

## Standard Polysomnography

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**SUMMARY:** The scope of polysomnography encompasses the monitoring of patients in a sleep facility using an array of medical equipment that is simultaneously recorded on a multi-channel analog or digital system. Sleep technologists are specially trained to perform polysomnography for the diagnosis and treatment of sleep and arousal disorders. They are part of a team under the direction of a physician who practices sleep disorders medicine. The team works in concert to ensure the proper diagnosis, appropriate management, and education for individuals that experience sleep disorders. They follow patient sensitive standards of care, which are the foundation for clinical/technical decision-making.

The sleep technologist prepares for and monitors the recording, requiring expertise in normal and abnormal sleep and multiple technical and medical monitors. Much of the utility of the polysomnogram (PSG) depends on the ability to correlate specific changes or abnormalities of one physiological parameter with specific conditions defined by another parameter or parameters. Consequently, polysomnography is a significantly more powerful and complex tool than could be provided by individual or independent measurements of each variable. The sleep technologist verifies and maintains the quality of the recording and can decipher artifact from true physiological signals. The technologist can recognize when medical intervention is required and responds according to the protocols provided by the medical director. Therefore, attended polysomnography by a trained sleep technologist produces the highest quality clinical tool.

The standard diagnostic PSG requires the recording and evaluation of sleep stages and arousals, respiration, limb movements, snoring, oximetry, body position, and cardiac rhythm disturbances. The resulting documentation is used to diagnose or assess the treatment of sleep disorders (1).

### KEY DEFINITIONS:

***Sleep facility*** – any sleep center whether it is hospital based or independent.

***Sleep technologist*** – trainee, technician or technologist for the purpose of this document (2). Note that the technologist designation usually refers to those who have passed the American

Board of Sleep Medicine (ABSM) examination and are identified by the Registered Sleep Technologist (RST) credential or the Board of Registered Polysomnographic Technologists (BRPT) examination, and are identified by the Registered Polysomnographic Technologist (RPSGT) credential or National Board of Respiratory Care examination and are identified by the Sleep Disorders Specialist (SDS) credential.

## **1.0 SCOPE**

This technical guideline will address PSG evaluations attended by a sleep technologist that are provided in a sleep facility. This technical guideline does not cover pediatric polysomnography, home or unattended PSG evaluations, or the therapeutic use of positive airway pressure (PAP), or oxygen.

### **1.1 Indications for Standard Polysomnography**

Standard PSG evaluation is necessary because physiological functions change during the sleeping state and many disorders are specifically induced by sleep. There are over 80 specific disorders of sleep and arousal that are identified in the International Classification of Sleep Disorders (ICSD-2). A PSG evaluation is one of the tools used by physicians that can result in a specific diagnosis of a sleep disorder that might otherwise remain obscure.

The most common reasons for an individual to be referred to a sleep facility for evaluation include: episodes of sleep at inappropriate times; difficulty sleeping during scheduled sleep periods; difficulty staying awake during scheduled wake periods; atypical behavioral events during sleep; documentation of the effectiveness of various therapeutic interventions utilized for the management of the documented sleep disorder; witnessed apnea and snoring.

### **1.2 Patient Referral Dynamics**

Standard PSG evaluations can be carried out within the sleep facility where patients are primarily physician-referred and their subsequent care is the responsibility of the referring physician; or preferably within the sleep facility where patients are either self- or physician-referred and in which complete clinical evaluation and treatment plans are formulated and implemented by the sleep specialist, patient education is provided by the sleep technologist and compliance and outcomes are tracked.

## **2.0 RECORDING TECHNIQUES**

### **2.1 Physiological Parameters Measured and Equipment Parameters**

This section will discuss the physiological parameters that are necessary to record during standard PSG to provide adequate data for interpretation by the sleep specialist. Each

parameter will be described and the standard methodology for preparation and monitoring will be outlined. It is the goal of polysomnography to capture the best quality recordings of the physiological channels.

## **2.1.1 Routine Variables**

### **2.1.1.1 Electrode Preparation and Application**

#### Description

Electrodes used in polysomnography conduct biopotentials from the patient to the recording circuit. Electrodes are used to record EEG, EOG, EMG, ECG, and sometimes respiratory effort. The best recordings are artifact free and have the maximum waveform amplitude possible. Because the subtle variations in current are muted by impedance, it is the goal of polysomnography to get the lowest impedance possible. The pathway in question is comprised of the source of the current being measured in each locale of the body, the various levels of tissue and the actual electrode cups and wires. It is through these layers that conductance is thwarted by impedance. Lower impedance allows higher conductance and produces larger amplitude waveforms. It is the goal of electrode application to obtain the lowest impedance possible without compromising patient comfort and skin integrity. To obtain the lowest possible impedance values it is necessary to abrade the skin area where the electrode is to be placed to the extent that the dead outer epidermal layer (stratum corneum) is removed without disrupting the dermis. To maximize the signal quality and minimize patient discomfort the sleep technologist should scrub only the area where the electrode will be placed. For optimal signal quality it is necessary to match the input impedance of all electrodes pairs as closely as possible. Impedance mismatching allows current to pass through to the amplifier and can lead to artifact. Common mode rejection is the cancellation of voltages equal to both input electrodes. Impedance mismatching also impairs common mode rejection. Therefore, optimal signal quality is possible when impedances are low enough to maximize amplitude, take advantage of common mode rejection, and avoid impedance mismatching. Ideally, impedances should range from 1-5k ohms regardless of the amplifier that is used, although its effect is less pronounced in some recent high input impedance amplifier designs.

