥ 30 min without breathing events

≥ 2 obstructive apneas, or
≥ 3 hypopneas, or
≥ 5 RERAs, or
≥ (3 min of loud or unambiguous snoring)

≥ 1 cm H$_2$O

≥ 10 min

≥ 1 cm H$_2$O

Minimum* 4 cm H$_2$O

≥ 5 min

≥ 2 obstructive apneas, or
≥ 3 hypopneas, or
≥ 5 RERAs, or
≥ (3 min of loud or unambiguous snoring)

If patient awakens and complains pressure is too high, a lower pressure that the patient reports is comfortable enough to allow return to sleep should be chosen, and resume titration

≥ 1 cm H$_2$O

≥ 15 min in supine REM sleep

Control of breathing events and

Stop if re-emergence of breathing events

TIME
DOWN TITRATION

A “down” titration is recommended due to the “hysteresis” phenomenon. During upward titration the PAP level at which flow limitation disappears is 2-5 cm H2O higher than the level at which it reappears during downward titration. If a “down” titration is implemented, at least one “up-down” CPAP titration (1 cycle) should be conducted during the night.

It should be conducted when at least 30 min has elapsed without obstructive respiratory events.

CPAP should be decreased by more than 1 cm H2O with an interval no shorter than 10 min, until there is reemergence of obstructive respiratory events.
Titration guideline for when and how to switch to BIPAP

1. When the patient complains that he/she is uncomfortable or is intolerant of high CPAP pressures. (Document this on the record.)

2. When CPAP level is 15 cm H2O and respiratory disturbances continue. (Document this on the record.)

Begin BPAP at EPAP 4 cm H2O or the CPAP level at which obstructive apnea was eliminated; set IPAP 4 cm H2O higher.

AASM clinical guideline for manual titration of PAP in OSA patients – update 2012
### AASM clinical guideline for manual titration of PAP in OSA patients – update 2012

<table>
<thead>
<tr>
<th>PATIENT&lt;12 YRS</th>
<th>Patients &gt;12 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum IPAP 8 cm of water, EPAP 4 cm of water</td>
<td>Minimum IPAP 8 cm of water, EPAP 4 cm of water</td>
</tr>
<tr>
<td>Maximum IPAP 20 cm of water</td>
<td>Maximum IPAP 30 cm of water</td>
</tr>
<tr>
<td>Minimum I/E difference 4 cm of water</td>
<td>Minimum I/E difference 4 cm of water</td>
</tr>
<tr>
<td>Maximum I/E difference 10 cm of water</td>
<td>Maximum I/E difference of 10 cm of water</td>
</tr>
</tbody>
</table>
• Increase both IPAP and EPAP pressures by a minimum of 1 cm H2O with an interval of no less than 5 minutes when the following occur:

<table>
<thead>
<tr>
<th>Patient age&lt;12 yrs</th>
<th>Patient age &gt;12 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>One obstructive apnoea</td>
<td>Two obstructive apnoeas</td>
</tr>
</tbody>
</table>

AASM clinical guideline for manual titration of PAP in OSA patients – update 2012
Increase IPAP pressure by a minimum of 1 cm H2O with an interval of no less than 5 minutes when the following occurs:

<table>
<thead>
<tr>
<th>&lt;12 years</th>
<th>&gt;12 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>One hypopnoea</td>
<td>Three hypopnoeas</td>
</tr>
<tr>
<td>Three RERAS</td>
<td>Five RERAS</td>
</tr>
<tr>
<td>One min of loud or unambiguous snoring</td>
<td>Three min of loud or unambiguous snoring</td>
</tr>
</tbody>
</table>
• Determining the Optimum Pressure

• The patient must be able to sleep in order for PAP titration to be successful. If the patient awakens and complains the pressure is too high, the pressure should be reduced to a level at which the patient is able to return to sleep.

• Mask and mouth leaks should be promptly addressed.

• Pressure relief technologies may be implemented to improve patient comfort.

• BPAP may be utilized for patients who are intolerant of high CPAP pressures.

AASM clinical guideline for manual titration of PAP in OSA patients – update 2012
• Supplemental Oxygen
  • when awake supine SpO2 on room air is less than 88% for 5 minutes or longer. Supplemental O2 may also be added during the PAP titration when SpO2 is ≤88% for ≥5 minutes in the absence of obstructive respiratory events

Supplemental oxygen should be introduced into the PAP device at the device tubing connection using a T connector, not at the PAP mask.

