

AARC Clinical Practice Guideline

Polysomnography

This Guideline was developed jointly by the AARC Cardiopulmonary Diagnostics CPG Focus Group and representatives of the Association of Polysomnography Technologists (APT). Both groups have approved its content.

PSG 1.0 PROCEDURE:

Polysomnography

PSG 2.0 DESCRIPTION/DEFINITION:

Polysomnography refers to the collective process of monitoring and recording physiologic data during sleep. The specific variables monitored during center-based polysomnographic evaluation of sleep-related respiratory disturbances are listed.(1,2) Home-based polysomnography(3) and unattended monitoring systems are not addressed in this guideline.

The variables monitored and recorded during polysomnography include but are not limited to:(4,5)

- 2.1** global neural electroencephalographic activity (EEG) from electrodes placed on the patient's scalp;
- 2.2** eye movements (electro-oculogram, or EOG) from electrodes placed near the outer canthus of each eye;
- 2.3** submental electromyographic activity (EMG) from electrodes placed over the mentalis, submental muscle, and/or masseter regions;
- 2.4** rhythm electrocardiogram (ECG) with two or three chest leads;
- 2.5** respiratory effort, by chest-wall and abdominal movement via strain gauges, piezoelectric belts, inductive plethysmography, impedance or inductance pneumography, endoesophageal pressure, or by intercostal EMG;
- 2.6** nasal and/or oral airflow via thermistor or pneumotachograph;
- 2.7** oxygen saturation (SpO₂) via pulse oximetry;

- 2.8 body position via mercury switches or by direct observation;
- 2.9 limb movements (arms and legs) via EMG;(6)
- 2.10 recordings of or vibration (frequency and/ or volume) may be recorded;(7)
- 2.11 end-tidal CO₂, transcutaneous CO₂, esophageal pH, penile tumescence, and bipolar EEG are beyond the scope and intent of this guideline.

PSG 3.0 SETTING:

Center-based polysomnography is performed within specialized hospital sleep laboratories,(1) appropriately equipped hospital rooms, or stand-alone sleep centers, with a qualified technician in constant attendance.(8)

PSG 4.0 INDICATIONS:

Polysomnography *may be* indicated in patients(9-12)

- 4.1 with COPD whose awake PaO₂ is > 55 torr but whose illness is complicated by pulmonary hypertension, right heart failure, polycythemia, or excessive daytime sleepiness;
- 4.2 with restrictive ventilatory impairment secondary to chest-wall and neuromuscular disturbances whose illness is complicated by chronic hypoventilation, polycythemia, pulmonary hypertension, disturbed sleep, morning headaches, or daytime somnolence and fatigue;
- 4.3 with disturbances in respiratory control whose awake PaCO₂ is > 45 torr or whose illness is complicated by pulmonary hypertension, polycythemia, disturbed sleep, morning headaches, or daytime somnolence and fatigue;
- 4.4 with nocturnal cyclic brady- or tachyarrhythmias, nocturnal abnormalities of atrioventricular conduction, or ventricular ectopy that appear to increase in frequency during sleep;
- 4.5 with excessive daytime sleepiness or insomnia;
- 4.6 with snoring associated with observed apneas and/or excessive daytime sleepiness;
- 4.7 with other symptoms of sleep-disordered breathing as described in International Classification of Sleep Disorders;(6)
- 4.8 with symptoms of sleep disorders described in the International Classification of Sleep Disorders.(6)

PSG 5.0 CONTRAINDICATIONS:

There are no absolute contraindications to polysomnography when indications are clearly established. However, risk-benefit ratios should be assessed if medically unstable inpatients are to be transferred from

the clinical setting to a sleep laboratory for overnight polysomnography.

PSG 6.0 PRECAUTIONS/COMPLICATIONS:

6.1 Skin irritation may occur as a result of the adhesive used to attach electrodes to the patient.

6.2 At the conclusion of the study, adhesive remover is used to dissolve adhesive on the patient's skin. Adhesive removers (eg, acetone) should only be used in well-ventilated areas.

6.3 The integrity of polysomnographic equipment's electrical isolation must be certified by engineering or biomedical personnel qualified to make such assessment.