The standard for electrode impedance upper limit is 5k ohms for EEG & EOG (3).

*The guideline is that impedances are as closely matched as possible (4).*

The standard for electrode impedance upper limit is 10k ohms for EMG (5).

*The guideline is that impedances are as closely matched as possible.*

The standard for electrode impedance upper limit is 10k ohms for EKG.

*The guideline is that impedances are as closely matched as possible*

### Methodology

The area where the electrode is to be placed is prepared by abrading the skin to allow optimal impedance without disrupting the dermis. The sleep technologist should take care to scrub only the area where the electrode will be placed. Electrodes should be of ample length for input from the electrode site to the headbox.

There are two methods used to secure the disk electrodes. First, the electrode discs are filled with electrolyte or electrode paste. The collodion method uses compressed air to attach collodion saturated gauze squares placed over the electrode disc securely to the electrode site.

With the electrode paste method, for scalp electrode sites, a small mound of electrode paste is placed on a gauze square to secure the electrode. Care should be taken to keep the electrode paste close to the electrode disc, as the electrode recording site is the entire area that electrode paste touches. For other electrode sites, fill the electrode disc with electrode paste and secure to the electrode site with tape or medical adhesive.

Various types of single use adhesive electrode discs are available and “snap on” electrode wires of appropriate length provide for input to the headbox.

After use, reusable electrode discs and wires should be cleaned and disinfected according to facility protocols for infection control.

### **2.1.1.2 Electroencephalogram (EEG)**

#### Description

The EEG is the primary variable to document wakefulness, arousals and sleep stages during the sleep study. A single central channel referenced to an ear mastoid site (C4-M1), a single frontal channel referenced to an ear mastoid site (F4-M1) and a single occipital channel referenced to an ear mastoid site (O2-M1) is sufficient for evaluating waveforms (6). The mastoid is located posterior to each ear. However, additional channels (C3-M2, F3-M2, O1-M2) are recommended to provide redundancy in case of electrode malfunction.

### Methodology

The electrodes should be placed on the scalp according to the International 10-20 System of Electrode Placement (7). Additional electrodes may be used as directed by the sleep facility's medical director for the evaluation of a patient with a possible nocturnal seizure disorder. Additional electrodes would be placed according to the International 10-20 System of Electrode Placement. Electrodes are applied according to section 2.1.1.1. The amplifier settings and calibration requirements for the recording of the EEG signal will vary according to the equipment specifications, but should adhere as closely as possible to AASM standards.

#### **2.1.1.3 Electrooculogram (EOG)**

##### Description

The EOG recording aids the identification of sleep onset by monitoring for slow, rolling eye movements that occur with transition to Stage N1 sleep and identification of REM sleep when rapid eye movements (REMs) that occur during Stage R (REM) sleep are present in the recording.

##### Methodology

At least two channels of EOG are recommended. Each EOG channel records from an electrode placed 1 cm above or below the outer canthus of the eye. An equal displacement of the electrodes insures equal amplitude of the conjugate eye movements. An ear mastoid site (M2) is generally used as the reference for both EOG electrodes; however a contra-lateral ear mastoid reference is sometimes utilized. With these derivations, conjugate eye movements produce out-of-phase voltage deflections in the two channels; whereas simultaneous EEG activity is usually in phase. To distinguish between vertical and lateral eye movement, additional EOG montages can be applied using electrodes placed 1 cm below and 1 cm lateral to the outer canthus of each eye referred to a supranasion reference electrode (Fpz) that produces deflections in phase with vertical eye movements and out of phase with horizontal eye movements. A supranasion reference electrode alone, however, may result in the integration of EEG activity with extra ocular movement potentials. Consequently, other reference locations may be required for specific circumstances. Electrodes are applied according to section 2.1.1.1. The amplifier settings and calibration requirements for the recording of EOG signals will vary according to equipment specification, but should adhere as closely as possible to AASM standards.

#### **2.1.1.4 Chin Electromyogram (EMG)**

### Description

The recording of EMG activity in the chin area is used for determining the level of muscle tone, which significantly decreases during Stage R (REM) sleep and may also be reduced with sleep onset. This channel also provides supplemental information regarding patient movements and arousals and may be useful in distinguishing artifact in other channels.

### Methodology

Three electrodes should be placed to record chin EMG as follows: one mental electrode placed in the midline 1 cm above the inferior edge of the mandible, one submental electrode placed 2 cm below the inferior edge and 2 cm to the left of the midline, and one submental electrode placed 2 cm below the inferior edge and 2 cm to the right of the midline. A single channel is sufficient with either of the submental electrodes referenced to the mental electrode (8). An additional electrode may be placed on the masseter muscle on the jaw line and referred to the mental electrode to better distinguish bruxism, but this should be included as an additional recording channel. Electrodes are applied according to section 2.1.1.1. The amplifier settings and calibration requirements for the recording of the EMG signal will vary according to equipment specifications, but should adhere as closely as possible to AASM standards.

## **2.1.1.5 Limb Movement**

### Description

Additional causes of sleep disturbances that may need to be identified and treated are periodic limb movements of sleep (PLMS). These movements are often visually detectable during the monitoring process. Monitoring the anterior tibialis muscles allows for the determination of the severity of the disorder by quantifying the rate of movements as well as the correlation with EEG arousal. Limb EMG of the upper extremities may also be recorded if clinically indicated.

