Simplifying the Complexity of Polysomnography - Understanding the Objective Measurement of a Sleep Disorder

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Australasian Sleep Association ASA ACCREDITED

RESPIRATORY & SLEEP SPECIALISTS
Experts in Sleep Health Management

Scope

- Subjective Measures of Sleepiness
- Physiologic/Biologic Measures of Sleepiness
- Polysomnography (PSG)
    - Sleep Unit based and Portable (Home)
    - Diagnostic PSG
    - Continuous Positive Airway Pressure (CPAP) titration PSG
    - Multiple Sleep Latency Test PSG

Sleepiness and Fatigue

Although these terms are used interchangeably there are differences.

Sleepiness refers to the urge to fall asleep. It is the result of a biological need to sleep that can be irresistible. Fatigue refers to the reluctance to continue a task as a result of physical or mental exertion or a prolonged period of performing the same task.

The Problem

Safe to work

News

Safety alert after sleeping driver causes heavy mine vehicle collision

By Editor on 28 August 2009 1 comments 217 views

THE Queensland Department Of Mines And Energy has issued a safety alert on vehicle collisions on mine sites.

According to the alert, the incident occurred at a surface mine on the first nightshift, at 4.30am.

An operator of a loaded rear dump truck fell asleep at the wheel on entering a left hand bend, crossed the lanes and collided with an approaching empty rear dump truck.

The operator of the empty truck saw what was happening, tried to avoid the collision, and also attempted communication on the 2-way radio without success. There were no injuries.

The incident is being investigated, but fatigue has been identified as a factor. The Department of Mines and Energy said there were no injuries because both trucks were left hand drive, both were heavy class vehicles, and the empty truck did not roll.

In April 2008, the Department of Mines and Energy issued safety Alert 194, drawing attention to a probable head on collision between two rear dump trucks, when a loaded truck lost control but was stopped by a substantial centre berm dividing the haul road.

Light and heavy vehicles are subject to a variety of hazards, including wet roads, micro sleeps, brake faults, speed, inexperience and various distractions to the driver.

Sleepy Driving

Have you fallen asleep while operating a motor vehicle or heavy machinery? Y ☑ N ☐ a momentary drop off on two or 3 occasions

Have you fallen asleep while operating a motor vehicle or heavy machinery? Y ☑ N ☐ once

4. PLEASE COMPLETE THE FOLLOWING QUESTIONS ABOUT YOUR SLEEP

Describe your sleep problem: fall asleep at traffic light.

4. PLEASE COMPLETE THE FOLLOWING QUESTIONS ABOUT YOUR SLEEP

Describe your sleep problem: I am sleeping too much 9-10 hrs at night, then afternoon nap. Tired all the time.

Describe your sleep problem:

FALLING ASLEEP WHILST DRIVING

Clinical history Fell asleep when stopped at traffic lights c/o tiredness + fatigue 6/12 Recent type 2 ∆ ☺ weight.

Investigation Required:

4. PLEASE COMPLETE THE FOLLOWING QUESTIONS ABOUT YOUR SLEEP

Describe your sleep problem:

Waking up unrefreshed from what i think is a good night sleep and sleepy at work.

4. PLEASE COMPLETE THE FOLLOWING QUESTIONS ABOUT YOUR SLEEP

Describe your sleep problem:

Always tired, no matter how much sleep I get. If I lie down to read a book or watch T.V. during the day will often fall asleep.

4. PLEASE COMPLETE THE FOLLOWING QUESTIONS ABOUT YOUR SLEEP

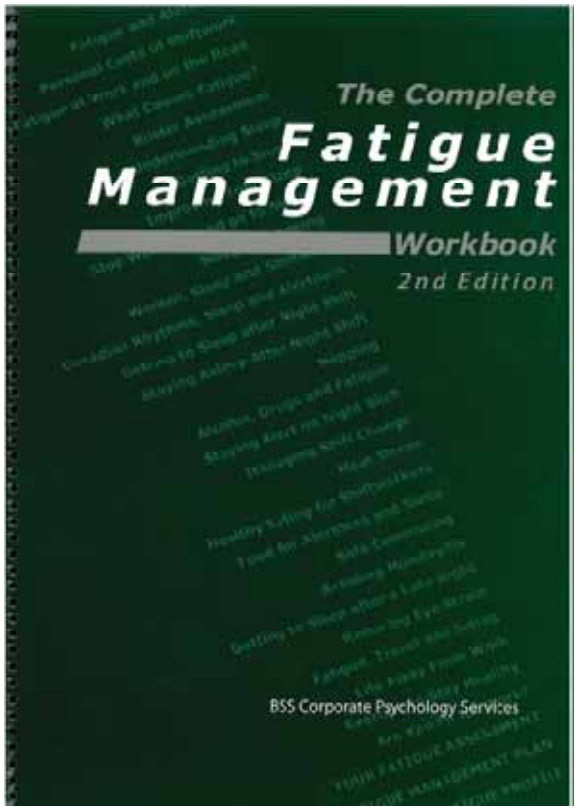
Describe your sleep problem:

TIRD WHEN WAKE UP. SLEEPANYTIME

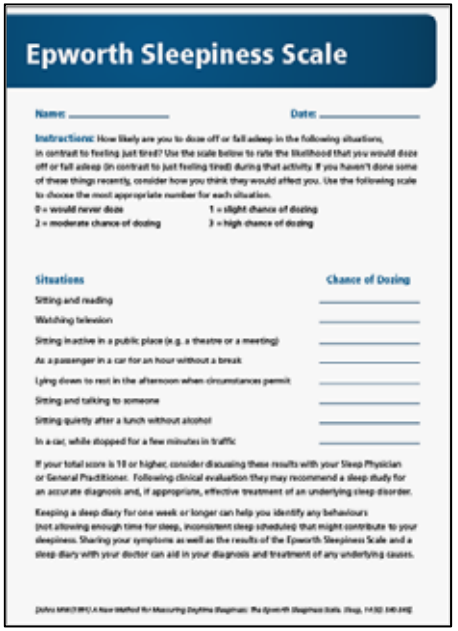
Site Fatigue Management Training

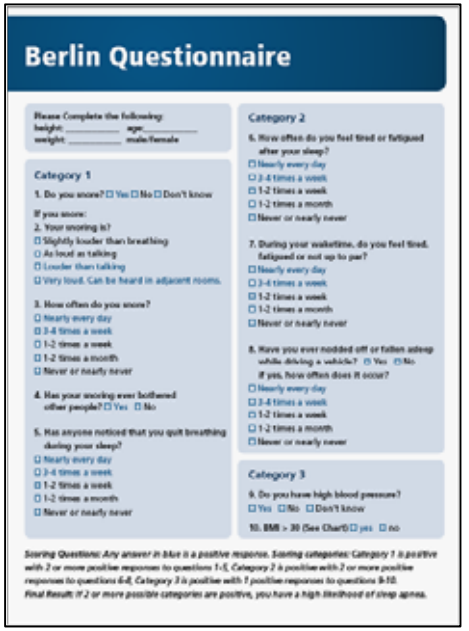
- Fatigue and Alertness
- Personal Costs of Shift work
- Fatigue at Work and on the Road
- What causes Fatigue?
- Roster Assessment
- Understanding Sleep
- Getting to Sleep
- Improving Your Sleep
- Stop Worrying and go to Sleep!
- Sleep and Ageing
- Women, Sleep and Shift work
- Circadian Rhythms, Sleep and Alertness
- Getting to Sleep after Night Shift
- Staying Asleep After Night Shift
- Napping
- Alcohol, Drugs and Fatigue
- Staying Alert on Night Shift
- Managing Shift Change
- Healthy Eating for Shift workers
- Are you fit for work?
- Fatigue Assessment, management plan and fatigue profile

BSS CORPORATE PSYCHOLOGY SERVICES



Fatigue Calculators and Questionnaires





Subjective Measures of Sleepiness

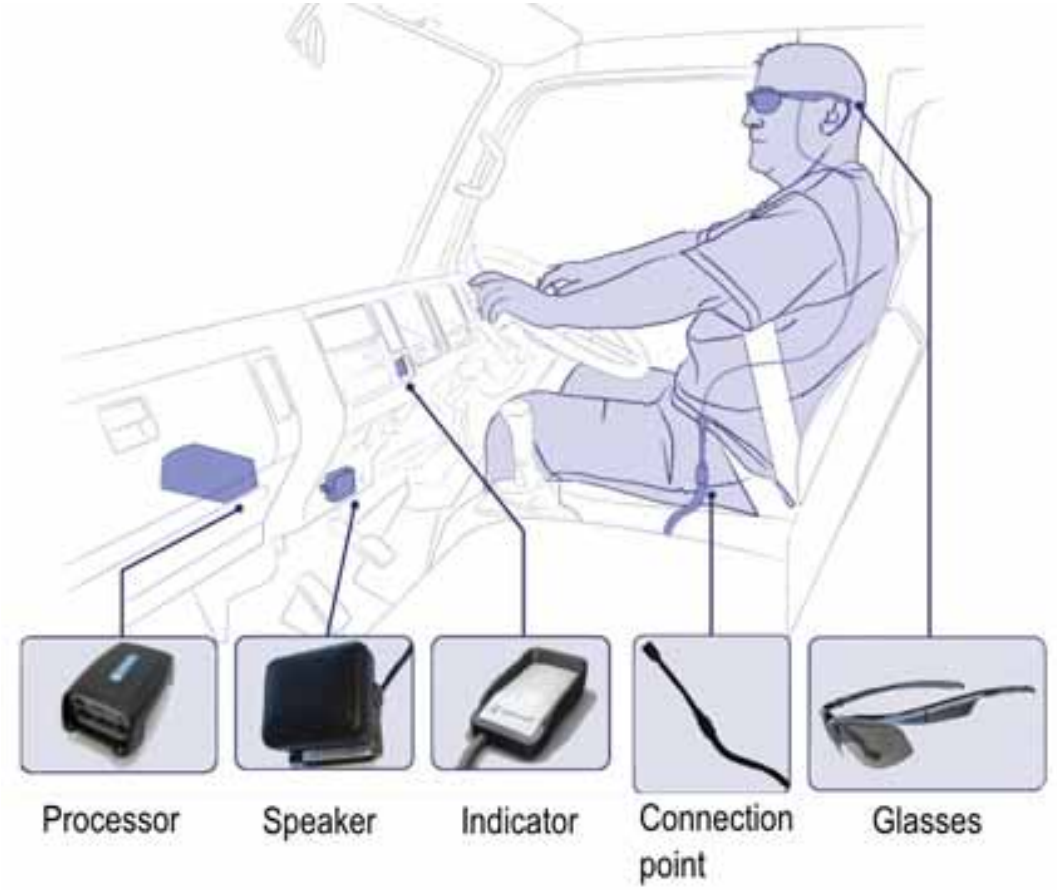
- **Improve level of knowledge and awareness**
- **May prompt individual action**
- **Subjective tools. Rely on personal honesty/integrity of the individual to use them or act on them**
- **Fatigue calculators may provide false sense of security**

Physiologic Measures – Signs of Sleepiness

OPTALERT™

Optalert Glasses (1992-)

Optalert's patented technology continuously measures drowsiness by using invisible pulses of light to detect eye and eyelid movement.
Tiny light emitters and receivers are built into the frames of **Optalert glasses** worn by the driver. The glasses are connected to the **Optalert Vehicle System**, installed within the vehicle, which processes all the information being transmitted from the glasses.
Whenever Optalert detects the onset of drowsiness – usually before the driver becomes aware of it – a loud beeping noise and a voice message warns the driver immediately.
Warnings can include:
Level 1 – Cautionary warning
Level 2 – Critical warning
Inattention
System warnings
Glasses not working



Physiologic Measures – Signs of Sleepiness

Smart Cap (2009)

Smart baseball cap monitors mining fatigue

NEW TECHNOLOGY aimed at combating fatigue-related heavy vehicle driving incidents will be piloted at Queensland mines.

SmartCap technology, brain-monitoring technology that aims to address the dangers of driver fatigue when operating heavy vehicles, has been developed over the last 12 months at the CRCMining mining research centre.

The centre was established by the Federal Government's Cooperative Research Centre's program to deliver safety and productivity enhancing technologies to the mining industry.

Fatigue information is collected by microelectronics concealed within a baseball cap.

The technology uses a number of sensors to measure brain-wave information through hair. It then applies an independently-validated formula to identify when the wearer is experiencing symptoms of fatigue.

Miners at Moranbah North and Capcoal mines will trial the SmartCap technology from December.

"When a fatigue danger limit is reached, a warning message is sent from the operator's cap to an in-cab display, notifying operators of the threat, and alerting them to the need to stop, rest and refresh," Queensland Minister for Mines and Energy, Stephen Robertson, said at the launch of the technology.

Invented by CRCMining engineer DrDaniel Bongers, this tool has been developed by CRCMining as part of an Australian Coal Association Research Program (ACARP) funded project.

Anglo American Chief Executive Cynthia Carroll said the technology was an exciting development for the mining industry.

"Anglo is looking forward to having its Australian coal mines host the SmartCap's onsite application and is even more eager to see the results the technology returns," Carroll said.

"For many years the mining industry has been searching for mechanisms to assist in the detection of operator fatigue, to prevent fatalities and our people from being injured."

To read more click here

MICHAEL MILLS

Mining Daily 1 October 2009

Physiologic Measures

- **Objective measure of signs of sleepiness if interpreting features correctly**
- **Provides potential opportunity for evasive action to me taken – potentially mitigating a real time accident**
- **Will not permit specification or quantification of a sleep disorder beyond identifying a very high propensity for sleep in a given individual**

Polysomnography or PSG or Sleep Study

Objective Measure of Sleepiness, Sleep Quality and Sleep Quantity performed in a sleep unit or at home/in a mine site donger with a portable PSG unit. Will provide data suitable for the medical diagnosis of a sleep disorder.

A PSG is the continuous and simultaneous recording of multiple physiologic variables during sleep, that is, electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG), electrocardiogram (ECG), respiratory air flow, respiratory movements, leg movements and other electrophysiologic variables.

The name is derived from Greek and Latin roots: ‘poli' (many), 'somnus' (sleep), and 'grapho' (to write).

Evolution of Polysomnography (PSG)

- 1930 Berger sleep vs. waking Electroencephlogram (EEG)
- 1937 Loomis EEG of different sleep states
- 1953 Aserinsky and Kleitman Electro-oculogram (EOG)
- 1957 Dement & Kleitman describe Rapid Eye Movement (REM) sleep
- 1959 Jouvet & Michel Electromyogram (EMG) decrease in REM sleep
- 1968 A manual of standardised terminology, techniques and scoring system for sleep stages of human subjects Allan Rechtschaffen and Anthony Kales
- 1978, 1980 McGregor,Weitzman, Pollack PSG to include oximetry, respiratory effort & airflow.

Evolution of Polysomnography (PSG)

- 1981 Colin Sullivan developed Continuous Positive Airway Pressure treatment for Obstructive Sleep Apnoea
- 1992 ASDA (American Sleep Disorders Association) EEG Arousals: Scoring rules and examples
- 1999 Sleep-related breathing disorders in Adults: Recommendations for Syndrome Definition and Measurement Techniques in Clinical Research - Report of an American Academy of Sleep Medicine Task Force (*Sleep* Vol 22 No. 5)

PSG – A Medical Test

Sleepy individual – Discusses their sleep problem with General Practitioner or Sleep Specialist.

If Dr agrees there is need for a sleep study – he or she completes the referral and faxes or emails it for booking.

