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Polysomnography Set-up (Adult Patients)

Sleep Science

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Chief Allied Health Officer

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Clinical measurement practitioners

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EQuIP and other criteria and standards

1. Purpose

This guideline provides recommendations regarding best practice to support high quality Polysomnography (PSG) throughout Queensland Health facilities.

2. Scope

This guideline provides information to sleep clinical measurement practitioners (CMP) who perform PSG Set-up for adult patients.

3. Related documents

This guideline is primarily based on the following documents:

- American Academy of Sleep Medicine (2009). *A technologist's guide to performing sleep studies*. [1]
- Iber, C. and American Academy of Sleep Medicine (2007). *The AASM manual for the scoring of sleep and associated events: rules, terminology and technical specifications*. [2]
- Australasian Sleep Association and Australasian Sleep Technologists Association. (2010). *ASTA/ASA Commentary on AASM Manual for the Scoring of Sleep and Associated Events*. [3]
- Keenan, S. A. (1992). *Polysomnography: technical aspects in adolescents and adults*. [4]

References from alternate sources of information have been identified in this document.

Policy and Standard/s:

- Informed Decision-making in Healthcare (QH-POL-346:2011) [5]

Procedures, Guidelines, Protocols

- Australian Guidelines for the prevention and control of infection in healthcare (CD33:2010) [6]

Forms and templates

- Consent to clinical digital images

4. Guideline for Polysomnography set-up (adult patients)

4.1. Emergency Protocol

- Follow local Hospital and Health Service protocols and procedures in the event of an emergency.

4.2. Infection Control Procedures

- Australian Guidelines for the prevention and control of infection in healthcare (CD33:2010) [6]
- Refer to equipment manufacturer's guidelines, in particular for single use items such as anti-bacterial filters, if used.

4.3. Gaining Consent

- Gain patient consent in accordance with Queensland Health's Informed Decision-making In Healthcare [5].
- Signed consent is required from the patient (or their legal guardian/carer) to record their digital clinical image. File the signed consent in the patient's hospital chart.

4.4. Identifying Indications/Contraindications

This guideline is primarily indicated in the set up of patients undergoing Type 1 PSG. The guideline, however, can be tailored to Type 2, 3 and 4 PSG as applicable (refer to separate Queensland Health guidelines for Type 2, 3 and 4 PSG).

A PSG is an assessment or treatment under the direction of a sleep physician and co-ordinated by a dedicated sleep facility. PSG is only suitable for patients who are clinically stable.

4.5. Facilities and equipment

Facility requirements

For Type 1 PSG, utilise a room which meets the requirements of a designated body-protected electrical area. Include all signals in the configurations for both monitoring and analysis.

Minimum Equipment Requirements

Minimum equipment requirements are detailed in:

- ASTA/ASA Commentary on AASM Manual for the Scoring of Sleep and Associated Events [3]
- The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications, 1st Edition [2]

For other ancillary equipment used within the recording configuration please refer to local Hospital and Health Service protocols and procedures and manufacturer guidelines.

4.6. Training requirements

A clinical measurement practitioner who performs PSG Set-up will have a tertiary qualification with a strong foundation in human physiology.

Additional qualifications relevant to the role may include:

- Board of Registered Polysomnographic Technologists (BRPT) - Registered Polysomnographic Technologist
- University of Western Australia - Graduate Certificate in Adult Sleep Science
- University of Western Australia - Graduate Diploma in Dental Sleep Medicine
- University of Western Australia - Graduate Diploma Sleep Science
- University of Sydney - Graduate Diploma in Sleep Medicine
- University of Sydney - Master of Medicine (Sleep Medicine)
- University of Sydney - Master of Science in Medicine (Sleep Medicine).

4.7. Test Procedure

The following describes the placement and application of sensors for patients undergoing a PSG. Refer to the appropriate Queensland Health guideline for each PSG *type* and the specific parameters to be recorded.

4.8. Prior to Patient Set-up

- Ensure appropriate documentation is available at the time of the PSG, including the referral form.
- Review the patient's hospital record prior to arrival.
- Record relevant medical history that may assist in the interpretation/reporting of the PSG.
- Evaluate the patient's background information for any special instructions or requirements, and for information to manage any potential emergencies that may arise.
- Confirm the patient's identity on arrival.
- Identify any special requirements for each patient (mobility, dietary).

- Unless otherwise specified, ensure the patient observes their usual pre-bedtime routine where possible (i.e. time in bed, use of medication and alcohol intake).
- Plan to set up the patient as close as practically possible to their usual bedtime.