### Methodology

Two electrodes are placed longitudinally on the anterior tibialis muscle of each leg 2-3 cm apart and secured with tape to record each leg separately. Although, one electrode can be placed on each leg and referenced together to record both legs on one channel, this is not optimal and may affect scoring periodic limb movements according to AASM published guidelines. Electrodes are applied according to section 2.1.1.1. The amplifier settings and calibration requirements for the recording of the EMG signal will vary according to equipment specifications, but should adhere as closely as possible to AASM standards.

### **2.1.1.6 Electrocardiogram (ECG)**

#### Description

The ECG monitors the heart rhythm. A single ECG channel is sufficient for standard PSG monitoring.

#### Methodology

The two standard ECG electrodes are applied in a lead II format. One electrode is placed below the right clavicle parallel to the right shoulder and a second electrode is placed on the torso at the fourth intercostal space on the left side parallel to the left hip. The placement used should be documented. Electrodes are applied according to section 2.1.1.1. The amplifier settings and calibration requirements for the recording of the ECG signal will vary according to equipment specifications, but should adhere as closely as possible to AASM standards.

### **2.1.1.7 Upper Airway Sound Recording**

#### Description

Detecting snore bursts can be a valuable supplemental tool for determining and verifying the nature of arousals. There are several commercially available devices but snoring is typically measured with a snore microphone or sound transducer.

#### Methodology

The snore sensor or microphone should be placed over the trachea or on the side of the neck and can be secured with tape. The decision of where to place the device should be based on obtaining a good signal without compromising patient comfort. The sleep technologist should feel for the area of maximum vibration while the

patient hums or snores. This will allow for recording of the snore sounds. The polygraph settings for detecting snore sounds are the same as those used for submental EMG detection.

### **2.1.1.8 Respiration (Measures of Airflow and Respiratory Effort)**

#### Description

Airflow and respiratory effort channels are utilized during the standard PSG to monitor respiration specifically for the detection of apneas, hypopneas, RERA's and other sleep related

breathing events. RERA is an acronym for Respiratory Effort Related Arousal. It is important to record at least three respiratory parameters: nasal/oral airflow, thoracic effort and abdominal effort.

### Methodology

Various transducers may accomplish the recording of airflow exchange. A thermal sensor [either a thermistor, thermocouple or polyvinylidene fluoride (PVDF) sensor] is used in the detection of apnea. Pressure transducers offer a sensitive method of recording airflow and are used for both hypopnea detection and RERA detection. It is necessary to use both methods of measurement to achieve accuracy from nasal and oral flow. It is important that both nasal and oral flow is monitored because air exchange can occur through a combination of these orifices (9). Secure flow sensors with tape.

Monitoring respiratory effort can be accomplished by several methods, including intercostal or diaphragmatic EMG electrodes, esophageal pressure monitoring; or calibrated or uncalibrated inductance plethysmography that permits differentiation between abdominal and thoracic movement. The most accurate measure of respiratory effort is esophageal pressure manometry; however, correct placement of the sensor is difficult and can cause patient discomfort and sleep disturbance. The recommended sensors are thoracoabdominal inductance plethysmography belts (9). Polyvinylidene fluoride (PVDF) effort sensors may be used as an alternative sensor for the detection of respiratory effort in adults.

The sleep technologist and medical director should evaluate the various flow and effort sensors available to determine the most appropriate for recording of these parameters in the sleep facility. Some of the points to compare would be the need for a calibrated signal for a quantitative signal versus qualitative signal, patient comfort, cost, replacement frequency, susceptibility to artifact, etc. The amplifier settings and calibration requirements for recording respiration signals will vary according to equipment specifications, but should adhere as closely as possible to AASM standards. Because apneas, hypopneas and RERA's frequently trigger arousals and interrupt the normal sleep cycle, it is important that respiratory effort and airflow are recorded to allow for the development of a sleep profile with which the breathing disturbance can be correlated.

#### **2.1.1.9 Blood Oxygenation (Oxygen Saturation - SpO2)**

##### Description

The diagnosis of obstructive sleep apnea during the standard PSG requires the continuous monitoring and display of blood oxygen saturation levels to provide crucial information about the severity of the sleep related breathing disorder. Pulse oximeters are generally built in to or can be easily interfaced with the PSG acquisition equipment. It is necessary to carefully evaluate the pulse oximeter for use in the sleep facility for sampling rate and analog output to interface with the polygraph. The output on the oximeter must be through a DC amplifier and the signal must be displayed simultaneously with other pertinent PSG variables. In modern PSG systems oximetry is integrated as a DC channel in the system amplifier. The polygraph DC amplifier requires calibration and the output can be displayed linearly or numerically, depending on the acquisition system.

Whichever method is used to record pulse oximetry, the device must be capable of a signal averaging time of 3 seconds or less.

### Methodology

Pulse oximetry transmits two wavelengths of light through a pulsatile vascular bed to measure arterial oxygen saturation. Pulse oximetry is frequently the method used to monitor blood oxygen levels in the sleep facility because of the ease and comfort to the patient. Pulse oximetry measurement is most commonly performed using a finger probe, although other placements such as the earlobe or toe may be used depending on the patient. It should be noted that pulse oximetry does not reflect total gas exchange and therefore, cannot detect changes in PaCO<sub>2</sub>.