6.4 The adhesive used to attach EEG electrodes, (eg, collodion) should not be used to attach electrodes near the patient's eyes and should always be used in well-ventilated areas.

6.5 Due to the high flammability of collodion and acetone, they should be used with caution, especially in those patients who require supplemental oxygen.

6.6 Collodion should be used with caution in those patients with reactive airways disease and in small infants.

6.7 Patients with parasomnias or seizures may be at risk for injury related to movements during sleep. Institution-specific policies and guidelines describing personnel responsibilities and appropriate responses should be developed.

PSG 7.0 DEVICE LIMITATIONS/VALIDATION OF RESULTS:

Due to the nature of the various physiologic variables that are examined during polysomnography, a variety of devices are attached to the patient, and the output of these devices is interfaced with a standard polysomnographic recorder; consequently, the potential exists for several individual device limitations, rather than any one specific limitation to polysomnography.

7.1 Records of EEG, EOG, and EMG activity. These variables are monitored by gluing or taping, small metal-disk electrodes to the patient.(13) The low impedance limit is 1,000 ohms (1 K), and, in the routine diagnostic polysomnogram recorded at 10-15 mm/s using referential EEG channels, an impedance \leq 10,000 ohms (10 K) is acceptable for all channels.(14-16) Slightly higher impedances are acceptable for limb EMG.(17) However, a maximum impedance of 5,000 ohms (5 K) is recommended for bipolar EEG channels frequently used in extended polysomnography montages when seizure activity is suspected.(18) Limitations associated with EEG, EOG, and EMG

monitoring include:

7.1.1 displacement of the electrode from the subject's skin causes a reduction, or complete loss, of the signal;

7.1.2 failure to properly prepare the skin or drying of the transduction gel inside of the electrode obscures the signal's characteristics;

7.1.3 artifactual signals can obscure actual physiologic signals;

7.1.4 environmental electrical noise can obscure actual physiologic signals.

7.2 Record of ECG activity. Rhythm ECGs are typically obtained by using two of the described EEG electrodes. Recording a modified Lead-II (right shoulder and left leg) or precordial lead (MCL) is sufficient. Limitations associated with rhythm ECGs obtained during polysomnography include:

7.2.1 The recording paper speed used during polysomnography may be slower than that used by cardiac monitors and recorders. This or improper filtering techniques may obscure P-wave or QRS-complex wave morphology.(5)

7.2.2 Other limitations can be the same as described in Section 7.1.

7.3 Record of chest-wall and abdominal movement. A variety of devices exist for measuring chest-wall and abdominal movement including mercury strain gauges, piezoelectric belts, inductance, and impedance pneumography.(1)

7.3.1 Mercury strain gauges are placed on or around the chest or abdomen. Limitations of strain gauges include:(19)

7.3.1.1 The quality and interpretability of the respiratory signal is affected 1) if the gauge slips from its original position and 2) if the patient changes position.

7.3.1.2 Calibration of strain gauges is difficult; consequently, the displayed data are more qualitative than quantitative.

7.3.1.3 The mercury in the Silastic tubing can develop bubbles that can affect signal integrity.

7.3.2 Piezoelectric belts are placed around the chest and/or abdomen. Limitations of piezoelectric belts include:

7.3.2.1 The quality and interpretability of the respiratory signal is affected if belts slip out of their original position.

7.3.2.2 Belts are generally not calibrated; consequently, the displayed data are more qualitative than quantitative.

7.3.3 Inductance plethysmography is accomplished by placing elastic belts around the abdomen and chest of the patient. Limitations of inductance plethysmography include:(20)

7.3.3.1 The slipping of a belt from its original position affects the calibration, and, consequently, the quality and interpretability of the respiratory signal.

7.3.3.2 Calibration of inductance plethysmography is difficult in

morbidly obese people, and, consequently, the data are more qualitative than quantitative.

7.3.3.3 The thin wires on the surface of inductance plethysmography belts are easily broken with a consequent loss of the monitored signal.

7.3.4 Impedance pneumography uses 2 or 3 electrodes attached to the patient in a configuration similar to that of a 3-lead ECG.