Queensland Respiratory Laboratory Pty Ltd

Sleep Study Referral Form

PATIENT DETAILS

PATIENT PRESENTATION: (required information)

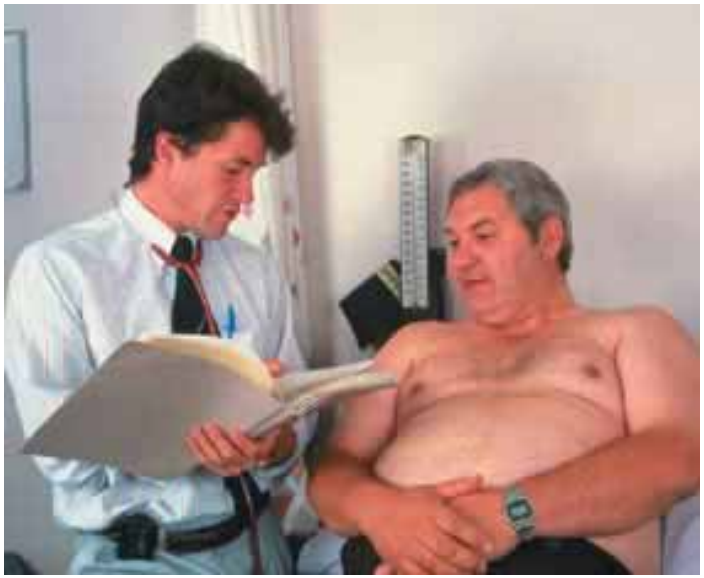
INVESTIGATION REQUIRED:

SPECIALIST REVIEW:

SLEEP STUDY TO BE CONDUCTED AT:

REFERRING DOCTOR DETAILS

Internal Office Use Only: Study Approved ☐ Signature Date



Polysomnographic Tests

- **Diagnostic PSG** - investigative study to determine if there are identifiable problems with the patient's sleep
- **CPAP titration PSG** - If a patient is identified as having obstructive sleep apnoea, a PSG is performed in which the nurse or technician adjusts the CPAP pressure level during the study
- **Split Night PSG-** Combines a diagnostic study and a CPAP titration study into one night. The patient is diagnosed during the first half of the night; CPAP applied the second half if required by protocol
- **Multiple Sleep Latency Test** (MSLT)
- **Maintenance of Wakefulness Test** (MWT)

Both MSLT and MWTs are daytime tests.

88 Sleep Disorders

THE INTERNATIONAL CLASSIFICATION OF SLEEP DISORDERS, REVISED

Diagnostic and Coding Manual

Produced by the

American Academy of Sleep Medicine

in association with the

European Sleep Research Society

Japanese Society of Sleep Research

Latin American Sleep Society

Inadequate Sleep Hygiene
Limit-setting Sleep Disorder
Environmental Sleep Disorder
Toxin-induced Sleep Disorder
Insufficient Sleep Syndrome

Sleep-state Misperception
Psychophysiologic Insomnia
Stimulant-dependent Sleep Disorder
Psychoses
Alcohol-dependent Sleep Disorder
Panic Disorder

Primary Snoring
Central Alveolar Hypoventilation Syndrome
Sleep-related Abnormal Swallowing Syndrome
Chronic Obstructive Pulmonary Disease
Obstructive Sleep Aprea Syndrome
Central Sleep Apnea Syndrome

Narcolepsy
Posttraumatic Hypersomnia
REM-Sleep Behavior Disorder
Recurrent Hypersomnia
Fatal Familial Insomnia
Parkinsonism
Sleep-related Headaches
Sleeping Sickness

Sleep-onset Association Disorder
Nocturnal Eating (Drinking) Syndrome
Food-Allergy Insomnia

Adjustment Sleep Disorder
Anxiety Disorders
Mood Disorders
Alcoholism
Hypnotic-dependent Sleep Disorder
Idiopathic Insomnia

Sleep-related Asthma
Sleep Choking Syndrome
Sleep-related Laryngospasm
Congenital Central Hypoventilation Syndrome
Sudden Infant Death Syndrome
Infant Sleep Aprea
Altitude Insomnia

Idiopathic Hypersomnia
Sleep-related Epilepsy
Nocturnal Paroxysmal Dystonia
Dementia
Cerebral Degenerative Disorders
Electrical Status Epilepticus in Sleep

Short Sleeper
Shift-Work Sleep Disorder
Advanced Sleep-Phase Syndrome
Irregular Sleep-Wake Pattern
Long Sleeper

Sleep Enuresis
Sleep Terrors
Rhythmic-Movement Disorder
Benign Neonatal Sleep Myoclonus
Sleep Paralysis
Confusional Arousals
Subwakefulness Syndrome
Sleepwalking

Restless Legs Syndrome
Sleep-related Gastroesophageal Reflux
REM-Sleep-related Sinus Arrest
Sleep-related Painful Erections
Pregnancy-associated Sleep Disorder
Sudden Unexplained Nocturnal Death Syndrome
Fibrositis Syndrome

Delayed Sleep-Phase Syndrome
Non-24-Hour Sleep-Wake Syndrome
Time-Zone Change (Jet-Lag) Syndrome

Nightmares
Sleep Bruxism
Sleep Starts
Fragmentary Myoclonus
Terrifying Hypnagogic Hallucinations
Sleep Talking

Nocturnal Leg Cramps
Periodic Limb Movement Disorder
Peptic Ulcer Disease
Impaired Sleep-related Penile Erections
Menstrual-associated Sleep Disorder
Nocturnal Cardiac Ischemia
Sleep Hyperhidrosis

We most commonly find……

- **Obstructive Sleep Apnoea**
- **Insomnia**
- **Narcolepsy**
- **Depression**
- **Periodic Limb Movements in sleep**
- **Withdrawal from stimulants**
- **Insufficient sleep syndrome**
- **Drug Dependence/Abuse**
- **Medication side effects**
- **Post Traumatic Hypersomnia**
- **Obesity Hypoventilation**
- **Respiratory Failure**
- **Patients with Night Terrors, REM Behaviour Disorders and Epilepsy**

Physiological measurements undertaken during Polysomnography

Sleep

- EEG (brain signals)
  - C4 – A1, C3 – A2
  - O2 – A1, O1 – A2
- EOG (eye muscle activity)
  - LOC (left eye) and ROC (right eye)
- EMG (chin muscle activity)
  - EMG s (chin = sub-mental)

Muscle Activity

- EMG leg EMG t (anterior tibialis muscle – along shin)

Respiration

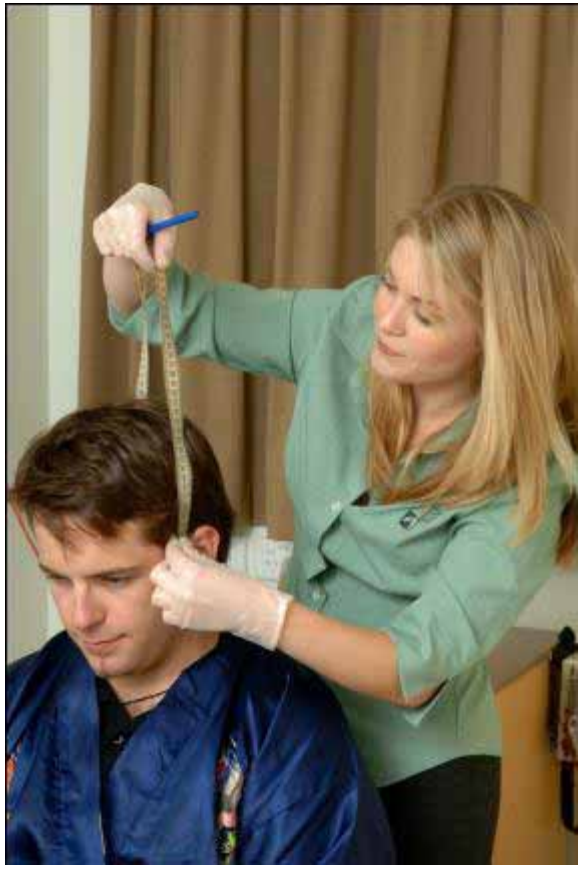
- Airflow (Oral -Thermistor, Nasal pressure - Cannula)
- Respiratory Effort
  - Thorax (Ribcage)
  - Abdomen (Diaphragm)
- Pulse Oximetry
  - SaO_2 (Oxygen saturation)
  - Pulse
- Body position
- Transcutaneous CO_2 (when requested)
- Microphone (snoring)

Cardiac status

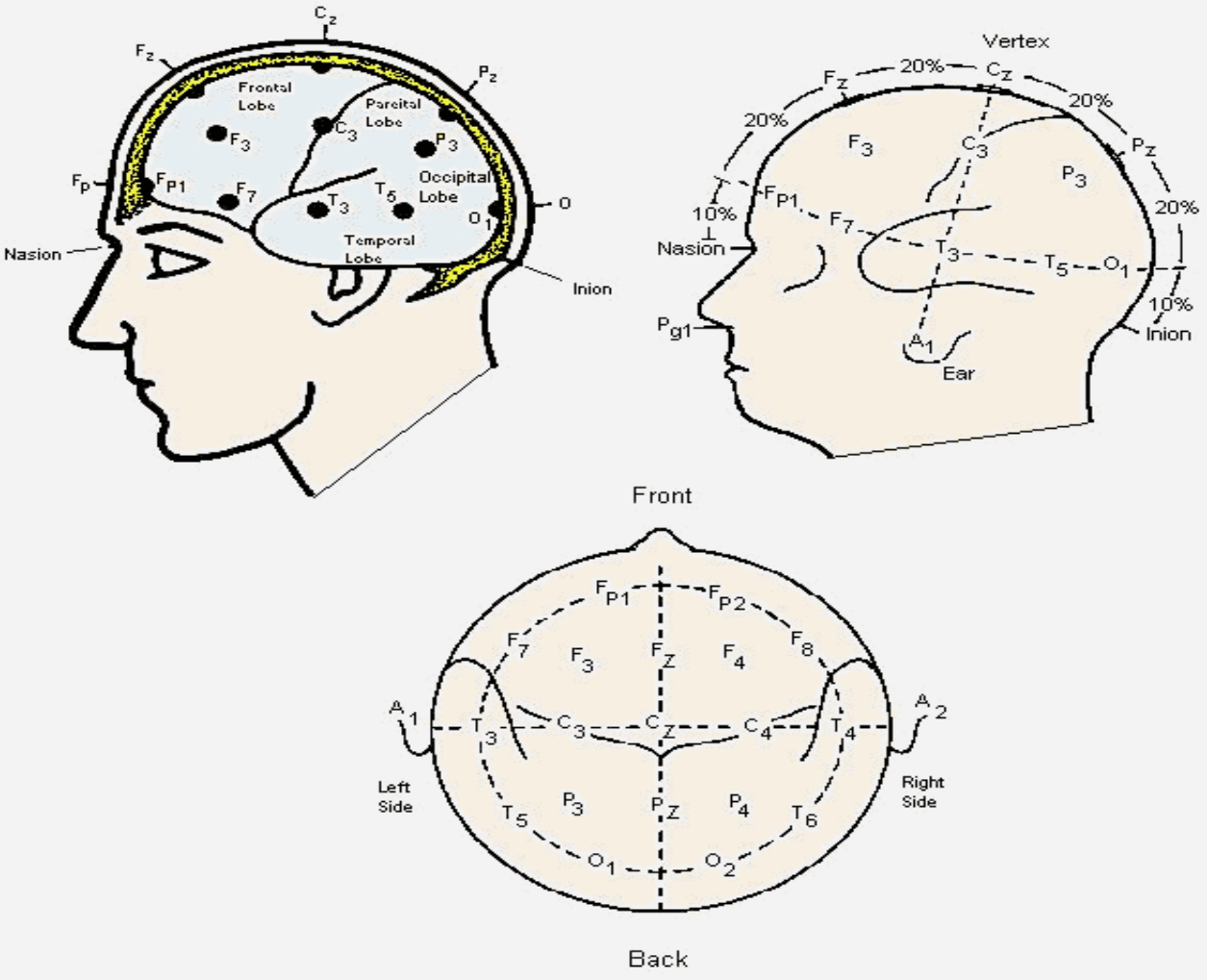
- ECG

Setting up for the Sleep Study

Head Measurement



10-20 System EEG electrode placement landmarks



Setting up for the Sleep Study

Site preparation and glue-on Electrode Application

Setting up for the Sleep Study

Application of 'Respi-Bands', Leg electrodes and Nasal Cannula

Setting up for the Sleep Study

Application of Nasal Cannula

RESPIRATORY & SLEEP SPECIALISTS

Setting up for the Sleep Study

Connection of Patient to 'Headbox'

The Diagnostic Sleep Study

Overnight attended monitoring of patient and data signals in the sleep unit

Brief Digression

Sleep Unit PSG?

or

Portable PSG?

Sleep Unit based PSG

- Performed for over 30 years.
- Considered ‘gold standard’. Usually conducted within a hospital sleep unit or sleep clinic.
- Patient is ‘attended’ overnight by a Scientist, Nurse or Medical staff.
- Patient well being and signal quality/data integrity is monitored and maintained.
- PSG hardware capable of 27+ channels for data capture.
- Video monitoring.
- Pressure titration of CPAP or Bilevel machines can be performed by a scientist, nurse or medical staff.

Portable (home based) PSG

- Performed for approximately 12 years in Australia.
- Usually conducted in the patient's home after evening clinic 'set-up'. Reduced cost.
- Non-attended.
- Potential for data loss if lead/s dislodged.
- Usually no video monitoring.

- 2007 - portable PSG hardware invented capable of measuring majority of sleep unit based channels.
- Some sleep service providers, chemists and other outlets still using single or double channel monitoring devices – NOT PSG -risk of false positives, false negatives sleep study results.
- Medicare Australia intervention 2008 - 2010

Portable monitoring devices 2010

	Stardust® II	ApneaLink Plus	ApneaLink	LifeShirt	Apnea Risk Evaluation System (ARES)
					
Contact Natus for cost information/1 Year	Call your Respironics representative/1 Year	$1,695/2 Year	$1,495/2 Year	$4,950-$10,000/1 year	$3,995/1 Year
Contact Natus for cost information	Call your local Respironics representative	~$7 (w/reusable Oximetry sensor)	~$7 (w/reusable Oximetry sensor)	$5-$15 per test	Varies based on services
Type II	Type III, IV	Type III	Type IV	Type III, upgradeable to Type II	Type II, upgradeable to Type II
24 Referential Channels 4 DC, 4 Differential, Pulse Oximetry	**7 Core Channels** Airflow/Pressure, Snore, Respiratory Effort, Spo_2, Pulse Rate, Body Position, Patient Marker **5 Additional Therapy Channels Available** Auto Detected Events, Therapy Pressure, Patient Flow, Leak, Respiratory Rate	**4 Channels** Nasal Flow, Pulse, Oxygen Saturation, Respiratory Effort	**3 Channels** Nasal Flow, Pulse, Oxygen Saturation	**5 Channels** Thoracic Respiratory Movement, Abdominal Respiratory Movement, ECG, Oxygen Saturation, Body Position/Activity Level	**7 Channels** Oxygen Saturation, Airflow (nasal pressure), Pulse Rate, Snoring, Respiratory Effort, Head Position/Movement, Sleep/Wake

	Somté	Somté PSG	Embletta® Gold	SleepTrek3	WatchPAT200
					
Contact Natus for cost information/1 Year	$5,995/1 Year	$8,200/1 Year	$3,500/2 Year	$3,995/3 Year	$4,400/1 Year Extended Warranty: $425
Contact Natus for cost information	>$12 per study	>$15 per study	$5-$7 cost per use	Cannulas that vary in price.	$75 per test
Type II	Types III, IV	Types: II, III, IV Can be upgraded to Type I	Type III	Type III	*CMS recognizes as a Type of its own.
13 Channels 2 EXG (EOG, EEG, EMG, ECG), Pressure, Airflow, Snore, Thoracic Effort, Abdominal Effort, Limb Movement, Body Position, Spo_2, Pulse Rate, Pulse Waveform, Oximeter Signal Quality	**Up to 27 Channels** 2 EEG, 2 EOG, EMG, ECG with Thoracic Impedance Option, EXG (EOG, EMG, EEG, ECG), Pressure, Airflow, Snore, Thoracic Effort, Abdominal Effort, Limb Movement, Body Position, Spo_2, Pulse Rate, Pulse Waveform, Oximeter Signal Quality. Aux: Selectable as Thermistor, External Body Position, Aux AC or Aux DC	**9 Input-14 Channel** Includes all inputs and derived channels	**6 Channels** Airflow, Snore, Respiratory Effort, Body Position, Pulse Rate, Spo_2	**6 Channels** PAT (Signal & Amplitude), Pulse Rate, Oxygen Saturation, Actigraphy, Snoring (in decibels), Body Position