4.8.1. PSG Documentation

Complete all documentation relevant to the PSG. Add the initial baseline observations and demographic data to the patient's PSG observation record.

This information includes, but is not limited to:

- patient identification (usually label from hospital chart)
- PSG date and type
- sleep CMP's name conducting the PSG
- patient's height and weight
- Epworth sleepiness score
- sleep pattern from previous 24hrs including reported naps
- blood pressure measurement prior to set-up
- baseline measurements for pulse oximetry
- alcohol and/or caffeine consumption prior to commencement of PSG
- any medication taken in the past 24 hours
- any allergies
- time for lights off
- any other relevant comments.

4.8.2. Sensor & Electrode Application

Prior to electrode application, prepare the skin with abrasives and cleansing agents to ensure optimal signal conductance.

Do not use chemical based products near the eyes (i.e. alcohol or collodion) for safety and consideration of patient comfort.

Follow local Hospital and Health Service protocols and procedures for specific instructions and items used for electrode and sensor application, with consideration given to the following:

- All paired electrodes are of the same type (e.g. gold-cup)
- If alternative or additional placements are required, document the change and an explanation for the alternative placement.

The recommended recording parameters and placements for each are listed below. See Appendix 1 for the recommended sampling rates and filter settings for each parameter.

Electroencephalogram (EEG)

The system of electrode placement used for routine PSG is based on the International 10-20 System for EEG (electroencephalogram) electrode placement [7, 8].

The three EEG derivations recommended are [3]:

- C4-M1 with C3-M2 as backup
- O2-M1
- F4-M1
- where M refers to the contra-lateral mastoid process
- additional electrodes are added as required.

Note: Secure the EEG leads together.

Reference and Ground Electrodes

Place a reference electrode, as described in the International 10-20 System for EEG electrode placement of Fpz [7, 8].

Apply a suitable ground electrode as required.

Electro-oculogram (EOG)

The EOG electrode placements are:

- E1-M2 (Where E1 electrode is placed one centimetre below the left outer canthus)
- E2-M2 (Where E2 electrode is placed one centimetre above the right outer canthus).

Additional EOG electrodes are recommended for the multiple sleep latency test::

- right upper eye (RUE) – M1 (where the electrode is placed on the forehead above the centre of the right eye)
- right lower eye (RLE) – M1 (where the electrode is placed on the lower orbital bone below the centre of the right eye).

Chin Electromyogram (EMG)

The chin EMG placements are EMG1-EMG2 (mentalis/sub-mentalis differential pair):

- the mentalis electrode is placed in the midline one centimetre above the inferior edge of the mandible
- the left and right sub-mentalis electrodes are placed two centimetres below the inferior edge of the mandible and two centimetres to the left and right of the midline, respectively. One of these will be used as a back-up electrode.

Electrocardiogram (ECG)

ECG acquisition is a single modified lead II placement (ECG1-ECG2):

- ECG1 - The negative electrode is placed below the right clavicle

- ECG2 - The positive electrode is placed on the sixth or seventh left inter-costal space on the midline of the patient's left side
- additional electrodes are added as required.

Leg EMG

Record the leg EMG from the anterior tibialis muscle of both the left and the right leg. Place electrodes two to three centimetres apart over the belly of the muscle for both right and left legs.

Body Position

Place a body position monitor on the patient to record left lateral, right lateral, supine and prone positions.

If an automatic position monitor cannot be used on the patient, ensure there is capacity for manual indication of the body position during the recording of PSG.

Sound – Decibel (dB) meter

Place the sound level meter approximately 1.2 metres from the patient's head.

Closed Circuit Television (CCTV) Monitoring

Only use CCTV Monitoring with Type 1 PSG and ensure the image displays the entire bed.

Pulse Oximetry

Ideally, place the sensor on the finger. Alternative sites include the toe or earlobe, however the sensor tends to dislodge more easily from these sites during sleep. Note the position of the sensor if it is not placed on the finger.

Thoracic and Abdominal Movement

Respiratory inductance plethysmography (RIP) bands are used for the recording of thorax and abdominal movement:

- fit the thoracic band under the armpits, and above the nipple line
- fit the abdominal band just above the hips, at navel level
- the bands need to be firm enough to expand and contract with the patient's breathing, yet loose enough for comfort.

Nasal Air Pressure

Position a nasal cannula in the nares to measure nasal air pressure.

Oro-nasal Thermal Sensor

Position an oro-nasal thermal sensor in the nares for nasal flow measurement, and over the mouth for oral flow measurement.