Limitations of impedance pneumography include:(21)

7.3.4.1 The technique provides only a qualitative indication of chest-wall movement. There is no direct relationship to the volume of air within the chest.

7.3.4.2 Because impedance pneumography displays only global chest-wall movement, obstructive apneic events cannot be clearly differentiated from central or mixed apneic events in the absence of airflow measures.

7.3.4.3 No standards exist for the frequency response, precision, and reliability of signal reproductions that represent changes in thoracic impedance.

7.3.4.4 Signal degradation can occur with changes in body position.

7.3.4.5 Impedance pneumography is susceptible to cardiogenic artifact.

7.4 Record of intercostal muscle activity. Intercostal EMG is monitored by gluing or taping small metal-disk electrodes to the patient's intercostal spaces. When these electrodes are placed near the insertion of the diaphragm, they can monitor EMG activity from both the diaphragm and intercostal muscles. Limitations of intercostal EMG recording are the same as those listed in Section 7.1.

7.5 Record of esophageal pressure changes:

7.5.1 Esophageal pressures are monitored via esophageal balloons or liquid-filled catheters, which are attached to pressure transducers and signal amplifiers. Esophageal balloons are inflated with air or liquid, whereas liquid-filled catheters are filled with water or saline. They are inserted into the nares, through the nasopharynx, and into the esophagus to monitor changes in intrathoracic pressures occurring with inspiration and expiration.(22)

7.5.2 An esophageal balloon consists of a catheter attached to an air-filled balloon, which is inserted into the esophagus. Problems with esophageal balloons include:

7.5.2.1 inadvertent tracheal intubation;

7.5.2.2 nasal trauma or irritation;

7.5.2.3 inadequate filling rendering the pressure measurements inaccurate;

7.5.2.4 patient discomfort to a degree sufficient to alter sleep staging;

7.5.2.5 patient movement's altering the position of the catheter, and, thereby affecting the accuracy of the pressure measurements.

7.5.3 Liquid-filled catheters are similar to esophageal balloons.

Limitations include:

7.5.3.1 air bubbles in the tubing can alter the characteristics of the pressure transmission through the tubing and cause the pressure readings to be inaccurate;

7.5.3.2 inadvertent tracheal intubation can give rise to irritation or aspiration of a catheter's contents into the lungs;

7.5.3.3 patient movement can alter the position of the catheter, thereby affecting the accuracy of the pressure measurements.

7.6 Record of airflow

7.6.1 Thermistors and thermocouples can provide information about the presence or absence of airflow based on temperature differences between inhaled and exhaled air. The devices incorporate small wiry sensors that can be taped below the patient's nostril and next to the mouth. Limitations include:(23)

7.6.1.1 the devices cannot be calibrated and, therefore, provide only qualitative information;

7.6.1.2 the collection of moisture on a sensor can affect its ability to detect temperature changes and affect signal integrity;

7.6.1.3 dislodgment from the subject results in partial or complete loss of the signal.

7.6.2 Pneumotachometers/pneumotachographs: Pneumotachography is used when quantitation of airflow and volume are necessary.

Limitations of pneumotachography include:(24)

7.6.2.1 The patient's nose and mouth must be securely covered (leak free) by a face mask with the pneumotachometer attached to it;

7.6.2.2 The pneumotachometer and face mask are obtrusive and cumbersome and may not be tolerated by the patient and, therefore, may not be suitable for routine polysomnography;

7.6.2.3 Pneumotachography requires calibration at different air flows, and the amplifiers need to be calibrated frequently to ensure linearity.

7.6.3Recording of tracheal sounds audible via microphone is inexpensive and can be used to quantitate snoring.(7)

7.7Recording of oxygen saturation (SpO₂). Pulse oximetry transmits two wavelengths of light through a pulsatile vascular bed to measure arterial oxygen saturation. Many factors can affect device accuracy and these have been well described.(25-29) With respect to polysomnography, limitations of pulse oximetry include:

7.7.1 During apneic events, the pulse oximeter may alarm and awaken the patient. Therefore, during polysomnography, it is important that the audible low-oxygen-saturation alarm be disabled. Alarms should be disabled only if a qualified technician is in constant attendance, monitoring the physiologic signals, and able to intervene if clinically indicated.