	Trex	Nomad (Pending 510k approval)	Trackit Sleep Walker	Trackit 18+8	Alice® PDx™
					
Contact Natus for cost information/1 Year	Contact Natus for cost information	Contact Representative/ 1 Year	Contact Representative/ 1 Year	Contact Representative/ 1 Year	Call your Respironics representative/2 Year
Contact Natus for cost information	$9.75/per use	$13/per use	Variable	Call your local Respironics representative	
Type II	Type III	Type II, Type III	Type II	Type II, III, IV	
20 Channels Airflow/Pressure, Snore, Thoracic/Abdominal Respiratory Effort, Spo_2, Pulse Rate, Body Position/Activity/EMG, EEG, Event, EKG/ECG, Pressure, Flow, Leak, Pulse Transit Time, Heart Rate	**12 Channels** Pressure Transducer, Thermistor, Snore Sensor, Chest Effort, Abdominal Effort, 2-EMG Channels, Oximetry (Sao_2, pulse, pleth wave), 1 DC input, Internal Body Position Sensor	**Up to 16 Channels** 4 EEG channels, 3 Poly channels, Pulse Ox outputs (Sao_2, Heart Rate, and Pulse Wave), Chest Effort, Abdominal Effort, PLM, Pressure Transducer with Snore Signal, Internal Body Position Sensor	**Up to 32 Recording Channels** 18 EEG, 8 Poly (monopolar, bipolar, or low voltage DC), 4 AUX high voltage DC channels, Pulse Oximeter (Sao_2 and Pulse Wave)		

	MediByte Jr	MediByte	MediPalm	Easy Ambulatory PSG	SleepScout
					
From $1,995/1 Year	From $4,495/1 Year	$9,995/1 Year	Cost varies based on channel configuration/1 Year	$5,990/1 Year	
$7	$7	$1	Varies. Contact Cadwell to discuss configuration.	<$4 per study	
Type III, IV	Type III, IV	Type II, III, IV	Types I to IV	Type III	
6 Channels Oximetry, Heart Rate, Pressure/Flow, Snore, RIP Chest Effort, Body Position, Event Marker, CPAP Flow, CPAP Pressure	**12 Channels** Oximetry, Heart Rate, Pressure Flow, Snore, Thermal Flow, RIP Chest Effort, RIP Ab Effort, SUM, Body Position, Audio, Volume, ECG, EMG, Event Marker, CPAP Flow, CPAP Pressure	**18 Channels** 3 EEG, 2 EOG, 1 EMG, 1 ECG, 2 Leg EMG, Oximetry, Heart Rate, Pressure Flow, Snore, Thermal Flow, Chest Effort, Ab Effort, SUM, Body Position, Event Marker	**1 to 32 Channels** EEG, EOG, EMG, ECG, Thermal Airflow, Snoring Microphone, Nasal Pressure Airflow, Nasal Pressure Snoring, Oral Pressure Airflow, Oral Pressure Snoring, Oral/Nasal Airflow, Oral/Nasal Snoring, RIP (Chest), RIP (Abdomen), Body Position Sensor, Spo_2, Oximeter, Pulse Rate, Leg Accelerometers, Arm Accelerometers, Single Channel Amplifiers	**9 Channels** Pulse Oximetry, Airflow (pressure based), Snore (derived from airflow), Thoracic Effort, Abdominal Effort, Body Position, Auxiliary DC (thermistor, blood pressure, etc), ECG, EMG

Regulation and Best Practice Guidelines
Portable PSG
Medicare Schedule Advisory Committee findings March 2010

10. MSAC's advice to the Minister

After considering the strength of the available evidence in relation to safety, effectiveness and cost-effectiveness, MSAC supports public funding for the use of Level 2 unattended sleep studies for investigation of obstructive sleep apnoea (OSA) for a duration of at least 8 hours, for an adult aged 18 years and over, where:

(a) the patient is referred for the investigation by a medical practitioner who has formed a reasonable clinical view that the patient has a high probability of having OSA

*[(b) the necessity for the investigation is determined by a qualified sleep medicine practitioner (as defined in the explanatory notes to the MBS) prior to the investigation;] [*referred study]

(c) a qualified sleep medicine practitioner has:

(i) established quality assurance procedures for the data acquisition; and

(ii) personally analysed the data and written the report;

(d) during a period of sleep, the investigation is a recording of a minimum of seven channels which must include continuous EEG, continuous ECG, airflow, thoraco-abdominal movement , oxygen saturation; and two or more of EOG, chin EMG and body position.

(e) interpretation and report of the investigation (with analysis of sleep stage, arousals, respiratory events and assessment of clinically significant alterations in heart rate) are provided by a qualified sleep medicine practitioner based on reviewing the parameters recorded under (d) above.

Regulation and Best Practice Guidelines

American Academy of Sleep Medicine
Clinical Guidelines for the use of unattended portable monitors 2007

JCSM
Journal of Clinical Sleep Medicine

SPECIAL ARTICLE

Clinical Guidelines for the Use of Unattended Portable Monitors in the Diagnosis of Obstructive Sleep Apnea in Adult Patients

Portable Monitoring Task Force of the American Academy of Sleep Medicine

Task Force Members: Nancy A. Collop, M.D.[1] (Chair); W. McDowell Anderson, M.D.[2]; Brian Boehlecke, M.D., M.S.P.H.[3]; David Claman, M.D.[4]; Rochelle Goldberg, M.D.[5]; Daniel J. Gottlieb, M.D., M.P.H.[6]; David Hudgel, M.D.[7]; Michael Sateia, M.D.[8]; Richard Schwab, M.D.[9]

[1]Division of Pulmonary and Critical Care Medicine, Johns Hopkins University, Baltimore, MD; [2]James A. Haley VA Hospital, Tampa, FL; [3]University of North Carolina, Chapel Hill, NC; [4]Department of Medicine, University of California, San Francisco, San Francisco, CA; [5]Sleep Medicine, Lankenau Hospital, Wynnewood, PA; [6]The Pulmonary Center, Boston University School of Medicine, and VA Boston Healthcare System, Boston, MA; [7]Henry Ford Sleep Disorders Center, Detroit, MI; [8]Section of Sleep Medicine, Dartmouth-Hitchcock Medical Center, Hanover, NH; [9]Division of Sleep Medicine, University of Pennsylvania, Philadelphia, PA

Based on a review of literature and consensus, the Portable Monitoring Task Force of the American Academy of Sleep Medicine (AASM) makes the following recommendations: unattended portable monitoring (PM) for the diagnosis of obstructive sleep apnea (OSA) should be performed only in conjunction with a comprehensive sleep evaluation. Clinical sleep evaluations using PM must be supervised by a practitioner with board certification in sleep medicine or an individual who fulfills the eligibility criteria for the sleep medicine certification examination. PM may be used as an alternative to polysomnography (PSG) for the diagnosis of OSA in patients with a high pretest probability of moderate to severe OSA. PM is not appropriate for the diagnosis of OSA in patients with significant comorbid medical conditions that may degrade the accuracy of PM. PM is not appropriate for the diagnostic evaluation of patients suspected of having comorbid sleep disorders. PM is not appropriate for general screening of asymptomatic populations. PM may be indicated for the diagnosis of OSA in patients for whom in-laboratory PSG is not possible by virtue of immobility, safety, or critical illness. PM may also be indicated to monitor the response to non-CPAP treatments for sleep apnea.

At a minimum, PM must record airflow, respiratory effort, and blood oxygenation. The airflow, effort, and oximetric biosensors conventionally used for in-laboratory PSG should be used in PM.

The Task Force recommends that PM testing be performed under the auspices of an AASM-accredited comprehensive sleep medicine program with written policies and procedures. An experienced sleep technologist/technician must apply the sensors or directly educate patients in sensor application. The PM device must allow for display of raw data with the capability of manual scoring or editing of automated scoring by a qualified sleep technician/technologist. A board certified sleep specialist, or an individual who fulfills the eligibility criteria for the sleep medicine certification examination, must review the raw data from PM using scoring criteria consistent with current published AASM standards.

Under the conditions specified above, PM may be used for unattended studies in the patient's home. A follow-up visit to review test results should be performed for all patients undergoing PM. Negative or technically inadequate PM tests in patients with a high pretest probability of moderate to severe OSA should prompt in-laboratory polysomnography.

Keywords: Clinical guidelines, portable monitoring, home study, obstructive sleep apnea, comprehensive evaluation

Citation: Collop NA; Anderson WM; Boehlecke B; Claman D; Goldberg R; Gottlieb DJ; Hudgel D; Sateia M; Schwab R. Clinical guidelines for the use of unattended portable monitors in the diagnosis of obstructive sleep apnea in adult patients. *J Clin Sleep Med 2007*;3(7):737-747.

The current standard for clinical practice, established through evidence-based reviews by the American Academy of Sleep Medicine (AASM), is to confirm the diagnosis of obstructive sleep apnea (OSA) with in-laboratory polysomnography (PSG).[1] This method has been proven to be accurate with a low failure rate because the study is attended by technical staff; PSG, however, is considered relatively expensive and technically complex. Portable monitoring (PM) has been utilized as an alternative diagnostic test for OSA based in part on the premise that it is less expensive and quicker to deploy compared to in-laboratory PSG. However, there is a paucity of evidence that shows PM is equivalent to PSG in regards to diagnosis, treatment, and outcomes. The available literature typically shows PM can be as accurate as PSG for diagnosis in selected populations; however, in practice it is often used without prior determination of whether the patient is an appropriate candidate for PM.

The first practice parameter on PM was published in 1994.[2] A subsequent paper on the indications for polysomnography was published in 1997.[3] The Agency for Healthcare Research and Quality (AHRQ) reviewed articles and performed a meta-analysis

Disclosure Statement
This was not an industry supported study. The authors have indicated no financial conflicts of interest.

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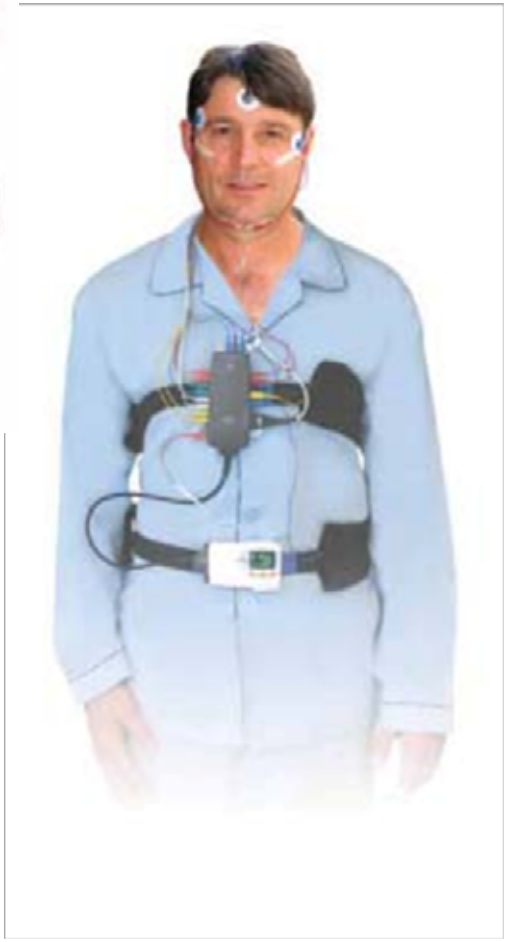
1.2.1. PM is not appropriate for the diagnosis of OSA in patients with significant comorbid medical conditions that may degrade the accuracy of PM, including, but not limited to, moderate to severe pulmonary disease, neuromuscular disease, or congestive heart failure.

1.2.2. PM is not appropriate for the diagnostic evaluation of OSA in patients suspected of having other sleep disorders, including central sleep apnea, periodic limb movement disorder (PLMD), insomnia, parasomnias, circadian rhythm disorders, or narcolepsy.

Objective Testing – Our Service
Portable Sleep Study performed with Somte PSG device



Meets Medicare Australia (2008-2010) guidelines.

Meets AASM (2007) guidelines as a Level 2 device.

14 – 27 channels including multiple EEG for precise sleep staging by scientist.

Clinically robust data capture – no false positive or negative results.

RESPIRATORY & SLEEP SPECIALISTS

Instructions for use

Before bed: Please check the display on your Somté PSG. If there is a lead that has been dislodged or is faulty it will be displayed or will flash e.g. EEG- or

You will need to reattach this lead if it has been dislodged. Refer to handout for the locations and colours of all the leads.

Problems at night: If you require assistance at night there is 24 hour help available.

Please phone: Mackay Sleep Studies on-call support on 0418 762 682 or Sleep Specialists on-call support on 0418 611 288 (Please note: on-call support will return your call so minimum call costs apply).

In the morning: You will need to return to Pioneer Valley Hospital between 8-9am for the removal of leads by a technician. Please ensure all equipment and paperwork is returned.

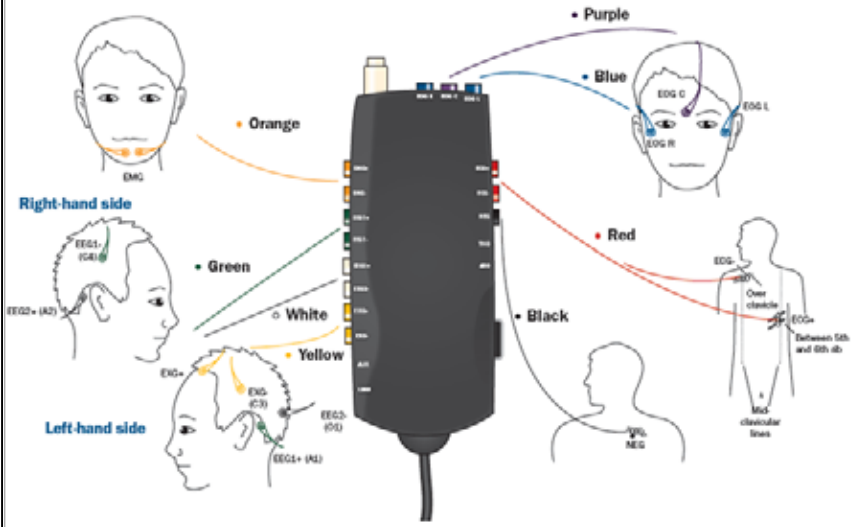
Warning

- **Do not get the equipment wet (no washing up, shower or bathing children)**
- **Do not expose to extreme high or low heat**
- **Turn off all electrical equipment within your bedroom (inc mobile phones, electric bed/blankets)**
- **Do not drop or damage the unit**
- **Do not change the batteries**
- **Do not participate in physical activity while wearing the device**

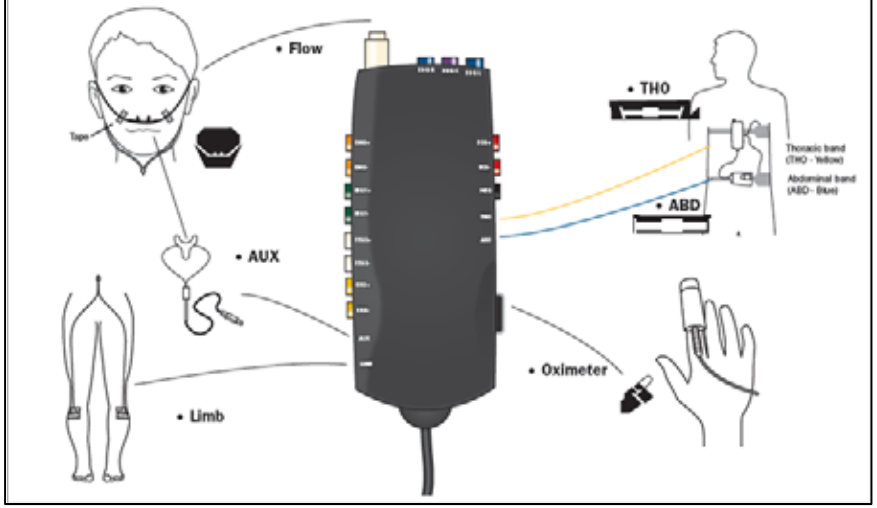
Freecall: 1800 155 225 or (07) 3870 2144
Web: sleepspecialists.com.au E-Mail: sleep@sleepspecialists.com.au