Positive Airway Pressure (PAP)

Attach a pressure line to the mask to allow measurement of mask pressure. Measure calibrated leak and flow if available.

Supplemental Oxygen:

Without PAP

- Where possible, use a double-lumen cannula to allow concurrent measurement of nasal flow and oxygen delivery. If a double-lumen cannula is not available, it may not be practical to position two cannulae in the nares. In this case, omit the nasal cannula for pressure.

With PAP

- Deliver oxygen into the ventilation circuit following local Hospital and Health Service protocols and procedures.

4.8.3. Optional Parameters

Utilise optional parameters in extended PSG recording configurations according to clinical need and local Hospital and Health Service protocols and procedures. These may include, but are not limited to, the following.

Diaphragm EMG:

There are two options for placement.

1. A diaphragm 2-lead differential can be used. Attach three electrodes (all same type) and record from the best quality signal pair:
   - place electrode 1 at the right lateral diaphragm attachment (ninth rib intercostal)
   - place electrode 2 over the base of the sternum (ensiform cartilage)
   - place electrode 3 at the left lateral diaphragm attachment (ninth rib intercostal).
2. Intercostal diaphragmatic EMG electrodes can also be used:
   - electrodes are placed in the sixth and seventh intercostal space on the right-hand side at the mid-clavicular line
   - an alternate placement is at the mid-clavicular line on the diaphragm not more than one centimeter below the costal margin and two finger spaces apart.

Oesophageal pressure manometry:

Insert the oesophageal balloon catheter into the mid-third of the oesophagus as per local Hospital and Health Service protocols and procedures.

Transcutaneous carbon dioxide monitoring

Apply the transcutaneous carbon dioxide electrode as per the manufacturer guidelines, to a well-vascularised area with minimal skin thickness. The electrode may need to be re-sited every four hours to prevent possible skin damage from the heated probe.

Sound

Place the tracheal microphone at the site of largest snoring vibration. This is identified by palpating the neck during a simulated snore. Fix the microphone/sensor to this site.

Synchronised Digital Video Recording

Display the entire patient on the video image.

Arm Movement

Place electrodes two to three centimetres apart over the belly of the extensor digitorum muscle for both the right and left arm.

4.8.4. Connecting to the PSG system

Once sensor and electrode application is complete and the patient is ready for bed, ensure that:

- there is easy access to the staff alert system
- the patient is comfortable (e.g. urine bottles are available, appropriate bedding and bed position)
- there is clear access to the patient (e.g. removal of obstacles at patient bedside, and outside the room).

4.8.5. Signal Display and Impedance Checks

Prior to the commencement of the PSG:

- connect all electrodes and sensors to the PSG system
- perform a visual check to ensure signals are clear and free of interference with a stable baseline
- perform and document an impedance check of AC recording parameters including the reference and ground. Ensure that impedances are below ten kΩ for ECG and limb EMG, and below five kΩ for all other signals
- undertake a patient bio-calibration (once appropriate corrective action is taken, if required)
- record a square wave signal of known amplitude to confirm amplifier and filter settings.

If the signal quality is poor, review the sensor and electrode attachment on the patient before adjusting the polysomnograph display.

Document any changes to the default values of sensitivity and filter settings for AC inputs such as EEG, EOG, and ECG.

All other AC recording parameters may require small adjustments in sensitivity to occupy adequate space in the trace layout configuration as described above.

4.8.6. Patient Bio-Calibration

Record patient bio-calibrations to:

- ensure and demonstrate that all electrodes, sensors and other monitoring devices are functioning correctly prior to the commencement of the PSG
- acquire a set of baseline data for the PSG.

During the patient bio-calibration, observe the recorded signals to ensure that the correct PSG responses are evoked for all of the defined manoeuvres. See Appendix 2 for the most commonly performed patient bio-calibration tests. Ensure the patient bio-calibration is available for review during analysis and interpretation of the raw data.

Make every effort to correct poor signals observed during bio-calibration or before "Lights Off". The PSG is ready for data acquisition once successful bio-calibration and impedance testings are completed. At this stage, follow the appropriate PSG-*type* Queensland Health guideline.

4.8.7. Quality Control Procedures

Elements of quality control are outlined within this guideline. For further readings related to quality management within sleep disorder services refer to the electronic article Australasian Sleep Association (2012) *Standard for Sleep Disorders Services*[9].

5. Definition of Terms

Definitions of key terms are provided below.