#### **2.1.1.10 Capnography**

##### Description

Capnography can be used to measure the patient's carbon dioxide (CO<sub>2</sub>) level.

##### Methodology

There are two types of capnographs: end tidal and transcutaneous. For a transcutaneous PCO<sub>2</sub> (TC PCO<sub>2</sub>) recording, the TC CO<sub>2</sub>/PO<sub>2</sub> electrode is placed directly on the skin and heated to 42 – 45 degrees centigrade. Care must be taken to insure that the electrode temperature does not burn patients with fragile skin. The transcutaneous sensor measures the transpired PCO<sub>2</sub>, which fairly accurately reflects tissue PCO<sub>2</sub>. This is the preferred method for monitoring neonates in an intensive care setting; however, in adults it is accurate only in patients with good tissue perfusion.

End tidal capnography is commonly used in children and some adults to measure PCO<sub>2</sub> using a nasal or nasal/oral cannula or a tight fitting mask to produce numerical and graphical displays of CO<sub>2</sub> levels. End tidal measurement reflects the concentration of CO<sub>2</sub> in the lungs and in the blood at the end of expiration. The normal range is 35-45 mmHg.

#### **2.1.1.11 Body Position**

##### Description

Many disorders such as apnea can be exacerbated by body orientation during sleep. Therefore, a valuable tool for accurate diagnosis and treatment of sleep disorders is a determination of body position on a continuous basis throughout the recording.

##### Methodology

Body position can be monitored with various commercially available body position monitoring devices. These devices use mercury switches and can be interfaced on the polygraph if an AC channel is available. Alternatively, the sleep technologist can observe the patient and document body position changes on the recording. For report generation, it is optimal to be able to correlate body position in the assessment of sleep disordered breathing. Simultaneously recorded EEG channels will determine if movements originate from wake or sleep and whether arousals correlate with limb or body movement.

#### **2.1.1.12 Behavioral Observation**

##### Description

The capability of observing the patient during the recording of the standard PSG is required for patient safety as well as clinical and technical assessment. The recommendation is to use audio monitoring and digital video recording that is synchronized with the PSG.

##### Methodology

Patient observation can be performed using an audio and video monitoring system that allows the sleep technologist to observe and document patient behaviors (i.e. body position, body movements, etc.) during the study. Audio monitoring allows the patient to communicate with the sleep technologist and provides a mechanism for the technical staff to hear and document snoring sounds and other patient vocalizations during the sleep study. PSG data acquisition systems are generally equipped with digital video monitoring systems which can be viewed on

the computer monitor and archived simultaneously with the PSG data. Synchronized video recording at a minimum frame rate of 1 frame/second is standard for recording digital video however higher frame rates of 15 to 20 frames/second are required for recording patients with seizure disorders, movement disorders and parasomnias.

## 2.2.0 Recording Environment

### Description

The standard PSG protocol is designed to obtain the maximum clinically relevant physiological information with the least disruption of the patient's normal sleep patterns. The sleep study should be initiated as close as possible to the patient's normal sleep time and conducted in a safe, private, quiet, dark, and comfortable room that resembles a bedroom or hotel room.

### Methodology

PSG acquisition equipment should be physically separated from the patient with appropriate shielding of light and sound. The control room should be close to patient rooms, and must be on the same floor. Interruptions during the night can be kept to a minimum with "back-up" electrodes and by merely changing the channel derivation in the montage. The bedroom must allow easy access for emergency personnel to reach patients. A bathroom must be available and at least one patient bedroom and bathroom should be handicapped accessible.

### 2.2.1 Montage Filter & Sensitivity Settings

The standard PSG recording montage should consist of the measurement of the above-defined parameters. An example of a montage is as follows:

Channel	Derivation	Sensitivity	High Filter	Low Filter	Sampling Rate
L outer canthus	E1- M2	5–7 $\mu\text{v}/\text{mm}$	35 Hz	0.3 Hz	500 Hz
R outer canthus	E2 - M2	5-7 $\mu\text{v}/\text{mm}$	35 Hz	0.3 Hz	500 Hz
Chin EMG	EMG1- EMG2- EMG3	10 $\mu\text{v}/\text{mm}$	100 Hz	10 Hz	500 Hz
Frontal EEG	F4-M1 F3-M2	5-7 $\mu\text{v}/\text{mm}$	35 Hz	0.3Hz	500 Hz
Central EEG	C4-M1 C3-M2	5-7 $\mu\text{v}/\text{mm}$	35 Hz	0.3 Hz	500 Hz

Occipital EEG	O2-M1 O1-M2	5-7 $\mu\text{v}/\text{mm}$	35 Hz	0.3 Hz	500 Hz
Left Anterior Tibialis	LAT1 LAT2	10 $\mu\text{v}/\text{mm}$	100 Hz	10 Hz	500 Hz
Right Anterior Tibialis	RAT1 RAT2	10 $\mu\text{v}/\text{mm}$	100 Hz	10 Hz	500 Hz
ECG	ECG1 ECG2	20 $\mu\text{v}/\text{mm}$	70 Hz	0.3 Hz	500 Hz
Snore		20 $\mu\text{v}/\text{mm}$	100 Hz	10 Hz	500 Hz
Pressure Flow		20 $\mu\text{v}/\text{mm}$	15 Hz	0.1 Hz	100 Hz
Thermal Flow		20 $\mu\text{v}/\text{mm}$	15 Hz	0.1 Hz	100 Hz
Thoracic Effort Belts		10-100 $\mu\text{v}/\text{mm}$	15 Hz	0.1 Hz	100 Hz
Abdominal Effort Belts		10-100 $\mu\text{v}/\text{mm}$	15 Hz	0.1 Hz	100 Hz
CPAP	DCx		5 Hz		100 Hz
SpO2	DCx		5 Hz		25 Hz

60 Hz notch filters should not ordinarily be used in EEG or EOG, as this may conceal the presence of artifact, and the use of 60 Hz notch filters should be avoided in the EMG channels. The sleep facility director should determine the specific montage and the equipment and recording devices used.