GOLD COAST BRISBANE TOOWOOMBA SUNSHINE COAST MACKAY DARWIN LISMORE MARYBOROUGH HERVEY BAY

Location and Colour of Leads



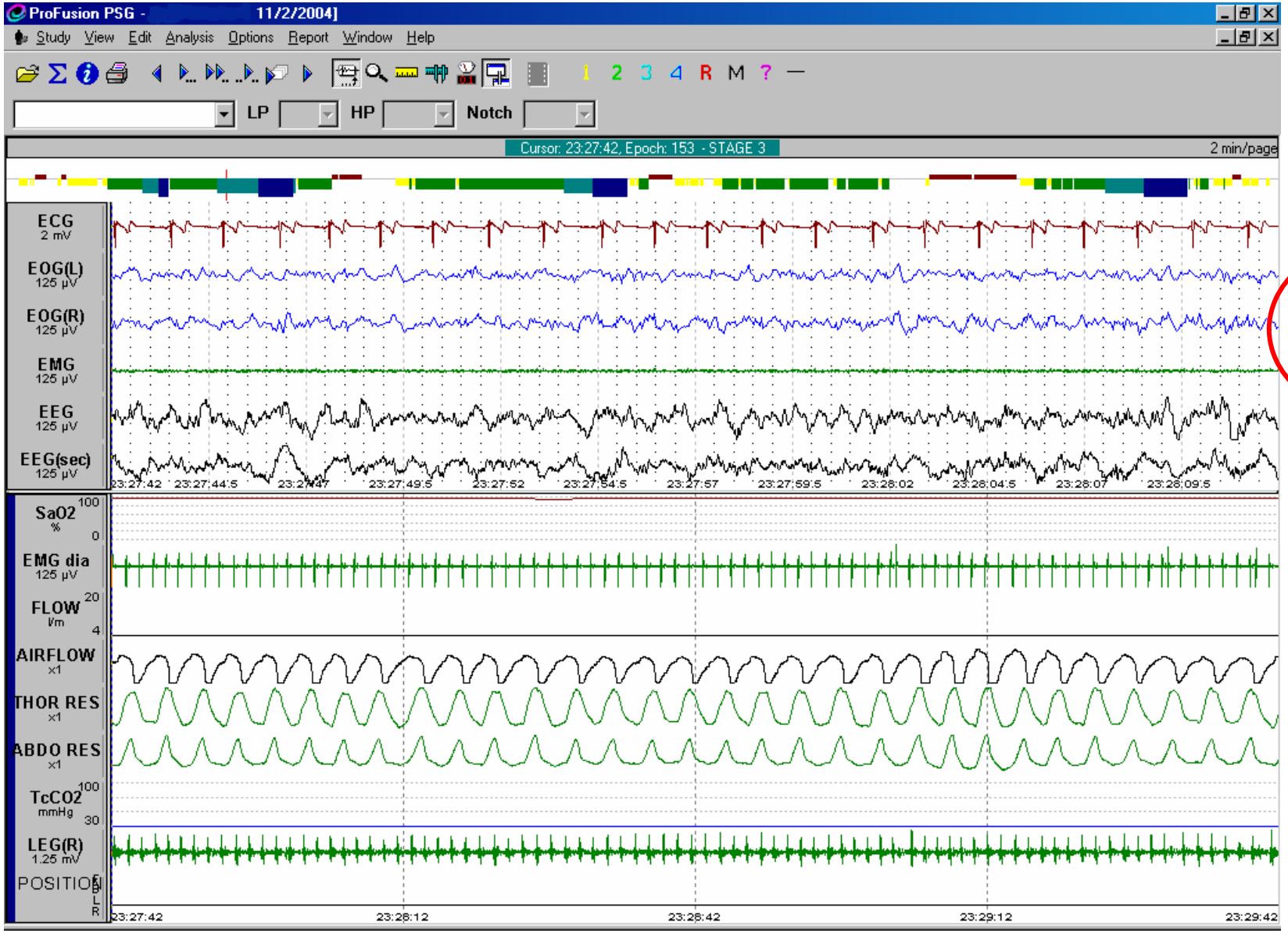
Other Leads



PSG Analysis

Study data is scored by a qualified Sleep Scientist and reported by Sleep Physician

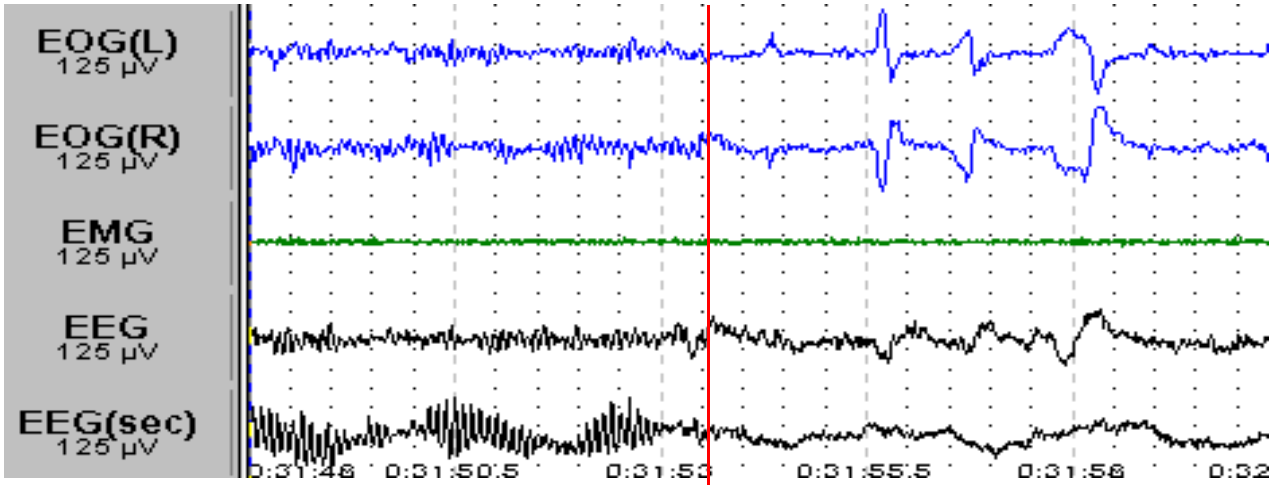
Diagnostic Sleep Study Signals



Upper Pane

Lower Pane

Awake



Awake - eyes closed

EEG Alpha waves – 8-13Hz

EOG Reflects EEG

EMG highest level of recording

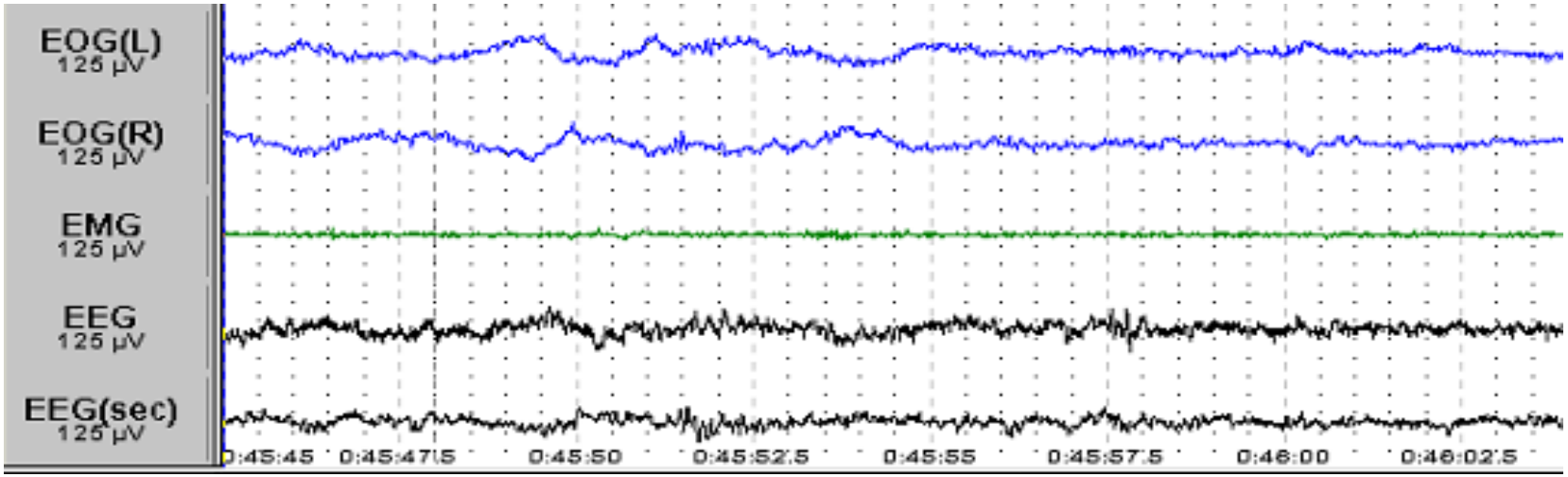
Awake - eyes open

EEG small amplitude, mixed frequency

EOG blinks

EMG highest level of recording

Stage 1 Sleep

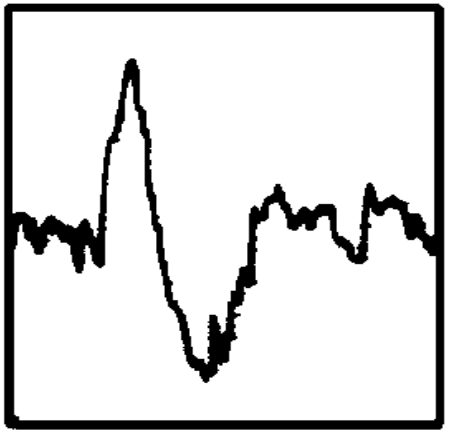


EEG: Slower activity than wake, can see each distinct wave.

EOG: Rolling eye movements, sinusoidal waves in opposing directions

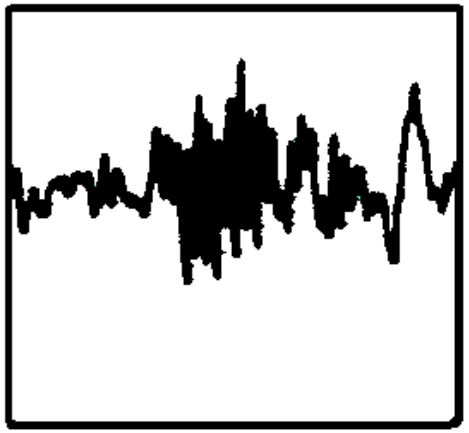
EMG: Slightly reduced from wake

Stage 2 Sleep



K – complex

Sharp negative wave followed by positive.

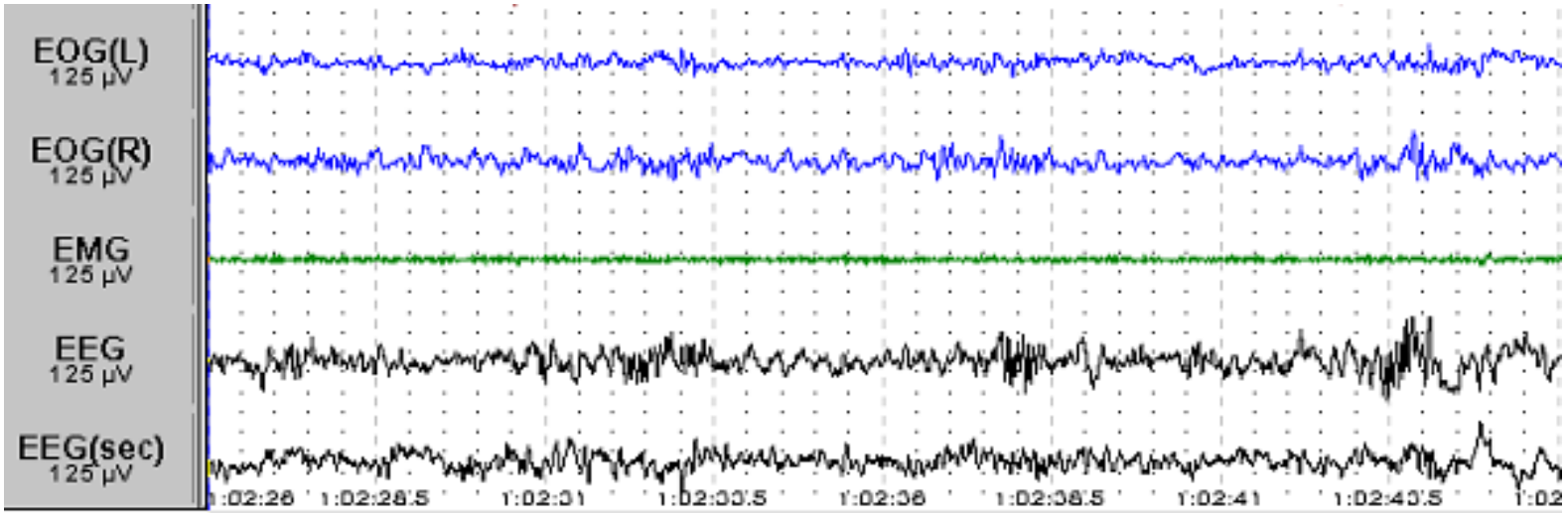


Spindle

12-14Hz

>0.5 seconds duration

Stage 2 Sleep

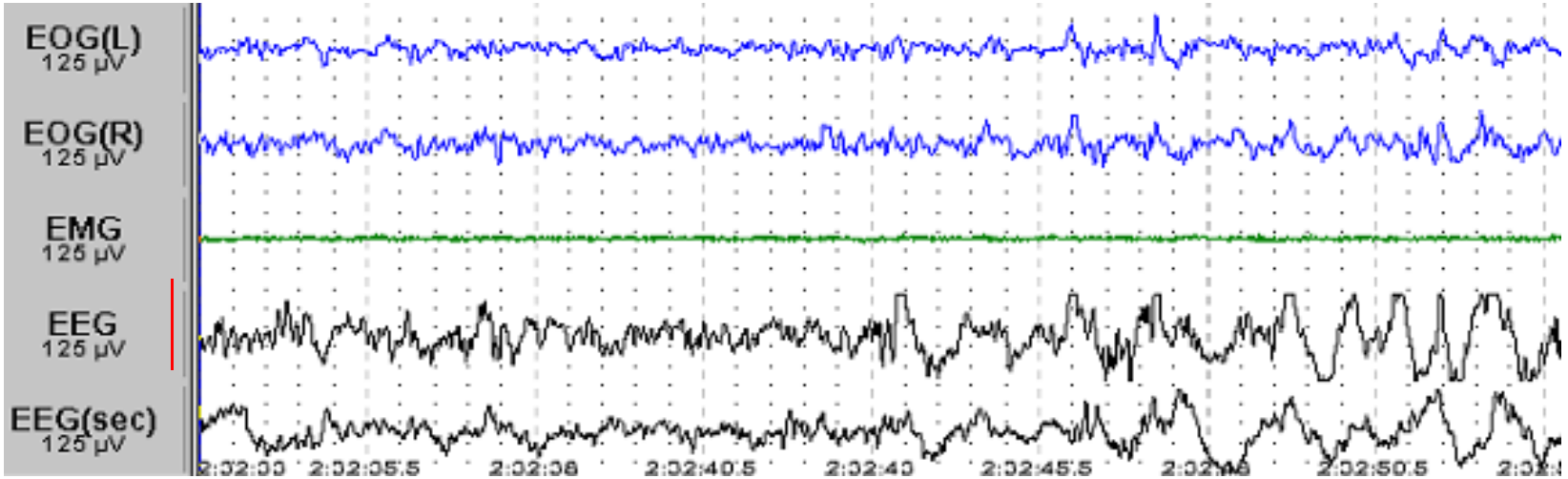


EEG: Presence of spindles or K-complexes

EOG: No movements but may reflect EEG activity

EMG: Slightly reduced

Stage 3 Sleep

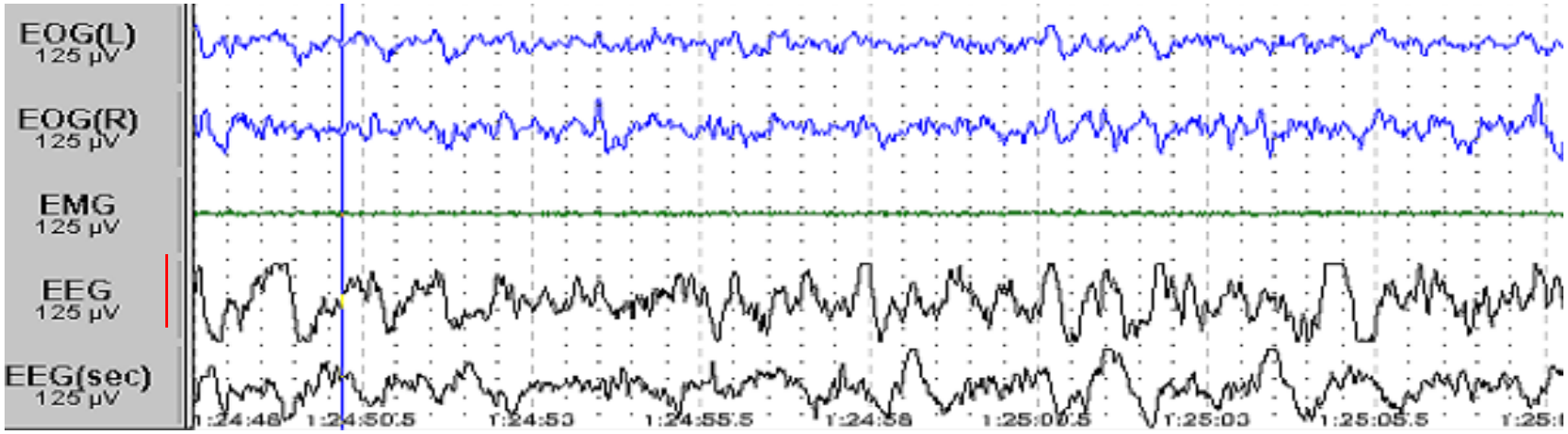


EEG: 20-50% of the epoch has waves 75µV in amplitude, of frequency less than 4 cycles per second.