The recommended minimum starting rate for adult and pediatric patients is 1 L/min.
  Titrate O2 in 1 L/min increments with an interval of no less than 15 minutes until SpO2 is between 88% and 94.

Types of Titration achieved

1. Optimal
2. Good
3. Acceptable
4. Unacceptable
Optimal titration is achieved when-

1. The Respiratory Disturbance Index (RDI) is < 5 per hour for a period of at least 15 minutes at the selected pressure and within the manufacturer’s acceptable leak limit.

2. The SpO2 is above 90% at the selected pressure.

3. Supine REM sleep at the selected pressure is not continually interrupted by spontaneous arousals or awakenings.

*AASM clinical guideline for manual titration of PAP in OSA patients – update 2012*  
Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008
Good titration is achieved when

1. The Respiratory Disturbance Index (RDI) is < 10 per hour (or is reduced by 50% if the baseline RDI was <15) for a period of at least 15 minutes.

2. The SpO2 is above 90% at the selected pressure.

3. Supine REM sleep at the selected pressure is not continually interrupted by spontaneous arousals or awakenings.

Adequate Titration-

Which does not reduces overnight RDI<10 per hour but reduces RDI>75% of baseline in severe OSA patients or in which titration grading criteria of optimal or good titration are achieved with exception that supine REM does not occur at selected pressure.

- *Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008*
Split-Night Studies

• Split-night studies must be performed using algorithms identical to those used for full-night PAP titration and should include greater than 3 hours of titration time.

• Split-night studies should not be performed in children less than 12 years old.

• Due to the reduced titration time available during split-night studies, increase PAP pressures by a minimum of 2 cm H2O with an interval of no less than 5 minutes.
INTERPRETATION OF EEG
EEG electrode position determined by international 10-20 system.

A minimum of 3 EEG derivations are required in order to sample activity from frontal, central and occipital regions.

This system is based on the relationship between the location of an electrode and the underlying area of cerebral cortex.

"10" and "20" refer to the actual distances between adjacent electrodes are either 10% or 20% of the total front–back or right–left distance of the skull.
• Recommended derivations are F4-M1, C4-M1, O2-M1.
• M1 and M2 refer to right and left mastoid process
EOG

Right    Left
Electrooculography picks up the inherent voltage of the eye. During eyes-open wakefulness, sharp deflections in the EOG tracing may indicate the presence of eye blinks.
During drowsiness and stage one sleep, the eyes begin to slowly roll (SEM’s). Brain wave activity (theta) starts to enter into the EOG tracing as an artifact.
During REM sleep, the eyes move rapidly under closed eyelids while dreaming. This produces rapid conjugate eye movements which appear as out-of-phase EOG channel deflections.
CHIN EMG-

Three electrodes should be placed to record chin EMG-

• One in the midline one cm above the inferior edge of mandible.
• One two cm below the inferior edge of mandible and 2cm to right of midline.
• One two cm below the inferior edge of mandible and two cm to the left of mandible
SCORING OF SLEEP STAGES-

Stages of sleep:

- Stage N1
- Stage N2
- Stage N3
- Stage R

- Scoring by Epoch - Scored in 30 second sequential epoch
- Assign a stage to each epoch.
- If two or more stage coexist during single epoch, assign the stage comprising the greatest portion of epoch
Frequency band width

Frequencies in polysomnography limited to 4 distinct patterns:

- **Delta**: $< 4$ Hz
- **Theta**: 4-7 Hz
- **Alpha**: 8-13 Hz
- **Beta**: $> 13$ Hz

![Graph](image)
EEG scoring

EEG waves can be described in terms of their SHAPE:

**Vertex waves**: sharp positive waves, theta frequency range, occurring *latter part* of **Stage 1**

**K Complex**: sharp positive wave, followed by slower negative component, seen in **Stage 2**

**Sawtooth waves**: low amplitude sawtooth appearance seen in **REM**

**Spindle**: short rhythmic waveform clusters of 12-14 Hz seen in **stage 2**
Light sleep

Deep sleep

Stage 1

Stage 2

Stage 3(4)

REM

Non

Rapid

Eye

Mov

Awake: low voltage – random, fast

Drowsy: 8 to 12 cps – alpha waves

Stage 1: 3 to 7 cps – theta waves

Stage 2: 12 to 14 cps – sleep spindles and K complexes

Delta sleep: (stages 3 and 4) ≤ 2 to 2 cps – delta waves > 75 μV

REM sleep: low voltage – random, fast with sawtooth waves
STAGE W

More than 50% of epoch has alpha rhythm over occipital region or any of the following are present:

- Eye blink at a frequency of 0.5 -2 Hz
- Reading eye movement
- Irregular conjugate rapid eye movements associated with normal or high chin muscle tone
Alpha Activity

- Alpha EEG: 8-13 cps.
- Alpha: occipital region
- Alpha: crescendo-decrescendo appearance
- Decrease in frequency occurs with aging
Stage Wake

• >50% of each epoch contains alpha activity.