### 2.2.2 Instrumentation

#### Description

The equipment used to gather, analyze & store the data from the sleep study must be maintained and documented as such by a trained biomedical technician or other responsible party.

#### Methodology

Differential amplifiers are designed to distinguish between the desired physiologic voltage at the exploring electrode site and all other unwanted voltages from the body & the external environment using common mode rejection. The standard minimum limit for PSG common mode rejection ratio is 10,000:1. The signal must be sampled often enough to provide an accurate waveform but not so often as to use unnecessary resources. According to Nyquist theory this minimum rate is 2 times the highest frequency being measured, which is 200 Hz and is also the minimum recommended setting (10). The recommended setting is 500 Hz.

Proper electrode placement; adequate site preparation; proper sampling; and appropriate filtering and amplification provide good physiologic basis for conversion to a digital representation. The digital signals must be displayed and recorded to maximize appropriate visualization of the recorded signals. Proper screen resolution is most often determined by the video equipment manufacturers and should not be altered to manipulate things like font size. For PSG viewing on the monitor, use the highest resolution available and recommended by the manufacturer. The minimum digital resolution is 12 bits per sample.

### **2.2.3 Calibration**

#### **Description**

In order to validate the study it is necessary to perform various pre- and post calibrations to illustrate that the system was properly calibrated and all equipment and sensors are working correctly throughout the study. This includes verifying electrode impedances as outlined in section 2.1.1.1

#### **Methodology**

##### **Amplifier Calibration**

The first calibration should be an all channel calibration that passes a negative 50  $\mu\text{v}$  DC signal for an epoch of 30 seconds at 10 mm/sec, through the amplifiers while each recording channel is set to the same sensitivity and filtering. The resulting waveforms should be saved as part of the permanent record. If the waveforms do not show equal and correct amplitude, fall times and polarity then adjustments must be made to the channel in question until there is uniformity.

##### **DC Instrument Calibration**

Before the study is run a calibration check of all attached DC instruments, such as pulse oximeters, must be made to insure that minimum and maximum values correspond to physiologic variables. For example, the minimum and maximum readings of oximeters should be set to translate at zero and 1volt. Many digital PSG data acquisition systems have integrated this function into the amplifiers.

##### **Physiological Calibration**

After the amplifier calibration has been performed, physiological calibrations are conducted to insure the quality of the recorded signal. This provides a reference while monitoring and for scoring and interpreting the polysomnogram. All calibration signals must be annotated.

## Physiological Calibration Instructions

Ask the patient to lie supine, if possible, through the patient calibration procedure and follow the instructions listed below. Verify the quality of the signal and make adjustments as necessary to the electrodes and sensors or to the sensitivity, gain, polarity or filter settings. Replace electrodes or sensors as necessary.

Annotate the instructions given as the patient is instructed to perform the calibration procedures. Give the instructions slowly and clearly. Below is a standard set of patient calibrations. Follow the facility's calibration procedure, making sure that there is one calibration for each type of channel. Body position can be visually verified and oximetry should be double-checked if not within a normal range. Instruct the patient to relax and try to lie still.

E/C            Eyes closed for 30 seconds

Ask the patient to close his/her eyes and lie quietly.

E/O            Eyes open for 30 seconds

Ask the patient to open his/her eyes and look straight ahead.

LR&L        Look right & left

Ask the patient without moving his/her head to look to the right then to the left several times.

LU&D        Look up & down

Ask the patient without moving his/her head to look up then down several times.

BLNX        Blink eyes

Ask the patient to blink his/her eyes 5 times.

JAW            Clench jaw or grit teeth

Ask the patient clench the jaw or grit their teeth.

SNORE        Snore sound

Ask the patient to simulate a snore sound or hum.

FLEX            Flex foot

Ask the patient to point and flex each big toe (foot) separately. Annotate each leg separately on the recording. Repeat 2 times on each leg.

IN/OUT        Breathe in and out

Ask the patient to breathe normally, and then upon your instruction take a breath in and out. Check polarity and mark the record IN and OUT accordingly.

**HOLD**            Take a deep breath and hold it

Ask the patient to breath normally and then on your instruction take in a deep breath and hold it for 10 seconds (to a count of 10), then resume normal breathing.

Begin “Lights Out” procedure. Instruct the patient to move to a comfortable sleeping position and go to sleep. Remind the patient that the sleep technologist is readily available and if the patient should need anything to call the sleep technologist.

### **Post Calibrations**

At the end of the study, perform “Lights On” procedure. Enter the room to wake the patient and turn on the light. Repeat both amplifier and physiological calibrations before ending the recording.