EOG: No movement. May reflect EEG waves.

EMG: Slightly reduced.

Stage 4 Sleep



EEG: more than 50% of the epoch has waves 75µV in amplitude, of frequency less than 4 cycles per second

EOG: No movement. May reflect EEG waves

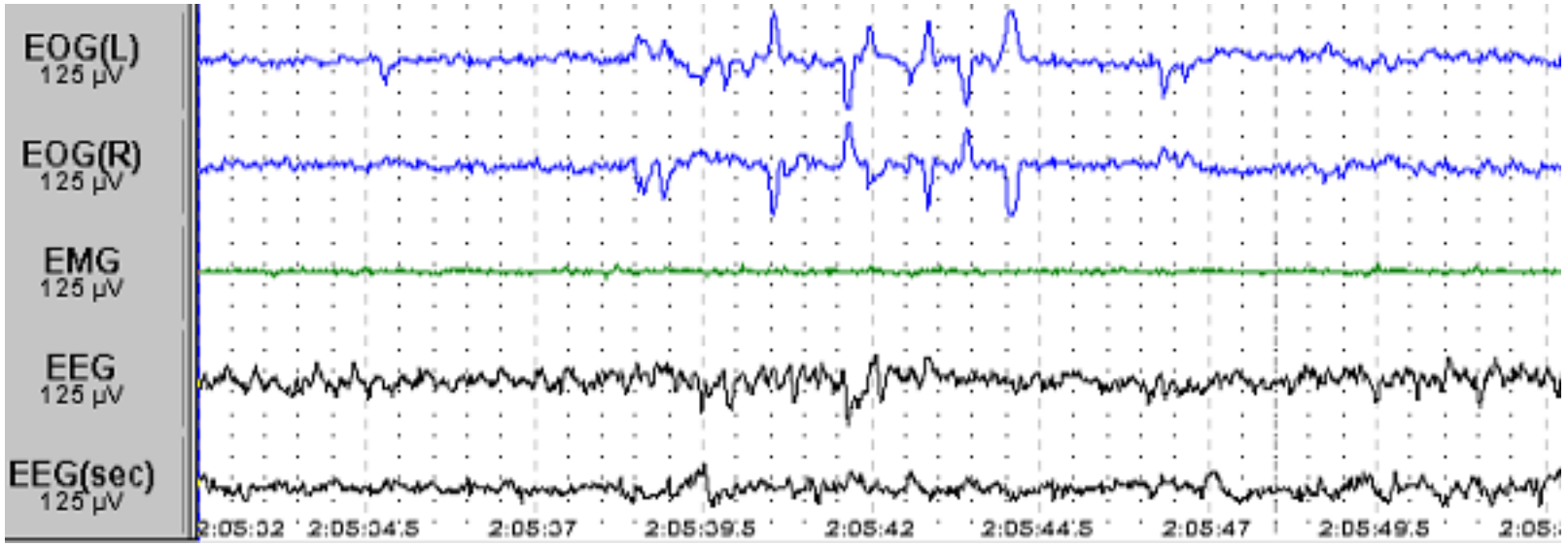
EMG: Slightly reduced.

REM Sleep

Sawtooth wave

Low amplitude wave with sawtooth appearance

REM Sleep



EEG: small amplitude, mixed frequency. May have sawtooth waves. Resembles awake with eyes open.

EOG: rapid eye movements in opposing directions.

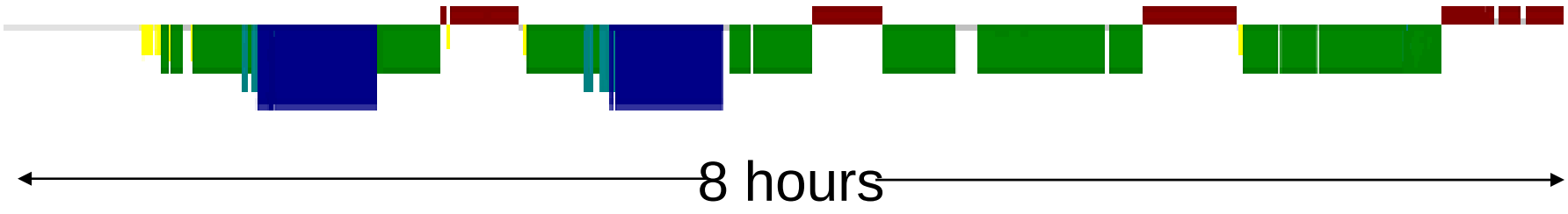
EMG: reduced to lowest level of recording.

Normal Sleep Architecture

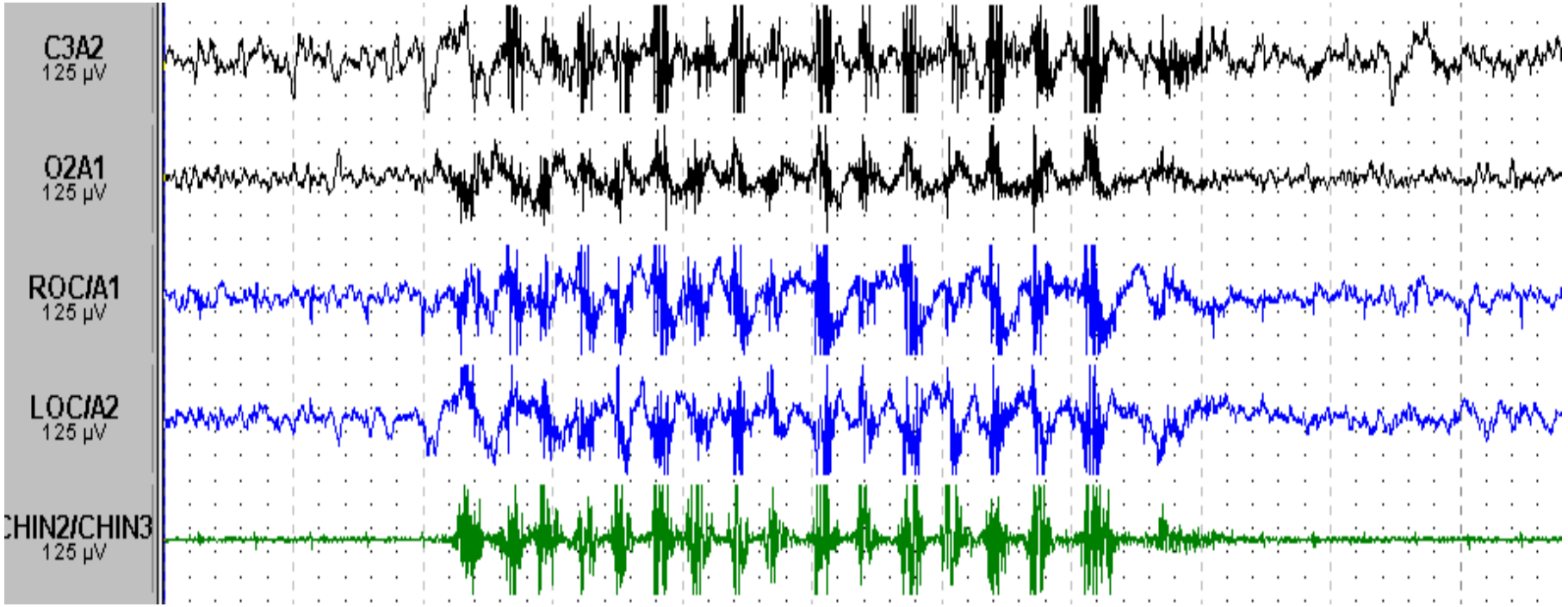
- Normal sleep cycle:

Stage 1	4%
Stage 2	38%
Stage 3	4%
Stage 4	16%
REM	16%

(Mathur and Douglas, 1995)

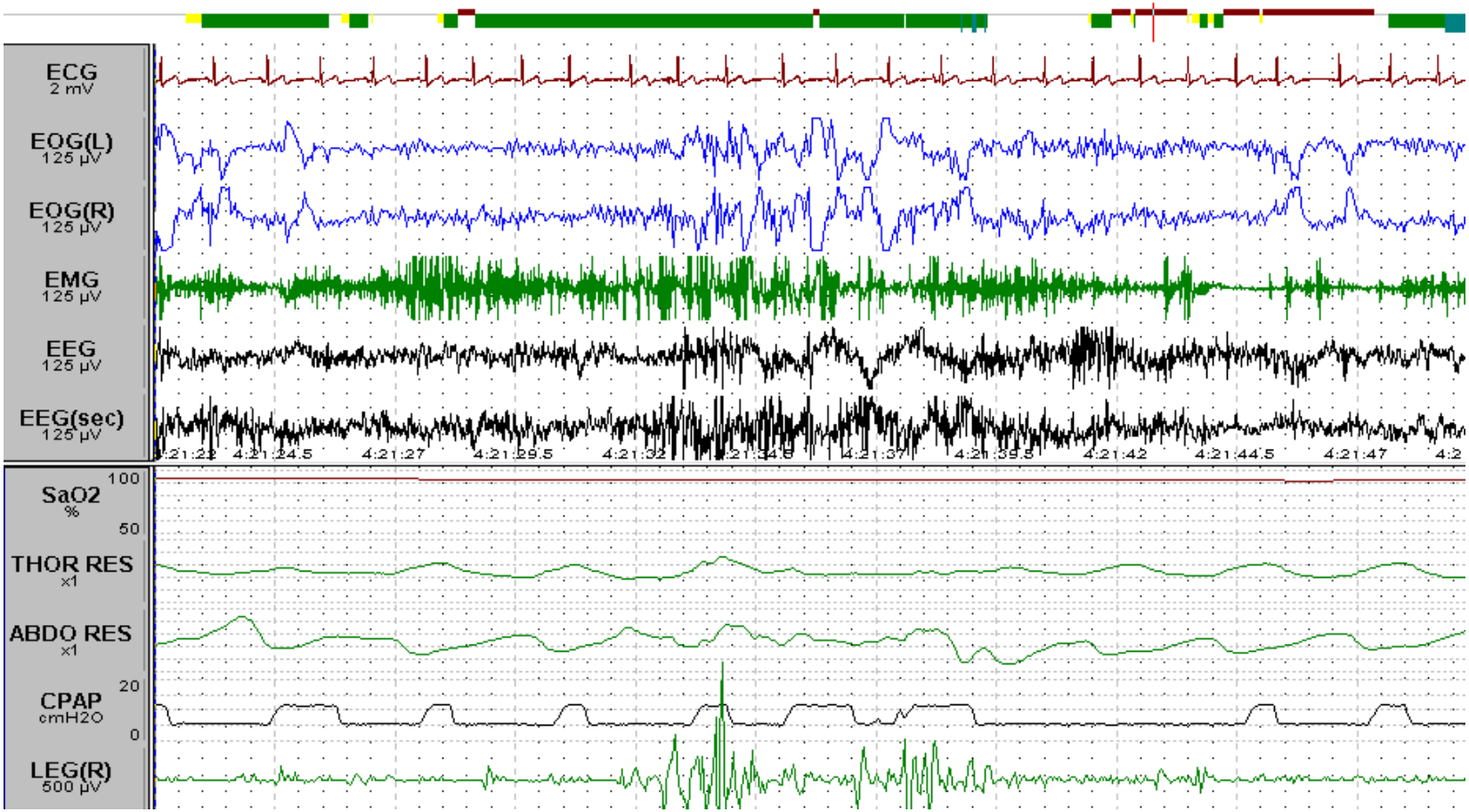


Bruxism



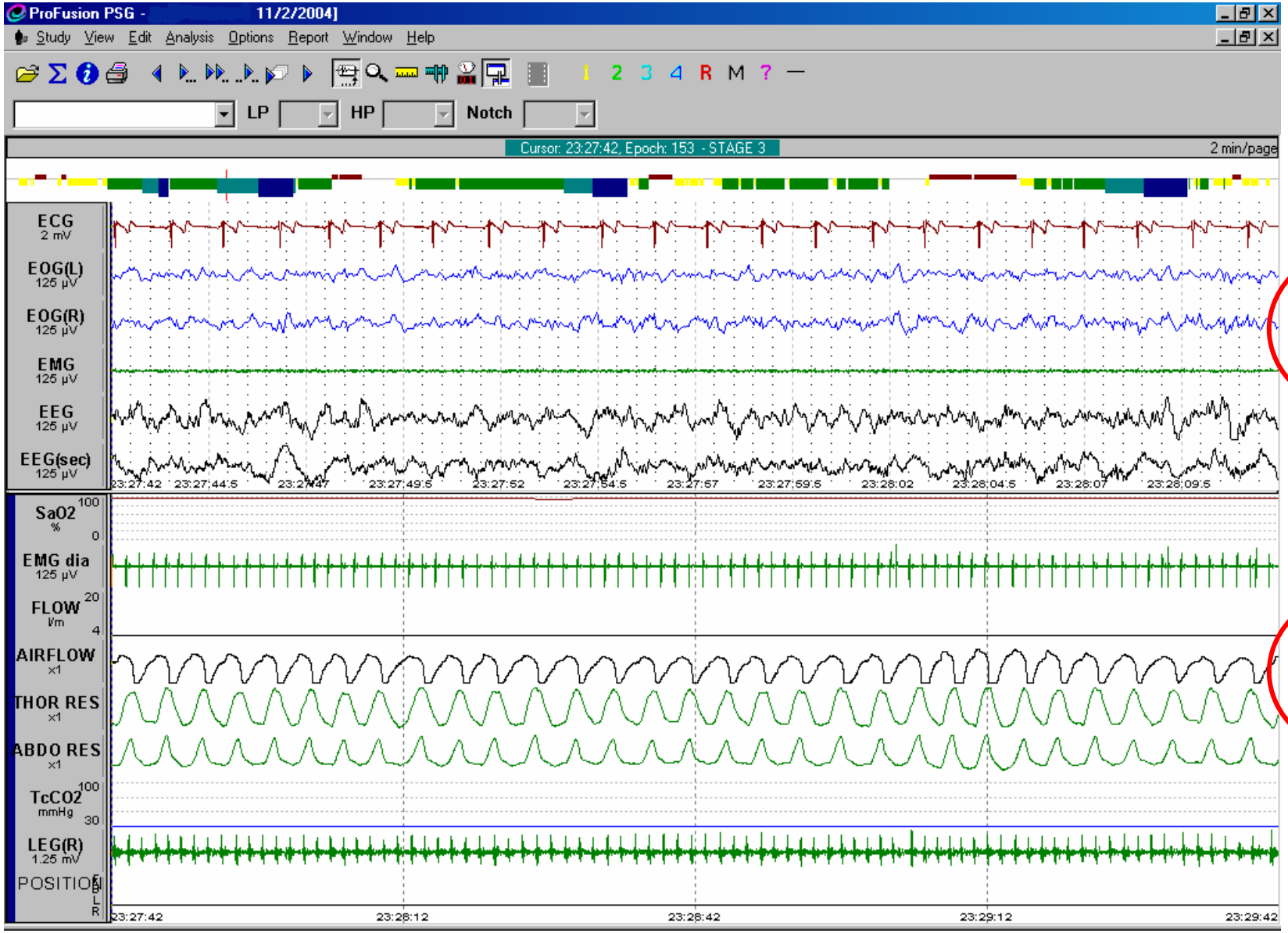
Rhythmic muscle activity, reflected in EEG/EOG channels