7.7.2 Not all pulse oximeters have an analog output that can be interfaced with the polygraph recorder.

7.7.3 Pulse oximetry does not reflect total gas exchange (cannot detect changes in PaCO₂).

7.7.4 The polygraph amplifier requires calibration to ensure that the oximeter recording is linear and displayed within institutional requirements (ie, each drop in SpO₂ causes a 1-mm pen deflection).

7.7.5 Lengthy signal averaging in some older pulse oximeters may produce imprecise values during acute events such as apnea.(29)

PSG 8.0 ASSESSMENT OF NEED:

In those patients who are suspected of sleep-related respiratory disturbances, periodic-limb-movement disorder, or other sleep disorders described within The International Classification of Sleep Disorders, Diagnostic and Coding Manual.(6) polysomnography is used to assess and quantify the presence and severity of such disturbances and their effect on oxygenation, cardiac status, and sleep continuity.

PSG 9.0 ASSESSMENT OF TEST QUALITY:

9.1 With respect to sleep-related respiratory disturbances, polysomnography should either confirm or eliminate a diagnosis.

9.2 Documentation of findings, suggested therapeutic intervention, and/or other clinical decisions resulting from polysomnography should be noted in the patient's chart.

9.3 Each laboratory should devise and implement indicators of quality assurance with respect to equipment calibration and maintenance, patient preparation and monitoring, scoring methodology, and intertechnician scoring variances.

PSG 10.0 RESOURCES:

10.1 Equipment:

10.1.1 A polygraph recorder capable of recording a minimum of 10 channels of high-frequency physiologic data. The data should be recorded on strip-chart paper, in ink (or by inkless pens writing on heat-sensitive paper) at a paper speeds from 10-30 mm/s. The polygraph may also be interfaced with an analog or digital storage device (cassette tape, optical disk) that has the ability to store and to print all raw data collected during the study.(30) The polygraph should be equipped with both alternating (AC) and direct-current (DC) bioamplifiers, with user-selectable electrical filters and sensitivities.

10.1.2 To record EEG and EOG, the polysomnographic recorder should have the sensitivity to give a pen deflection of 5.0-10.0 mm for a 50 microvolt signal. A calibration signal of 50 microvolt/cm is most

common. It is essential that the recorder be calibrated prior to the study because changes in signal amplitude are one criterion for scoring the study.(13)

10.1.3 When recording EMGs, a pen deflection of 2 microvolt/mm is common; however, the absolute magnitude of the amplitude is irrelevant. Rather, the emphasis is placed upon relative changes in the EMG amplitude.(13)

10.1.4 EEG and EOG signals are amplified with an AC amplifier. The high-frequency-filter setting should be $>$ or $=$ 30-35 Hz with a low-frequency-filter setting of $<$ or $=$ 0.3 Hz.(13)

10.1.5 The EMG signal is also amplified with an AC amplifier. A high-frequency-filter setting of 70-120 Hz and a low-frequency-filter setting $>$ or $=$ 5 Hz are suggested.(13)

10.1.6 To record the rhythm ECGs, two additional EEG electrodes are configured for Leads I, II, III, or MCL. No particular emphasis need be placed on signal amplitude provided the signal is large enough to be discernible.

10.1.7 Output from respiratory effort and airflow-sensing devices and oxygen-saturation data are directed to the recorder and displayed with the other data.

10.1.8 Body position may be determined with mercury switches, with output signal directed to the recorder and displayed with the other data. If body position is monitored by direct observation, the patient's position should be noted at the beginning of the recording and whenever changes in position occur.

10.2 Personnel qualifications:

Level-I personnel are designated as those with at least a high school education but without formal credentialing in polysomnographic technology and with no professional credentialing or licensing. Level-I personnel can be described as those who meet minimal job requirements and have received on-the-job polysomnographic training. Both Level-I and Level-II personnel should work under the direction of a physician specifically trained in the diagnosis and treatment of sleep disorders. Any personnel responsible for observing the patient should hold a current course-completion care in cardiopulmonary resuscitation (CPR) at, at least, the basic life support (BCLS) level and be competent to perform cardiac defibrillation.(31)

10.2.1 Level-I personnel:

10.2.1.1 may perform polysomnography;

10.2.1.2 need to be proficient in patient preparation, sensor application, and operation of the polysomnograph;(2)

10.2.1.3 should be familiar with operating principles and basic troubleshooting of the equipment listed in Section 7.0.