• Slow rolling eye movements or eye blinks will be seen in the EOG channels

• Relatively high submental EMG muscle tone
STAGE N1

• Alpha rhythm is attenuated and replaced by low amplitude mixed frequency activity more than 50% of epoch

In subjects who do not generate alpha rhythm score stage N1 with any of the following phenomenon-

• Activity in range of 4-7Hz with slowing of background frequency by >_ 1Hz from those of stage W

• Vertex sharp wave

• Slow eye movements
Theta Activity

- A frequency of 4-7 Hz
- Produced in the central vertex region
- No amplitude criteria for Theta
- The most common sleep frequency
• 50% of the epoch contains Theta activity (3-7 cps.) There may be alpha activity within <50% of the epoch.
• Slow rolling eye movements in the EOG channels
• Relatively high submental EMG tone
STAGE N2

• Score N2 (in absence of criteria for N3) if one or both occur in first half of epoch or last half of the previous epoch-
  • One or more k complexes unassociated with arousal
  • One or more trains of sleep spindles

Continue to score epochs with low amplitude mixed frequency EEG activity without K complexes or sleep spindles as N2 if they are preceded by K complex unassociated with arousal or sleep spindle

AASM MANUAL OF SCORING SLEEP 2007
Stage Two Sleep

- Background EEG is Theta (3-7 cps.)
- K-Complexes and Spindles occur episodically
- Mirrored EEG in the EOG leads
- Low tonic submental EMG
K Complex: A well delineated negative sharp wave immediately followed by a positive component standing out from the background EEG, with total duration $\geq$ or equal to 5 seconds, usually maximal in amplitude when recorded using frontal derivations.

Sleep Spindle: A train of distinct waves with frequency 11-16 Hz with a duration of $\geq$ and equal to 0.5 seconds usually maximal in amplitude using central derivations.
End of N2 sleep when one of the following events occur-

• Transition to stage W or N3 or stage R

• Major body movement followed by slow eye movements and low amplitude mixed frequency EEG without nonarousal associated K complexes or sleep spindles

AASM MANUAL OF SCORING SLEEP 2007
• STAGE N3- When 20% or more of an epochs consists of slow wave activity irrespective of age.

• Sleep spindles may persist in stage N3 sleep.

• Eye movements are not typically seen in N3 sleep.

• In N3 stage the chin EMG is of variable amplitude often lower than in stage N2 sleep and sometimes as low as in stage R sleep.

• AASM MANUAL OF SCORING SLEEP 2007
Delta Activity

• Sleep Delta Activity - frequency of .5-2 cps.

• Seen predominantly in the frontal region

• Delta Activity - amplitude of > 75mn
Stage Three Sleep

- 20% to 50% Delta Activity is seen
- EOG leads will only pick up the EEG activity
- EMG may be slightly lower than that of Stage two
STAGE R

• Low amplitude mixed frequency EEG
• Low chin EMG tone
• Rapid eye movements
• Saw tooth waves

AASM MANUAL OF SCORING SLEEP 2007
Stage R: phasic twitching

- Very short muscle twiches that normally occur in REM sleep
- "Saw tooth" waves: jagged & evenly formed EEG pattern seen usually in the vertex region

These arrows are pointing to phasic twitching
MAJOR BODY MOVEMENTS-

• Movement and muscle artifact obscuring EEG for > half of epoch to the extent that sleep stage can not be determined

Score an epoch with major body movement as follows-
• If alpha rhythm is present for part of epoch score as stage W.
• Otherwise score the epoch as the same stage as the epoch follows it.
PULSE TRANSIT TIME

• Pulse transit time (PTT) is the time taken for the arterial pulse pressure wave to travel from the aortic valve to a peripheral site. For convenience, it is usually measured from the R wave on the electrocardiogram to the pulse wave arrival at the finger.

• Pulse transit time is inversely proportional to blood pressure, and the falls in blood pressure which occur with inspiration (pulsus paradoxus) correspond to rises (lengthening) in pulse transit time.
• Pulse transit time may, therefore, provide a clinically useful noninvasive and quantitative measure of inspiratory effort in patients with sleep-related breathing disorders.

_Eur Respir J., 1995, 8, 1669–1674_