REM Behaviour Disorder



Increased EMG, reflected in EEG/EOG

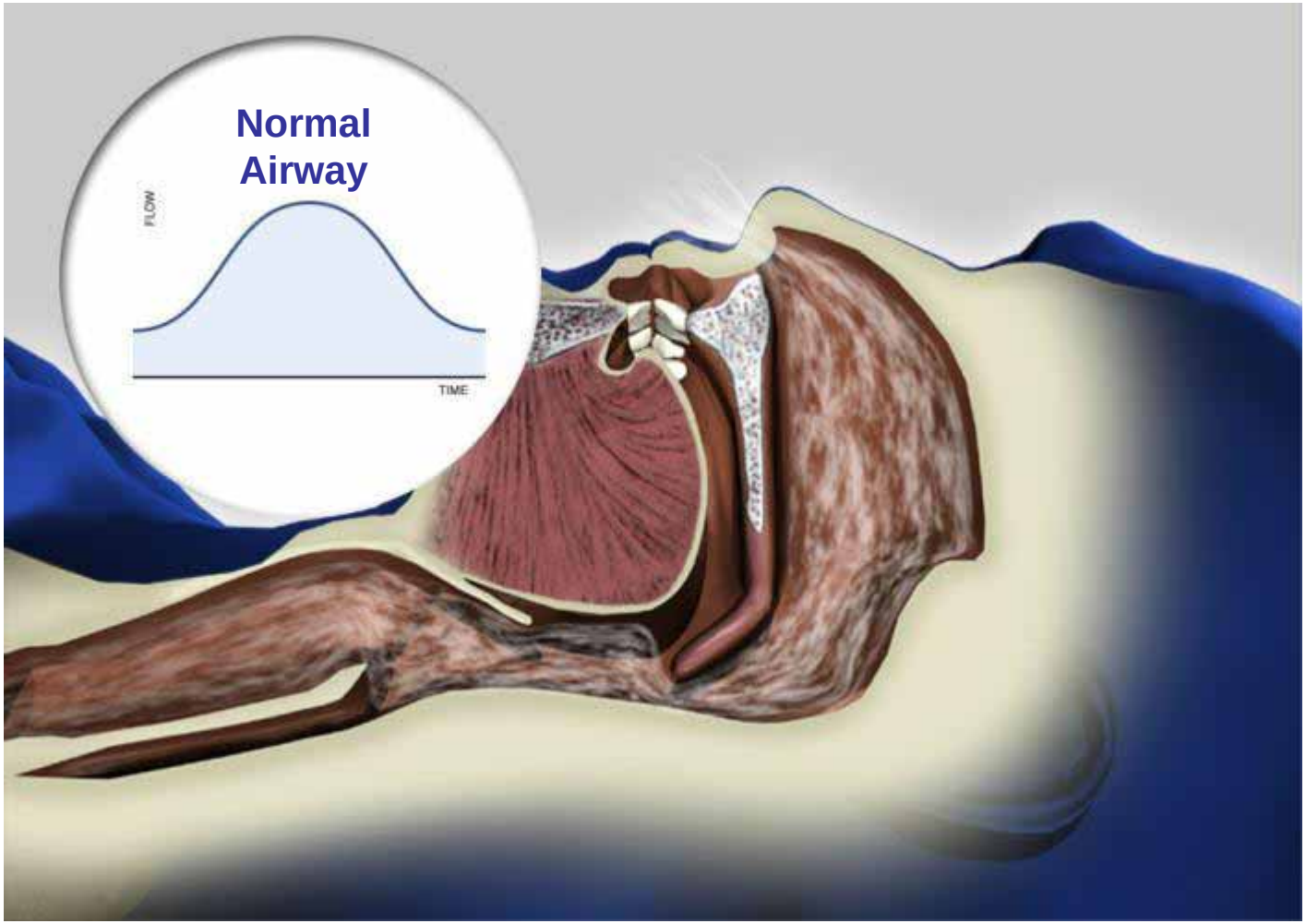
Diagnostic Sleep Study Signals



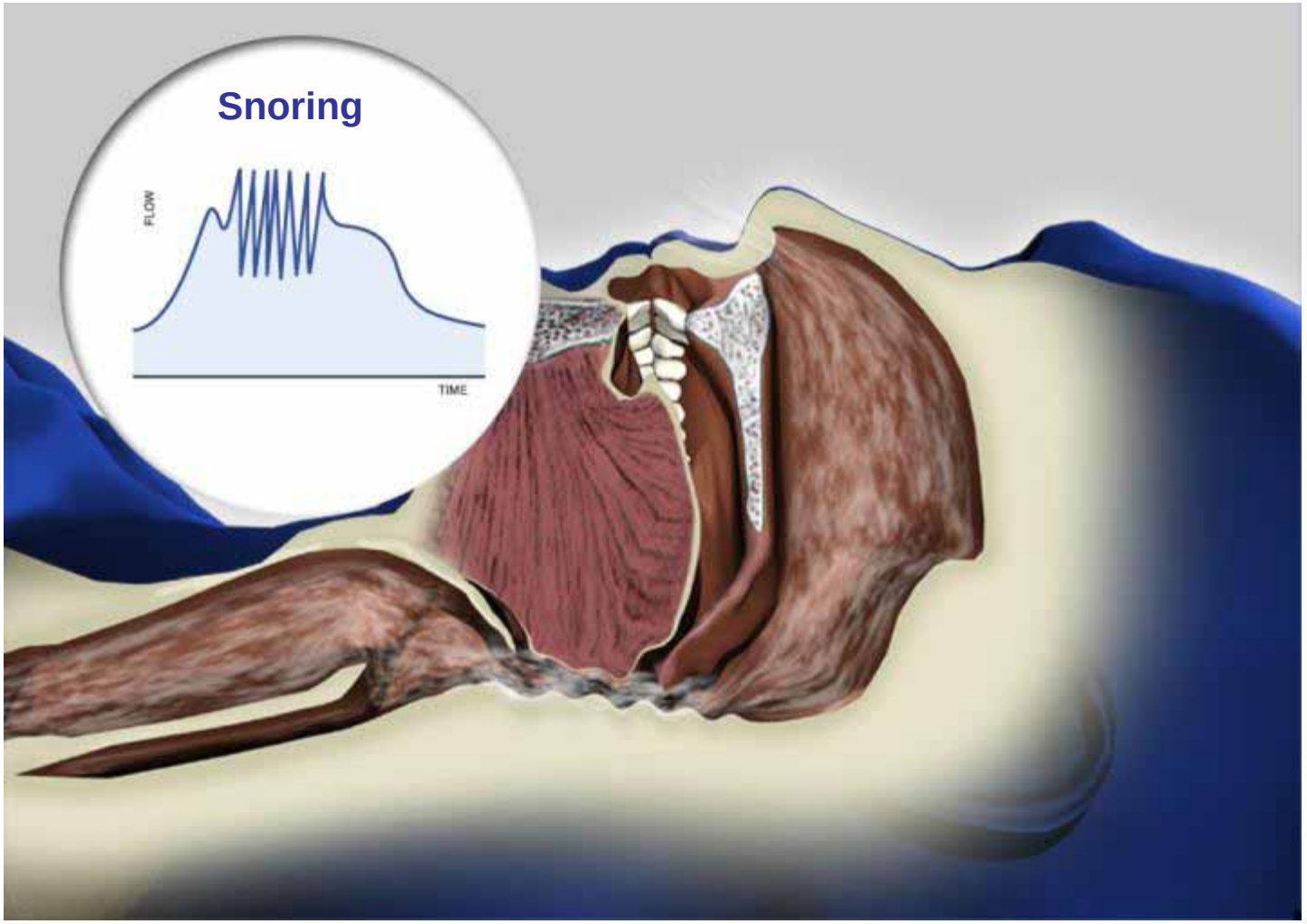
Upper Pane

Lower Pane

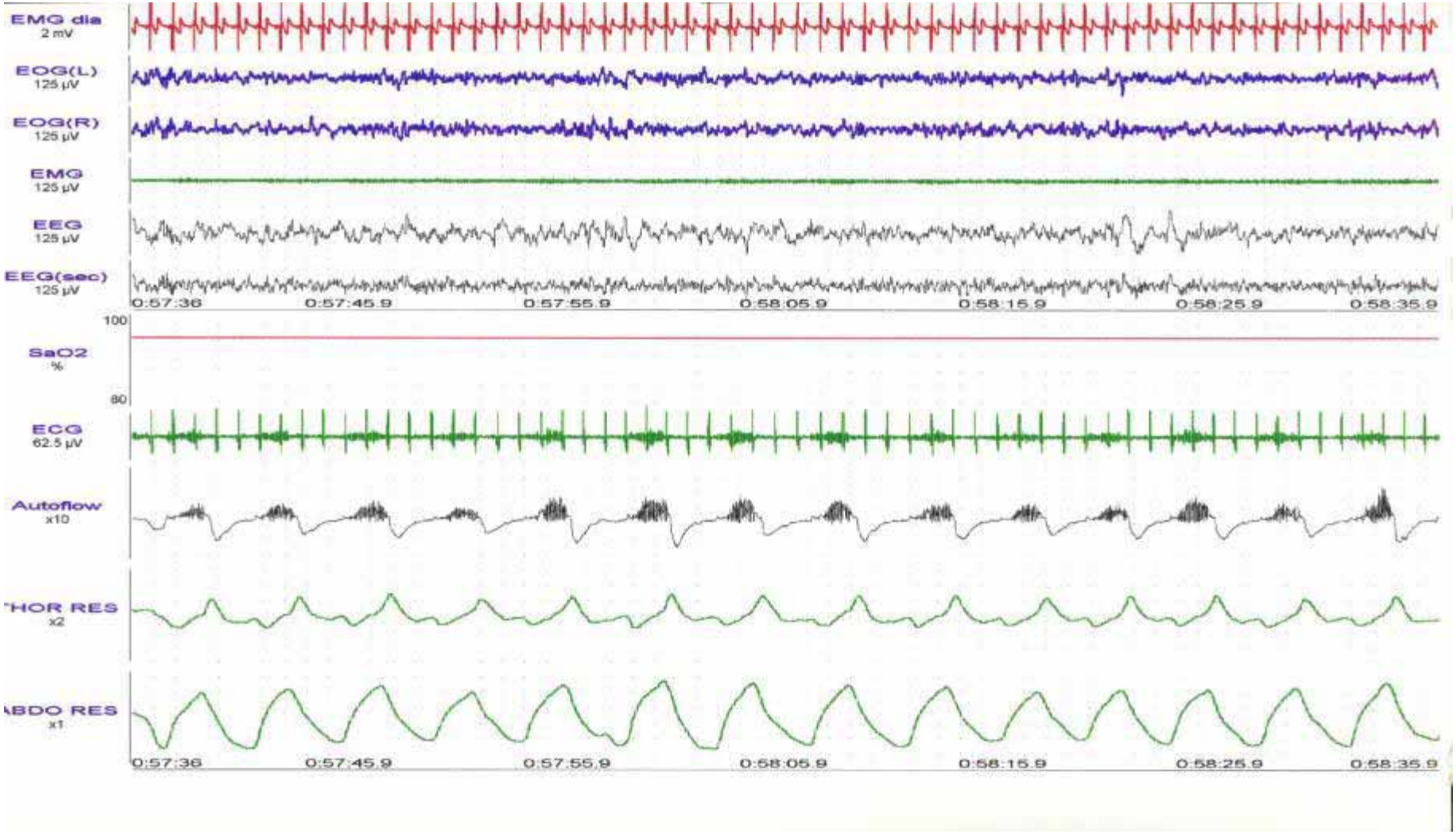
What happens when an individual has obstructive sleep apnoea?



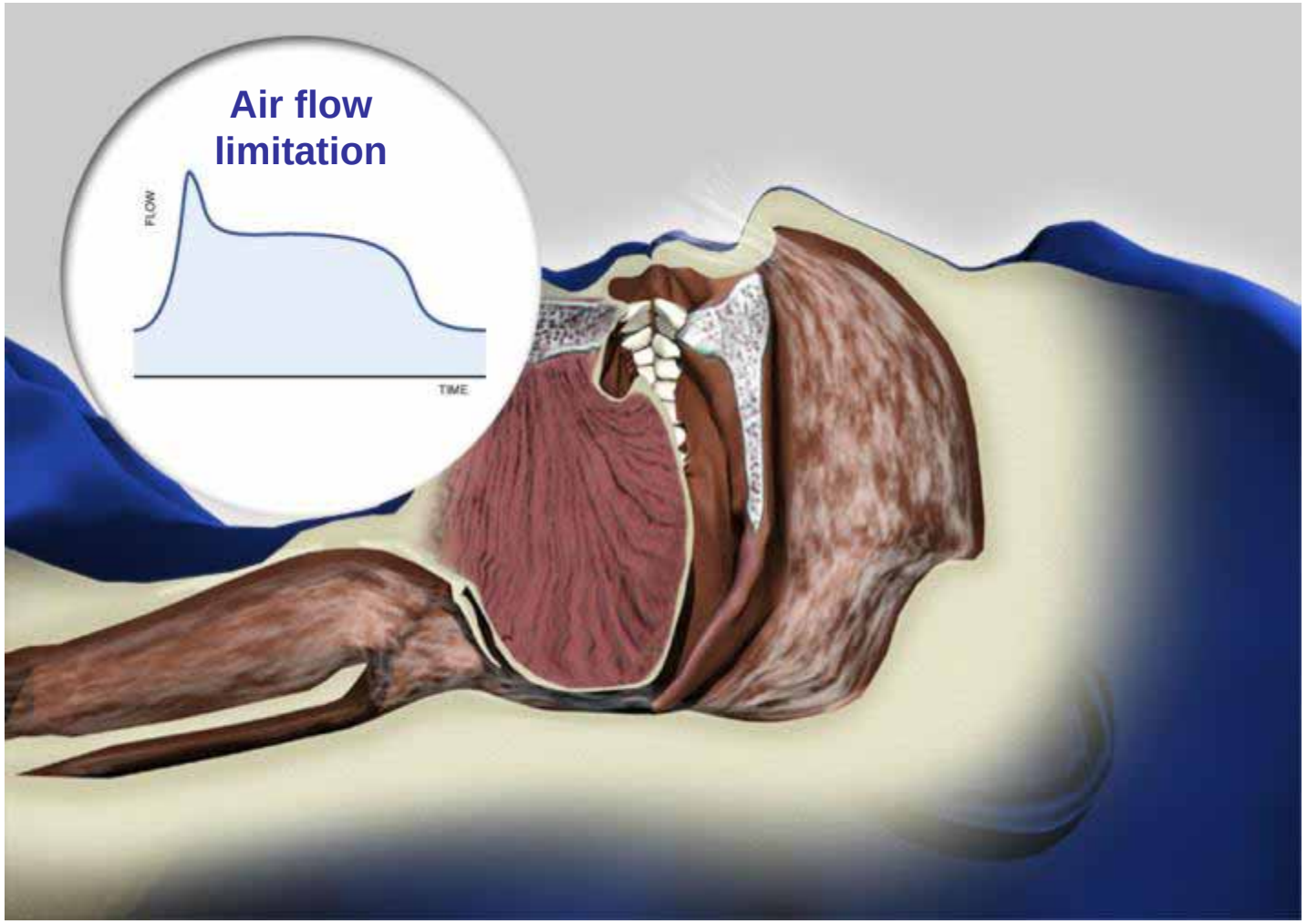
What happens when an individual has obstructive sleep apnoea?