10.2.1.4 have an appreciation for the scoring and interpretation of

polysomnograms and their use in the diagnosis of patients with sleep disorders;

10.2.1.5 have effective patient assessment and communication skills relative to recognizing and reporting adverse patient conditions (ie, a decline in the patient's clinical condition).

10.2.2 Level-II personnel

10.2.2.1 should have the knowledge and demonstrated ability to perform Level-I responsibilities,*and*

10.2.2.2 should be either credentialed or licensed as a Registered Polysomnographic Technician (RPSGT), a Registered Electroencephalographic Technologist (REEGT), Respiratory Care Practitioners (CRTT or RRT), or a Registered Nurse (RN);

10.2.2.3 must demonstrate the ability to score polysomnographic recordings and have an understanding of interpretative methods.

10.2.2.4 should have documented ability to recognize the patterns of polysomnographic variables as they are monitored and recorded enabling the practitioner to differentiate among technical difficulties and occult pathophysiology during polysomnography;

10.2.2.5 should display a proficiency in interpreting respiratory variables affected by initiation of continuous positive or bi-level positive airway pressure or nocturnal ventilatory support and should demonstrate knowledge of normative ranges for such variables as those measured during the monitoring of arterial blood gas, end-tidal CO₂, oxygen saturation, respiratory movement, and airflow;(32)

10.2.2.6 should be able to initiate and titrate supportive therapy for sleep-related respiratory disorders;(32)

10.2.2.7 should be able to assess the patient's response to therapy;

10.2.2.8 should be able to recommend modifications to prescribed therapy, as appropriate;

10.2.2.9 should be familiar with operating principles, interface techniques, data acquisition, scoring, and reporting for other than cardiopulmonary-based studies, such as penile tumescence and seizure disorders.

PSG 11.0 MONITORING:

11.1 During polysomnography, the patient variables to be monitored are those listed in Section 2.2. Intervention is required if the physiologic signals are lost due to problems with instrumentation or become obscured by artifact.

11.2 Infrared or low-light videocameras and recording equipment should permit visualization of the patient, by the technician, throughout the procedure.(30)

11.3 Patients undergoing polysomnography are being evaluated for the presence of a chronic disease; therefore, their clinical status is

unlikely to deteriorate acutely. However, the center-based polysomnographic studies described in this guideline require the presence of a technician throughout the study. Therefore, the technician should intervene if an acute change in physiologic status occurs and communicate these changes to appropriate medical personnel.

PSG 12.0 FREQUENCY:

12.1 A second polysomnographic study may be indicated

12.1.1 if the first study is technically inadequate due to equipment failure;

12.1.2 if the subject could not sleep or slept for an insufficient amount of time to allow a clinical diagnosis;

12.1.3 if initiation of therapy or confirmation of the efficacy of prescribed therapy is needed.

PSG 13.0 INFECTION CONTROL:

Practitioners should exercise Universal Precautions and precautions for prevention of the spread of tuberculosis as appropriate.(33,34)

13.1 Nondisposable patient use items (eg, pneumotachometers, face masks, electrodes) should undergo cleaning and sterilization procedures as recommended by the manufacturer. If sterilization is not feasible, then high-level disinfection is warranted.

13.2 The syringe and flat-tipped needle used to inject transduction gel into the EEG, EOG, and EMG electrodes should be discarded after use.

13.3 With respect to body-position sensors, inductance and impedance pneumography, abdominal or thoracic strain gauges, or piezoelectric belts, no special precautions are generally required. Gas sterilization may be used if the sensors or belts become contaminated with body fluids.

13.4 Some thermistors are equipped with disposable sensors. If nondisposable sensors are used, they should be cleaned and subjected to high-level disinfection after use.

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