### **2.3 Routine for Standard PSG**

The protocol of the standard PSG should be clearly established by the sleep facility. Detailed clinical information about the patient's sleep-related problem as well as a medical history is necessary.

The sleep technologist should apply the required electrodes and sensors to monitor the channels listed in the montage. The sleep technologist will begin the recording after ensuring that impedances are acceptable, sensors and equipment are functioning properly and all calibrations have been performed. “Lights Out” and “Lights On” times should be clearly documented. The sleep technologist will continuously monitor the patient's clinical status and body position, and document changes on the sleep study and/or on a form designed by the sleep facility as defined by written protocol. Ideally, 8 hours of recording time should be obtained; however, a minimum of 6 hours is recommended for a standard PSG. The sleep technologist will assist the patient as necessary during the recording (helping them to the bathroom, addressing comfort issues, etc.) Intervention with therapy (oxygen, PAP) may be initiated during the recording per the facility's protocol. After “Lights On” procedures have been performed, the electrodes and monitoring devices should be removed with care and cleaned according to infection control standards.

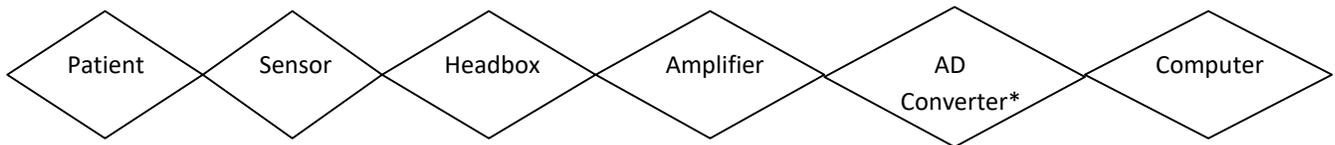
### **2.4 Artifact Recognition and Correction**

The sleep technologist is responsible for monitoring and maintaining the integrity of each recorded channel.

This requires that the sleep technologist differentiate between normal and abnormal patterns as well as patient-generated variations vs. true artifact. Once an artifact is identified, the sleep technologist must determine when it is necessary to make appropriate interventions and adjustments. Ideally, all channels should be artifact-free during the recording. All room entrances and artifact corrections should be documented.

The sleep technologist should use a systematic approach to troubleshooting artifact by tracing the recorded circuit from the patient to the computer monitor. Environmental interference (fans, cell phones, etc.) may have an effect on the recording and artifacts generated by environmental factors should be annotated.

Typical patient circuit:



\*Analog to Digital Converter

### 3.0 PSG DOCUMENTATION

The results of the standard PSG procedure must be presented in a comprehensive and concise report that summarizes all observations and an analysis of the recorded physiological parameters.

This report is typically presented in a chart or electronic format and includes all information pertaining to the patient's care at the sleep facility. The sleep technologist is responsible for completing a log and summary of the sleep study findings and events, highlighting the sleep technologist's observations of possible medical significance for the interpreting physician. In addition, the sleep technologist is responsible for ensuring that all other required documents are available before the study begins (history and physical, previous test results, referral, insurance information, bedtime questionnaires, etc.) (11). Reports of polysomnography must include all the recommended parameters from section II of The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology, and Technical Specifications (12). The following sections delineate the minimum information that should be included in technical documents.

#### 3.1 Patient Identification

In compliance with the Health Insurance Portability and Accountability Act (HIPAA), the PSG data and all reports should be clearly labeled on each page with the patient's full name, date of birth, medical record number and date of the study. Any additional information, such as identification numbers required for retrieval can also be included. Likewise, all long-term storage media containing patient data should be adequately labeled.

### **3.2 Patient History**

The patient's chart should contain sufficient historical information to document the reason the study was recommended, i.e. any significant existing medical conditions, current medications, and dosages, special therapy (i.e. supplemental O<sub>2</sub>). Any previous special procedures the patient has had that might influence the study results (i.e. LAUP, UPPP, tracheostomy, somnoplasty, bariatric surgery) and any previous sleep studies or diagnostic testing such as nocturnal oximetry should also be documented. A complete sleep history questionnaire completed prior to arrival at the sleep facility and/or a history and physical documented by the referring physician should be available for each patient. As part of the technologist's review of the sleep history and physical the special needs of the patient also need to be determined (i.e. physical limitations, emotional needs and language barriers). The technologist should discuss any key items in the questionnaire with the patient, and clarify any incomplete or missing information.

### **3.3 Technical Documentation**

#### **3.3.1 Log**

The sleep technologist should log notable events that occur during the study in chronological order. Notable events include "Lights Off", sleep onset, "Lights On", the sleep technologist entering or leaving the patient's room, the patient getting out of bed, initiating or adjusting PAP or oxygen therapy, position changes, technical difficulties, environmental disturbances, and any other observation that might be helpful to the interpreting physician.

#### **3.3.2 Summary**

The sleep technologist should completely summarize all technical and behavioral observations at completion of the standard PSG. This can be done on a form designed by the sleep facility, within the context of the format set forth by the manufacturer of the PSG data acquisition equipment, or on a flowsheet within an electronic medical record. The summary should include comments on sleep architecture, behavioral observations, myoclonus/limb movements, respiratory characteristics including respiratory events and desaturations, initiation of PAP, if applicable, and heart rate/ECG observations. The

technologist should also add any significant medical or sleep-related information discovered during patient assessment, testing, or before discharge.