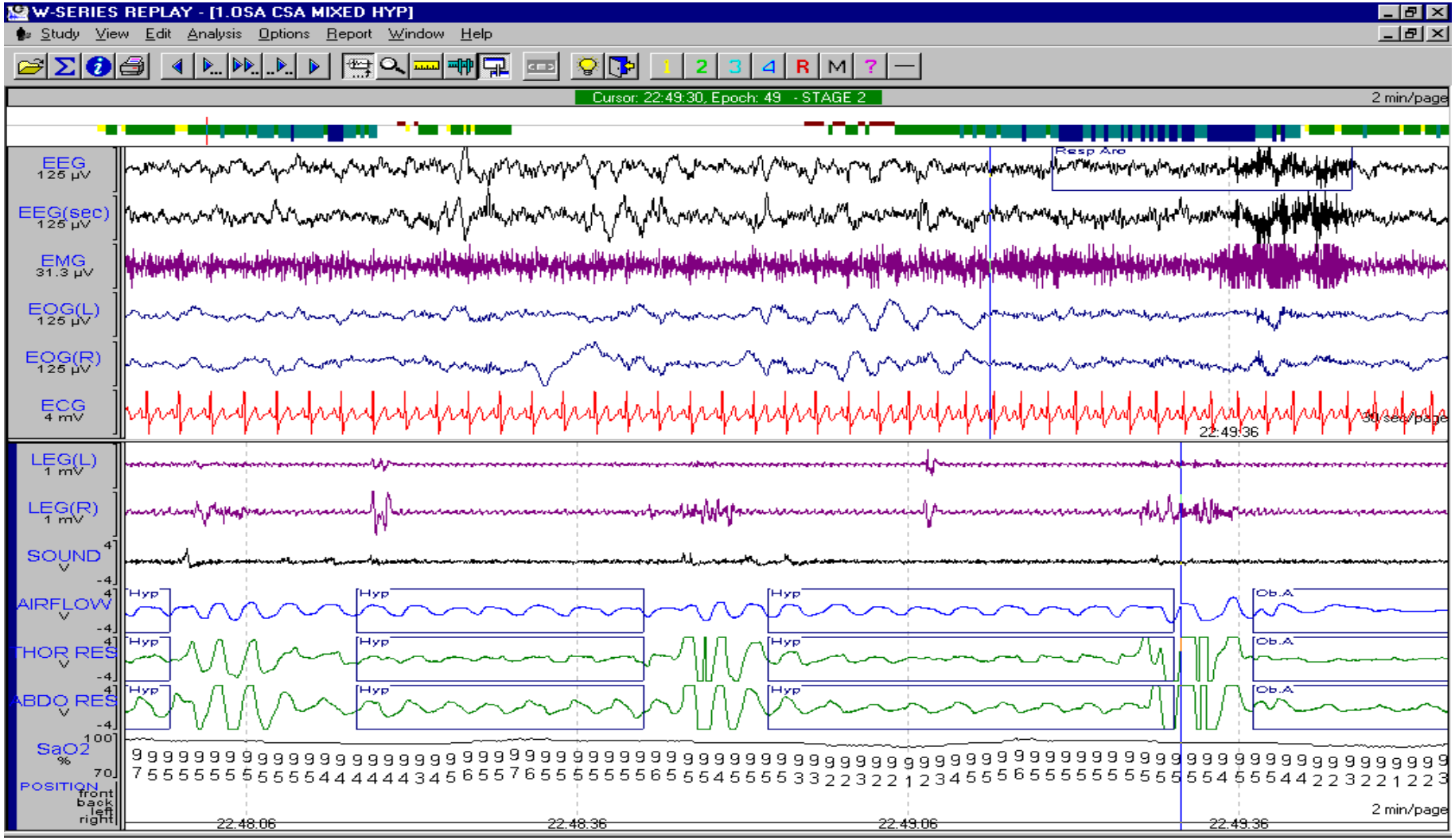
Snoring


EMG dia
2 mV
EOG(L)
125 µV
EOG(R)
125 µV
EMG
125 µV
EEG
125 µV
EEG(sec)
125 µV
0:57:36
0:57:45.9
0:57:55.9
0:58:05.9
0:58:15.9
0:58:25.9
0:58:35.9
100
SaO2
%
80
ECG
62.5 µV
Autoflow
x10
THOR RES
x2
ABDO RES
x1
0:57:36
0:57:45.9
0:57:55.9
0:58:05.9
0:58:15.9
0:58:25.9
0:58:35.9

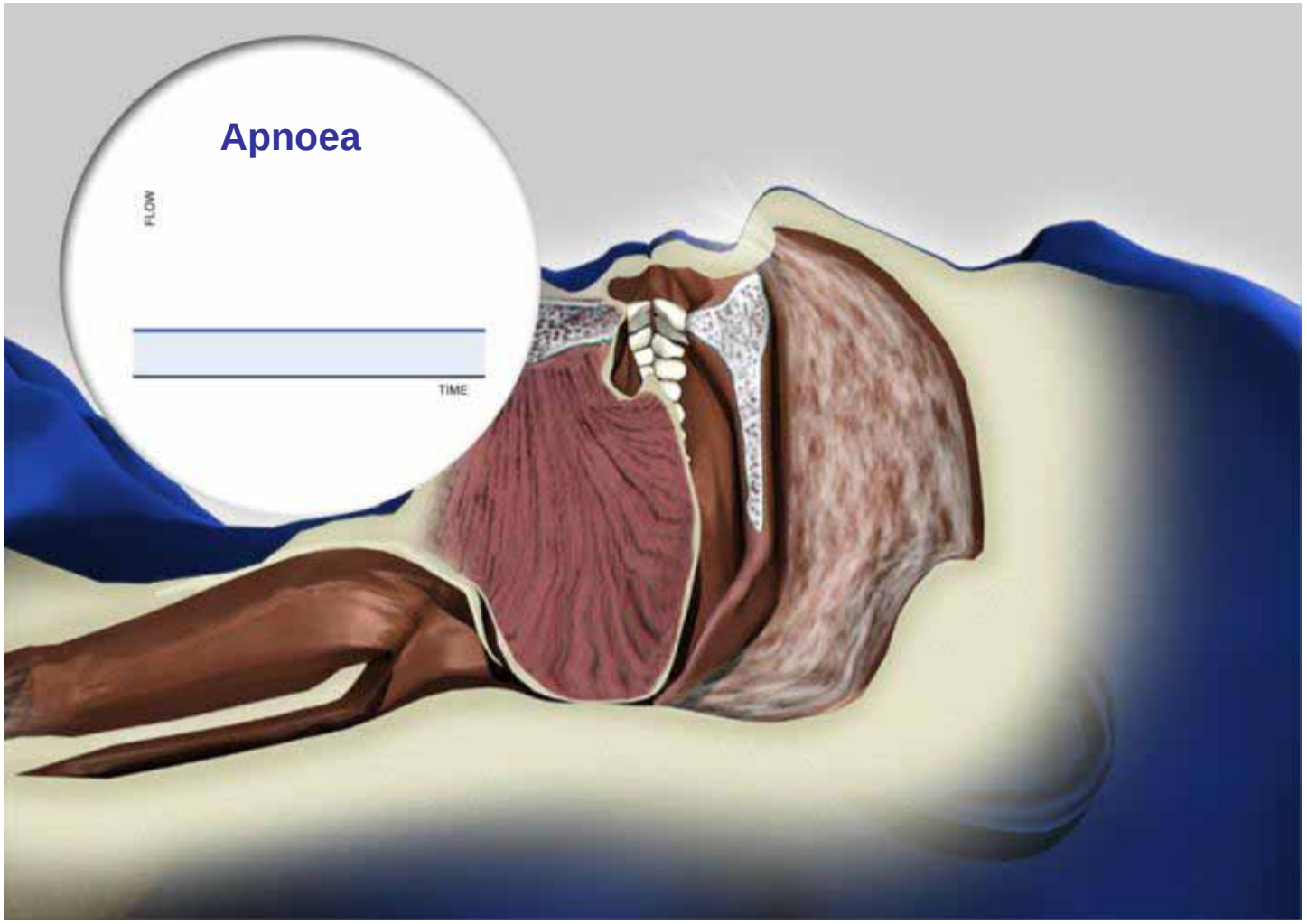
What happens when an individual has obstructive sleep apnoea?



Hypopnoea

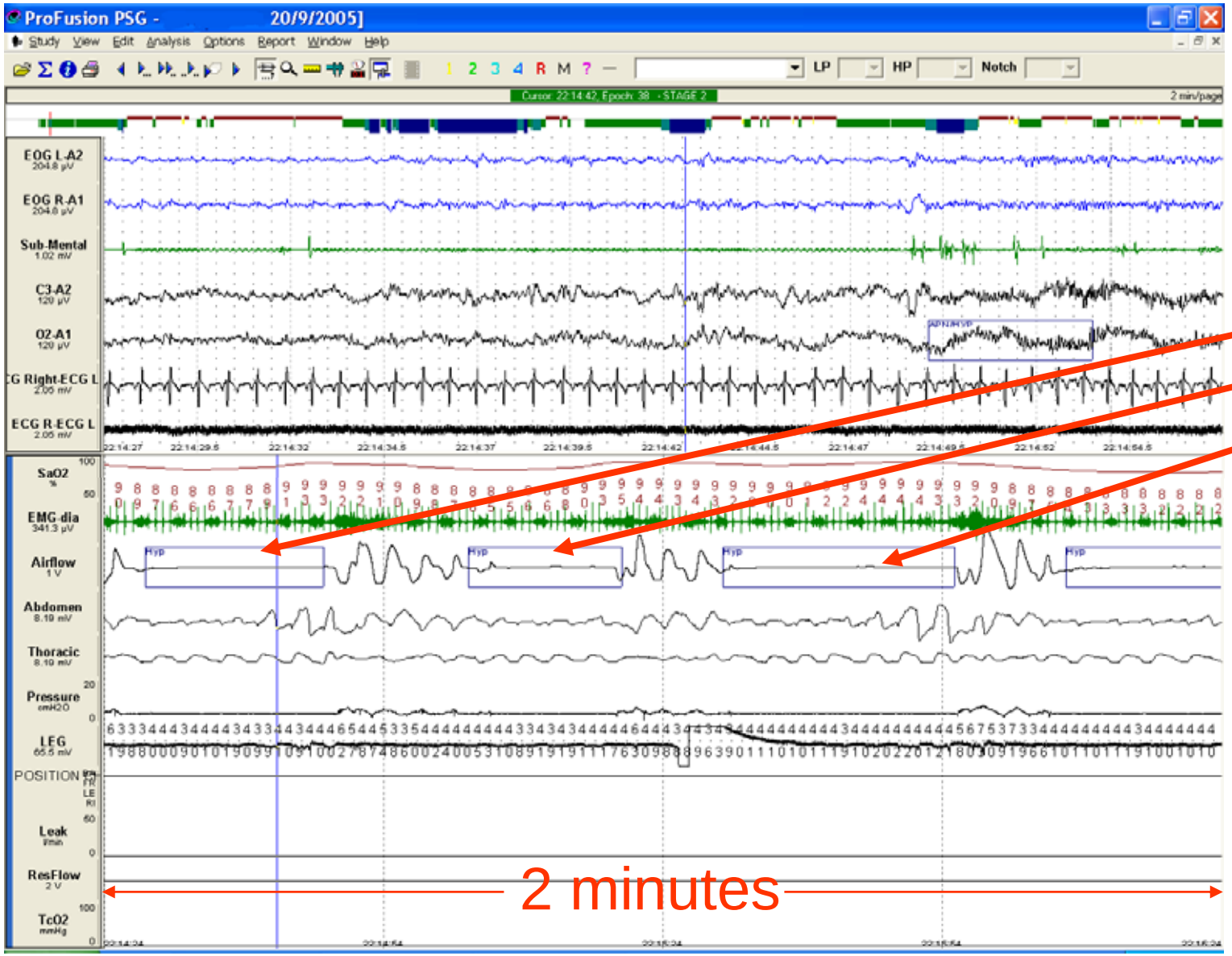

W-SERIES REPLAY - [1.OSA CSA MIXED HYP]
Study View Edit Analysis Options Report Window Help
Cursor: 22:49:30, Epoch: 49 - STAGE 2
2 min/page
EEG 125 µV
EEG(sec) 125 µV
EMG 31.3 µV
EOG(L) 125 µV
EOG(R) 125 µV
ECG 4 mV
Resp Aro
22:49:36
30 sec/page
LEG(L) 1 mV
LEG(R) 1 mV
SOUND
AIRFLOW
THOR RES
ABDO RES
Hyp
Ob.A
SaO2 %
POSITION
front
back
left
right
22:48:06
22:48:36
22:49:06
22:49:36
2 min/page

What happens when an individual has obstructive sleep apnoea?

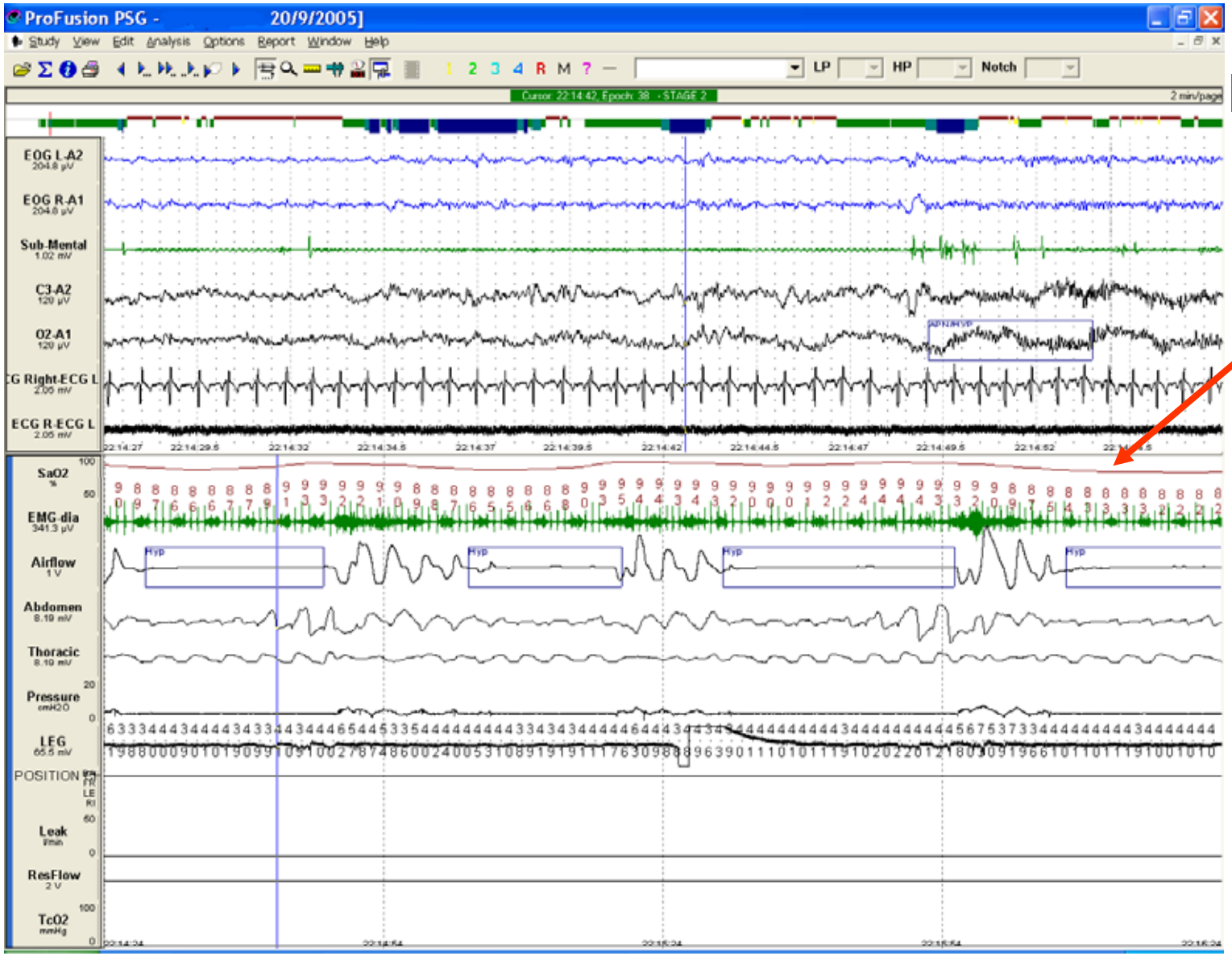


What happens when an individual has obstructive sleep apnoea?