Term	Definition / Explanation / Details	Source	See also
Adult patient	A patient ≥ 18 years of age.		
Bio-calibration	A series of exercises performed prior to initiating a polysomnogram, to verify correct input derivations and signal quality.	[10]	
Electrocardiogram (ECG)	A non-invasive transthoracic recording of the electrical activity of the heart.	[10]	
Electroencephalogram (EEG)	A non-invasive recording from the scalp of the electrical activity of the brain (cortical field potentials).	[10]	International 10-20 system for electro-encephalogram placement
Electromyogram (EMG)	A non-invasive recording of the muscle activity from the overlying skin.	[11]	

Electro-oculogram (EOG)	A non-invasive recording of the changes in orientation of the resting potential of the eye (a small potential difference exists between the cornea and retina).	12	
Filter settings	The limit of the frequencies of a recorded parameter.	10	
Ground electrode	The driven ground electrode completes a noise reduction circuit by inverting and cancelling out any signals that are common to the reference electrode and the ground.	10	Reference electrode
Informed Consent	Agreement to a proposed procedure, given after proper and sufficient explanation of the condition, the procedure, the general and specific risks, the benefits and anticipated outcomes, alternative treatment available, and the risk of not having the procedure.	5	
International 10-20 system for electroencephalogram placement	Standardised method for identifying equally spaced electrode positions on the scalp, based on four identifiable skull landmarks.	12	EEG
Lights off	Start of sleep opportunity, time (zero) from which sleep latency is calculated (also, referred to as Lights Out).	13	Lights on
Lights on	End of sleep opportunity.	13	Lights off
Montage	“A selected group of derivations”.	10	
Multiple sleep latency test (MSLT)	Measures the physiological tendency to fall asleep in a sleep inducing environment in the absence of competing stimuli. It is indicated as part of the investigation of individuals presenting with suspected narcolepsy or hypersomnolence not better explained by other causes.	13, 14	Narcolepsy
Nasal air pressure	Used to detect nasal airflow.	15	

Oro-nasal thermal sensor	Device to measure changes in airflow based on changes in temperature.	15	
Polysomnography (PSG)	PSG refers to the continuous recording of multiple physiological variables to measure sleep architecture and cardio-respiratory function during sleep. Type 1 PSG is considered the reference standard for sleep monitoring and the clinical evaluation of sleep disorders, and the effectiveness of treatment.	10	
Positive airway pressure (PAP)	Where room air is delivered via tubing connected from a turbine- or fan-driven air blower to a mask interface. Therapy types include Continuous Positive Airway Pressure (CPAP), Non-Invasive Ventilation [16], and Servo-Adaptive Ventilation (ASV).	12	
Pulse oximetry	A non-invasive measure of arterial oxygen saturation in blood (SpO2%) and pulse rate.	17	
Reference electrode	“An electrode against which voltage fluctuations from an exploring electrode are measured”. This is usually an electrically silent area.	10	
Respiratory inductance plethysmography (RIP)	“A method of detecting chest and abdominal movement secondary to changes in the inductance of bands around those regions.”	15	
Sleep physician	Trained physician who is a member of the Royal Australian College of Physicians with current accreditation by the Respiratory and Sleep Medicine Specialist Training Committee (STC) with continuous professional development and ongoing experience in adult sleep medicine.		

Type 1 polysomnography (PSG)	A sleep CMP-attended PSG with the following recording parameters: EEG, EOG, EMG (limb and chin), ECG, airflow, respiratory effort, pulse oximetry, and body position. This type of PSG allows for behaviour observations, standardised recording conditions, addressing technical issues, and making interventions during the night.	18	

6. Consultation

Key stakeholders (position and business area) who reviewed this version are:

- Queensland Health Sleep Sciences Working Party: Anita Brake (Health Practitioner - Advanced, Sleep Disorders Centre Royal Brisbane and Women's Hospital), Chris Brown (Respiratory and Sleep Scientist - Advanced, Respiratory and Sleep Unit The Townsville Hospital), Brett Duce (Scientific Director, Sleep Disorders Centre Princess Alexandra Hospital, President Australasian Sleep Technologists Association), Carl Downey (Senior Sleep Scientist, Sleep Disorders Centre, The Prince Charles Hospital), Matthew Leong (Sleep Scientist, Sleep Disorders Centre,The Prince Charles Hospital), Chloe Parsley (Mater Children's Hospital), Kelli Rixon (Sleep Sciences Working Party Chair, Senior Sleep Scientist, Sleep Disorders Centre Princess Alexandra Hospital), Teresa Shirlaw (Sleep Scientist, Sleep Disorders Centre Princess Alexandra Hospital), Philip Teuwen (Sleep Sciences Working Party Deputy Chair, Statewide Clinical Educator for Sleep Sciences), Patricia Wales (Clinical Nurse Consultant, Department of Respiratory Medicine and Sleep Unit, Mater Children's Hospital), Gordon Williams (Chief Paediatric Sleep Scientist, Department of Respiratory Medicine and Sleep Unit, Mater Children's Hospital).
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- Queensland Health Sleep Disorders Program Executive Committee: Dr James Douglas (Clinical Director, Sleep Disorders Centre, The Prince Charles Hospital), Dr Toby Tang (Respiratory and Sleep Physician, Gold Coast Hospital)
- Australasian Sleep Technologist Association: Tom Churchward (Secretary, Australasian Sleep Technologists Association), Andrew Thornton (Manager, Department of Thoracic Medicine, Chairman Research Ethics Committee, Royal Adelaide Hospital)
- Australasian Sleep Association Clinical Committee: Associate Professor Nick Antic, Clinical Director Adelaide Institute for Sleep Health, Staff Specialist Sleep and Respiratory Medicine Southern Adelaide Local Health Network
- Clinical Measurements Advisory Group (CMAG) for Clinical Education and Training.

- State-wide Clinical Measurements Network (SWCMN)

7. Guideline Revision and Approval History

Version No.	Modified by	Amendments authorised by	Approved by
1.0	Megan Harbourne		Dane Enkera – Chair State-wide Clinical Measurements Network Brett Duce – Chair Clinical Measurements Advisory Group (for clinical education)

8. Appendices

Appendix 1:

Recommended Sampling Rates and Filter Settings for each Recording Parameter

Channels	Minimum Sampling Rates	Polarity	Low Frequency Filter	High Frequency Filter
EEG	200Hz	negative	0.3 Hz	35 Hz
EOG	200Hz	negative	0.3 Hz	35 Hz
EMG	200Hz	positive/negative	10 Hz	100 Hz
ECG	200Hz	positive	0.3 Hz	70 Hz
Oro-nasal thermal sensor	25Hz	positive	0.1 Hz	15 Hz
Oximetry	10Hz	positive	-	-
Nasal pressure	25Hz	negative	0.1 Hz	15 Hz
Pressure	25Hz	positive	0.1 Hz	15 Hz
Patient flow/leak	25Hz	positive	0.1 Hz	15 Hz
Oesophageal pressure	25Hz	negative		
Piezo movement sensors	25Hz	positive	0.3 Hz	35 Hz
Body position	1Hz	-	-	-
Snoring sounds (microphone)	200Hz	positive	10 Hz	100 Hz
Snoring sounds (Piezo sensor)	25Hz	positive	0.1 Hz	15 Hz
Snoring sounds (decibel meter)	10Hz	positive	DC coupled	DC coupled
Thoracic and abdominal movements	25Hz	positive	0.1 Hz	15 Hz

Note: Set sampling rates for all external DC inputs and optional parameters to manufacturer recommendations and laboratory specific guidelines for the PSG system being used. An optional 50Hz notch filter may be required to eliminate external electrical noise.

Appendix 2:

Commonly Performed Patient Bio-Calibrations

Recording Parameter	Patient Instruction
EEG*	1. Eyes open, staring straight ahead 2. Eyes closed, but remain awake
EOG*	1. Look right, look left, look right, look left (keeping head still) 2. Look up, look down, look up, look down (keeping head still) 3. Blink five times
EMG* – mentalis/submentalis	1. Grit your teeth and swallow
Thermal Sensor, Nasal Pressure, Respiratory Inductance Plethysmography, Diaphragm EMG, Oesophageal Pressure, PAP	1. Hold breath (for approximately ten seconds)
Thermal Sensor, Nasal Pressure	1. Breathe through nose only 2. Breathe through mouth only
EMG – Anterior Tibialis	1. Move (dorsi-flex, then plantar-flex) right foot, and relax, repeat 2. Move (dorsi-flex, then plantar-flex) left foot, and relax, repeat
Body Position	1. Roll to right side, roll to left side (if able to)
Sound	1. Cough or make a snoring sound
EMG – extensor digitorum	1. Clench left hand…and relax, clench right hand…and relax, clench left hand…and relax, clench right hand…and relax

Note: ***** An abridged patient bio-calibration routine is performed for MSLT/MWT recordings using manoeuvres 1 to 3. Additional manoeuvres may be performed depending on the recording configuration utilised.

9. References and Suggested Reading

9.1. Suggested Reading

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