### **3.3.3 Sleep Parameters**

The report summary should include the details of the analysis of sleep stage scoring as well as clinical event scoring (13).

#### **3.3.3.1 Sleep Stage Parameters**

Total Recording Time (TRT) is defined as the time from “lights out” to “lights on”. Total Sleep Time (TST) is the total time asleep after sleep onset. To determine the how well the patient slept, the Sleep Efficiency (SE) is calculated by dividing the TST by the TRT and multiplying by 100.

Sleep studies are recorded on 30 second “epochs”. Sleep onset is defined as the first epoch scored as any stage other than stage W. Sleep Latency (SL) is the time from “lights out” to the sleep onset. Latencies to sleep stages are determined from sleep onset to the first epoch of that sleep stage.

Wake after Sleep Onset (WASO) is the time awake after sleep onset until “lights on”. To determine the percentage time spent in each of the sleep stages during the sleep study, the total minutes of the sleep stage is divided by the TST and multiplied by 100.

#### **3.3.3.2 Clinical Event Parameters**

To determine the severity of sleep disturbances, the indices of the clinical events scored are compared to normative values. The sleep technologist calculates these indexes by dividing the number of clinical events by the TST. These indices include the apnea index (AI), hypopnea index (HI), apnea/hypopnea index (AHI), periodic limb movement (PLMS) index, PLMS arousal index, Respiratory Effort Related Arousal (RERA) index, and the overall arousal index.

Usually the PSG equipment will analyze the heart rate and oxygen saturation and report the mean, maximum and lowest value by TRT, TST and sleep state, i.e. stage N1, N2, N3 (NREM) and stage R (REM). The technologist is responsible for manually verifying these parameters.

#### **3.3.4 Sleep Related Breathing Events**

The study summary should document sleep related breathing events with respect to sleep state. Information should be provided concerning the respiratory rate while awake and asleep, the presence or absence of snoring, the presence of paradoxical breathing, the number and index of apnea and/or hypopnea events, the longest apnea and/or hypopnea event, the mean

and minimum oxygen saturation. Notation should be made if sleep state or body position is related to the apnea/hypopnea index and/or desaturation. The absence or occurrence of Cheyne Stokes breathing pattern should be documented in all patients who demonstrate central apnea events.

### **3.3.5 Heart Rate/ECG Observation**

The average and highest heart rate while asleep and the highest heart rate during the recording should be annotated and the summary should document bradycardia (lowest rate observed), asystole (longest pause observed), sinus tachycardia (highest rate observed), narrow complex tachycardia (highest rate observed), wide complex tachycardia (highest rate observed) and atrial fibrillation on a yes/no basis. All other arrhythmias should be documented with respect to frequency of occurrence and type. It is particularly important to describe the occurrence of heart rate changes or arrhythmias with respect to sleep state (REM, NREM) and sleep related breathing events such as O<sub>2</sub> desaturations and apneic events (14).

### **3.3.6 Limb Movements**

Limb movement activity is recorded from the extremities and must be evaluated in terms of frequency of occurrence and periodicity, sleep/wake status, and presence or absence of subsequent arousal. Rhythmic leg movements observed during wakefulness can indicate Restless Legs Syndrome (RLS). The sleep technologist should ask about symptoms of RLS during patient assessment (difficulty initiating sleep due to a need to move) and document any relevant patient comments as well as evidence of RLS seen prior to or during the recording.

### **3.3.7 Behavioral Observations**

Any unusual or atypical behavioral events occurring during the patient's sleep and/or during wakefulness should be documented by the sleep technologist during the standard PSG. The sleep technologist should describe in detail what the behavior is and how it relates to the polysomnographic recording (i.e. nocturnal eating, enuresis, body rocking). When arousals are noted during the PSG recording, the sleep technologist should document the cause of the arousal, i.e. as the result of apneic events, limb movements, spontaneous or environmentally evoked.

## **4.0 STANDARDS OF PRACTICE**

### **4.1 Qualifications of Sleep Technologists**

Sleep technologists must demonstrate knowledge of polysomnographic recording instrumentation, including operating procedures, electrode application, calibration methods and routine troubleshooting as well as the ability to recognize sleep stages as outlined in the

AAST/AASM Sleep Technologist, Technician and Trainee Job Descriptions (15). The sleep technologist must have a thorough understanding of normal and abnormal sleep patterns and sleep disorders. The sleep technologist also must be trained in basic cardiopulmonary resuscitation (CPR) or professional rescuer adult/child CPR and automated external defibrillator (AED) use.

Staffing practices should adhere to the AASM accreditation guidelines for standards on patient: technologist ratio: staffing must be adequate to address the workload of the center/laboratory and assure the safety of patients. This includes a maximum patient to technician ratio of 2:1 under usual circumstances for attended polysomnography (16). The facility should consider the experience of the technologists as well as the difficulty of the studies being performed when a deviation from a 2:1 ratio is required (17). Technicians must fulfill all American Board of Sleep Medicine (ABSM) or Board of Registered Polysomnographic Technologists (BRPT) requirements to be eligible to take the registry exam (18, 19). Upon passing a credentialing exam, a technician advances to technologist and must continue to fulfill ABSM or BRPT requirements to maintain Registered Sleep Technologist (RST) or Registered Polysomnographic Technologist (RPSGT) status. All technologists, whether registered or not, should maintain the minimum CEC requirements outlined in their job descriptions. It is recommended that each facility employ at least one registered technologist, though the goal should be to have as many registered technologists as possible.

#### **4.2 Sleep Facility Organization and Record Keeping**

The sleep technologists should follow the sleep facility departmental policy and procedure manual. Patient charts, in either print or electronic format should be organized and available for appropriate use in the sleep facility. HIPAA guidelines should be followed regarding confidentiality of patient records (20). Equipment, sensor and recording maintenance procedures should meet the standards of the manufacturer.

Storage of the recorded PSG data on CD, DVD, hard drive or other media should be both secure and easily available for retrieval. If video recording, either digital or VHS, is used, an edited version that preserves the recorded events is acceptable and should be referenced appropriately. The length of storage for all patient data should be in compliance with the statutes set forth by the state in which the data is obtained and stored, often a seven-year minimum.

#### **4.3 Patient Safety in the Sleep Facility**

In the context of the technical sleep study, patient safety begins from the point of the patient's arrival until the patient leaves the facility (see 4.4.5). Ordering and performing the appropriate

test based on the patient's history and physical and previous test results are the responsibility of the sleep facility under direction from a board certified sleep physician.

The sleep facility must be safe and easily accessible to all staff and patients. The sleep facility must be handicapped accessible, meet fire code and health department regulations, and maintain electrical and mechanical safety. The patient rooms must be clean and have adequate audio and video monitors for patient safety and clinical assessment (21). All products used on patients should have Material Safety Data Sheets (MSDS) available in the sleep facility. All flammable materials must be stored in a fire safe. The technologist must be trained in all aspects of patient safety and the technologist must be familiar with each patient's medical history. Technologists should follow the sleep facility policy related to patient safety and security.

#### **4.3.1 Safety Equipment**

The sleep facility should have equipment available for patient care and emergencies: resuscitation bags, back boards, oxygen, biohazard spill kits, separate (temperature monitored) refrigeration for patient medication, blood pressure cuffs, and first aid kits. An Automated External Defibrillator (AED) should be available in the facility. There should also be multi-class fire extinguishers available. Proper ventilation equipment should be in place to handle fumes that may arise from collodion and acetone if they are used.

#### **4.3.2 Electrical Safety**

Electrical safety guidelines state that all equipment used must be properly grounded and have a dedicated wall outlet. In addition, any equipment that is connected to the patient must be on an isolated circuit equipped with a breaker. The electrical safety of all patient-related equipment should be tested and documented yearly.

#### **4.3.3 Mechanical Safety**

The technologist must practice proper lifting technique. All equipment involved with patient care must be located in a safe position relative to the patient.

#### **4.3.4 Fire Safety**

The technologist must be well acquainted with their facilities fire plan in case of fire. This plan should account for the prevention of fire as well. In the event of fire the technologist's ultimate priority is to remove the patient from danger.

#### **4.3.5 Patient Medical History and Current Medical Status**

It is the sleep technologist's responsibility to know and understand the patient's medical history, allergies and current medical status in order to alter procedures, contact a physician, or transfer the patient to emergency care, as necessary.

#### **4.3.6 Clinical Intervention and Emergency Procedures**

The sleep facility should have written guidelines for initiating any medical intervention (supplemental oxygen, patient transfer, CPR). The technologist must be trained to recognize life threatening changes in the patient's condition. Working in a nocturnal setting the technologist must also take steps to insure their own vigilance. There should also be a written plan for handling internal and external disasters (e.g. tornado, fire, flood, etc.) (22).

#### **4.3.7 Patient Discharge Guidelines**

The sleep technologist should make sure that the patient has had enough sleep and is not under the influence of medication or alcohol before release from the sleep facility. An early release form should be completed per sleep facility policy when indicated. Patients who have not had enough sleep should be encouraged to stay and sleep (with visual monitoring) even if the recording has been discontinued, per facility policy. For this reason it may be good policy to suggest that the patient arrange for transportation upon discharge.

### **4.4 Infection Control**

#### **4.4.1 Patient Contact Procedures**

Sleep technologists should exercise universal precautions and precautions for prevention of the spread of tuberculosis or other infectious diseases as appropriate (23, 24). Frequent hand washing is essential for the protection of both patients and sleep technologists. All items that will be in contact with a patient must be cleaned and disinfected before use.

#### **4.4.2 Equipment Decontamination**

There must be clearly designated areas for clean and dirty equipment and sensors.

#### **4.4.3 Non-disposable or Reusable Items**

Non-disposable or reusable items include items such as pneumotachometers, electrodes, respiratory belts, thermocouples, and body position sensors. Various disinfectant products are available commercially. These products are labeled with the instructions for disinfecting reusable items and the reusable items should have instructions for disinfecting and cleaning recommended by the manufacturer. When reusable items become contaminated and disinfecting is not feasible, gas or heat sterilization may be used or the item should be properly

disposed of. Bed linens should be handled with the assumption that biohazard could be present. Overall, it is recommended to use disinfecting products or procedures that are approved for the medical setting.

#### **4.4.4 Disposable items**

The syringe and flat-tipped needle used to inject electrolyte into the cup of electrodes should be discarded after use with the needle placed in a receptacle for needles (25). Disposable sensors should be disposed of after use. Likewise, nasal cannulas used for administering oxygen or to monitor flow with a pressure transducer are for single patient use only. These types of products should be disposed after each patient use.

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