Obstructive Sleep Apnoea

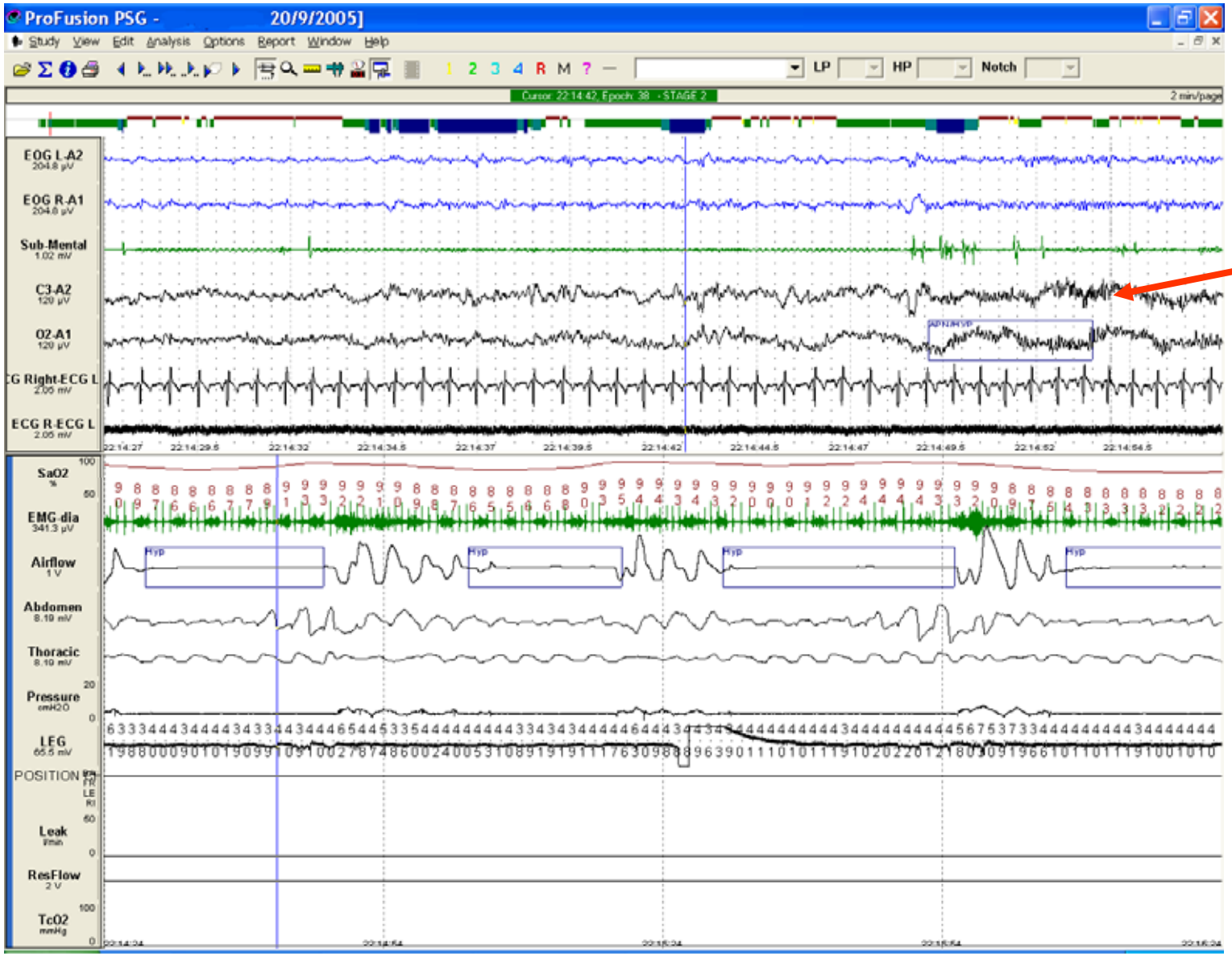


Obstructive Sleep Apnoea



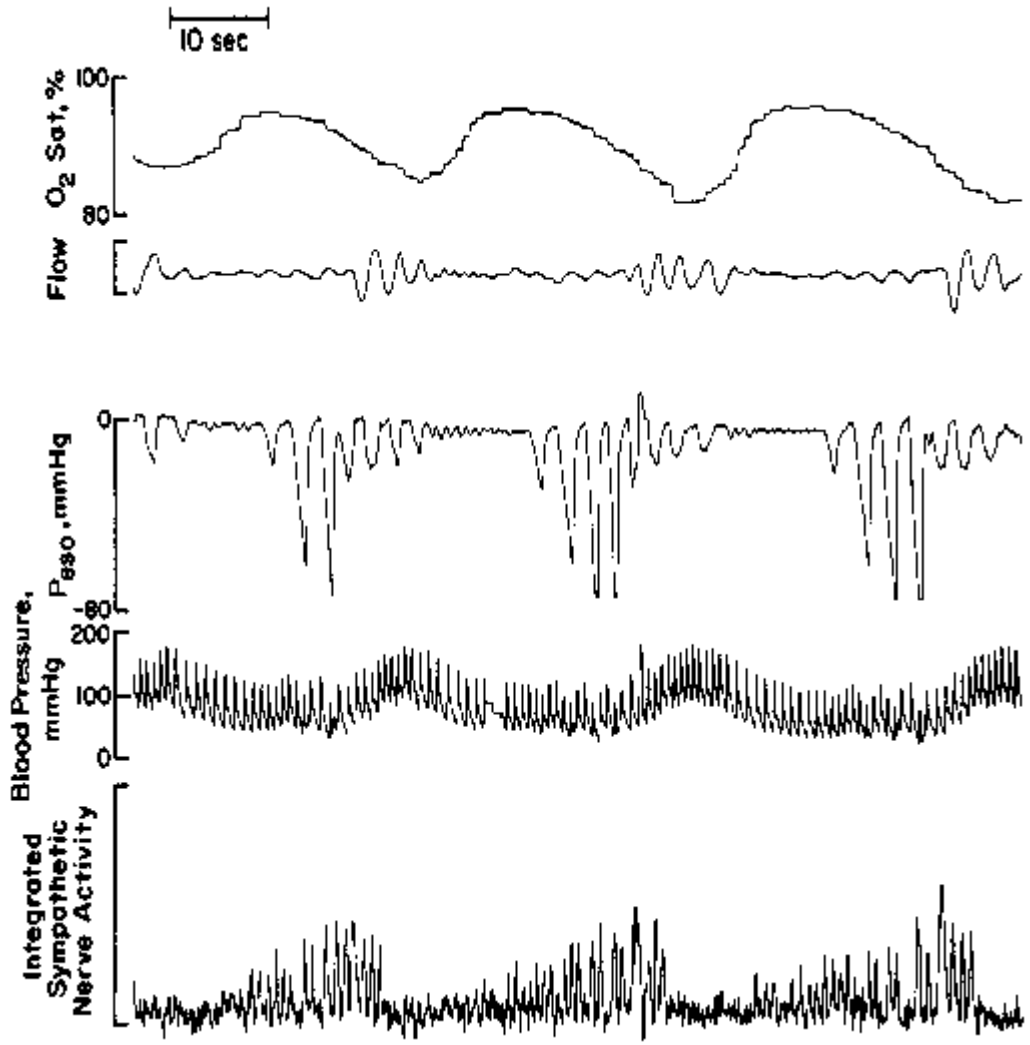
Drop in oxygen level to 82% (normal >95%) as a result of the obstructed airway

Obstructive Sleep Apnoea



Arousal from sleep due to obstruction and brain stimulating patient to breathe

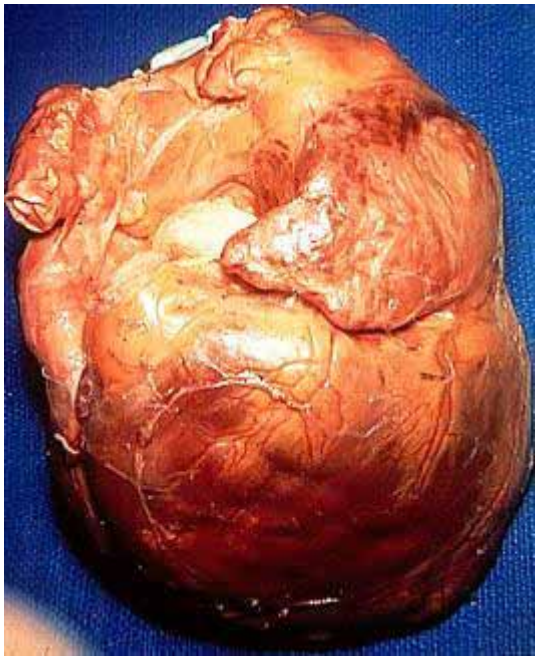
What happens when an individual obstructs?



Morgan et al, 1996.

OSA haemodynamic and autonomic effects

Effects of obstructive sleep apnoea



Hypertension

Coronary artery disease

Congestive heart failure

Transient Ischaemic Attacks/ Cerebrovascular Accidents

Atrial Fibrillation

Type 2 Diabetes/ Insulin resistance

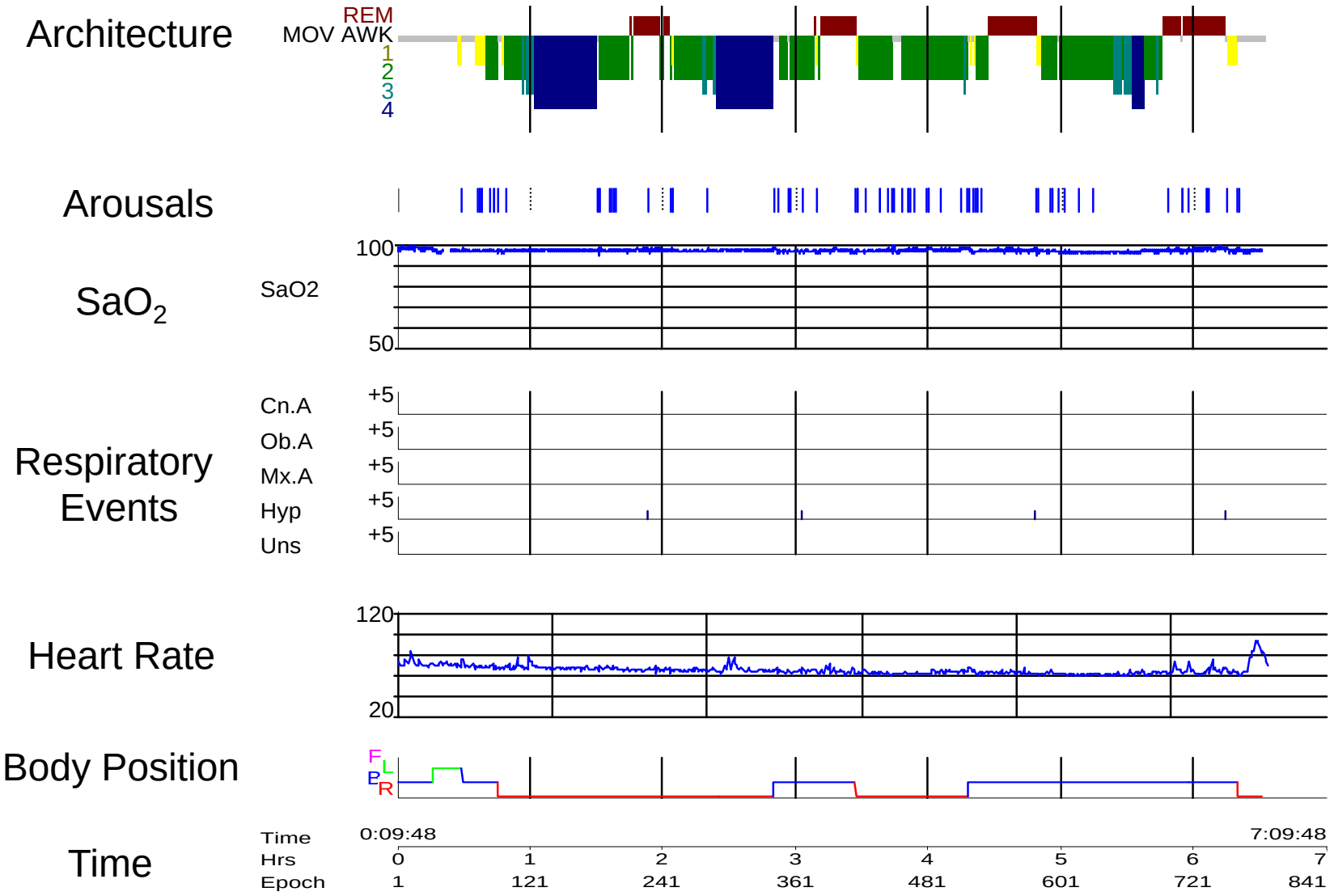
Severity of Obstructive Sleep Apnoea

Total number of complete cessations (apnoea) and partial obstructions (hypopnoeas) of breathing occurring per hour of sleep. These pauses in breathing must last for 10 seconds and are associated with a decrease in oxygenation of the blood.

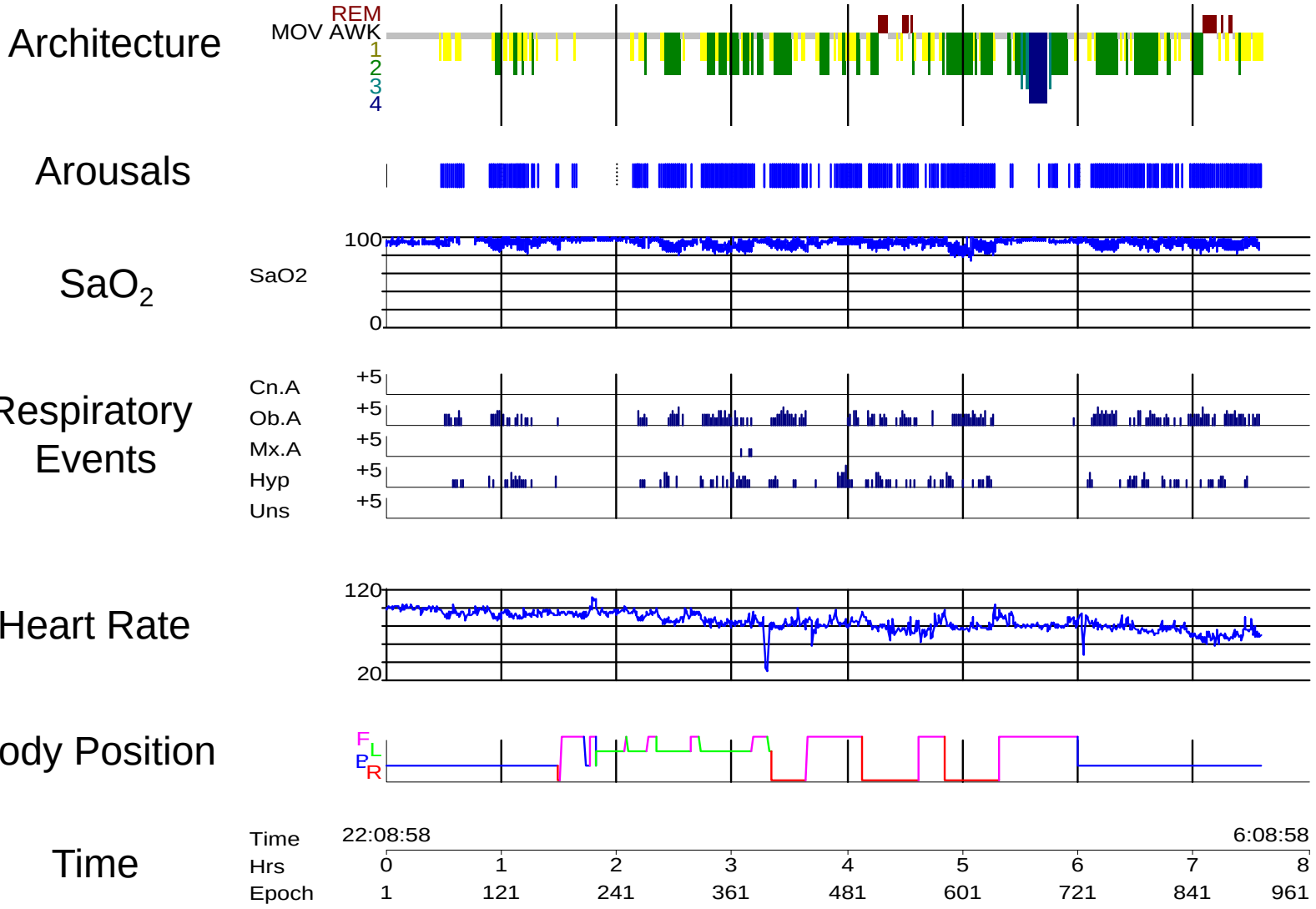
Respiratory Disturbance Index (RDI)	**<5 /hr**	**Normal**
	5-14 /hr	**Mild**
	15-30 /hr	**Moderate**
	> 30 /hr	**Severe**

Severe patients can obstruct over 150 times per hour (over 1000 times per night).

The Sleep Report – Normal Study



The Sleep Report – Obstructive Sleep Apnoea

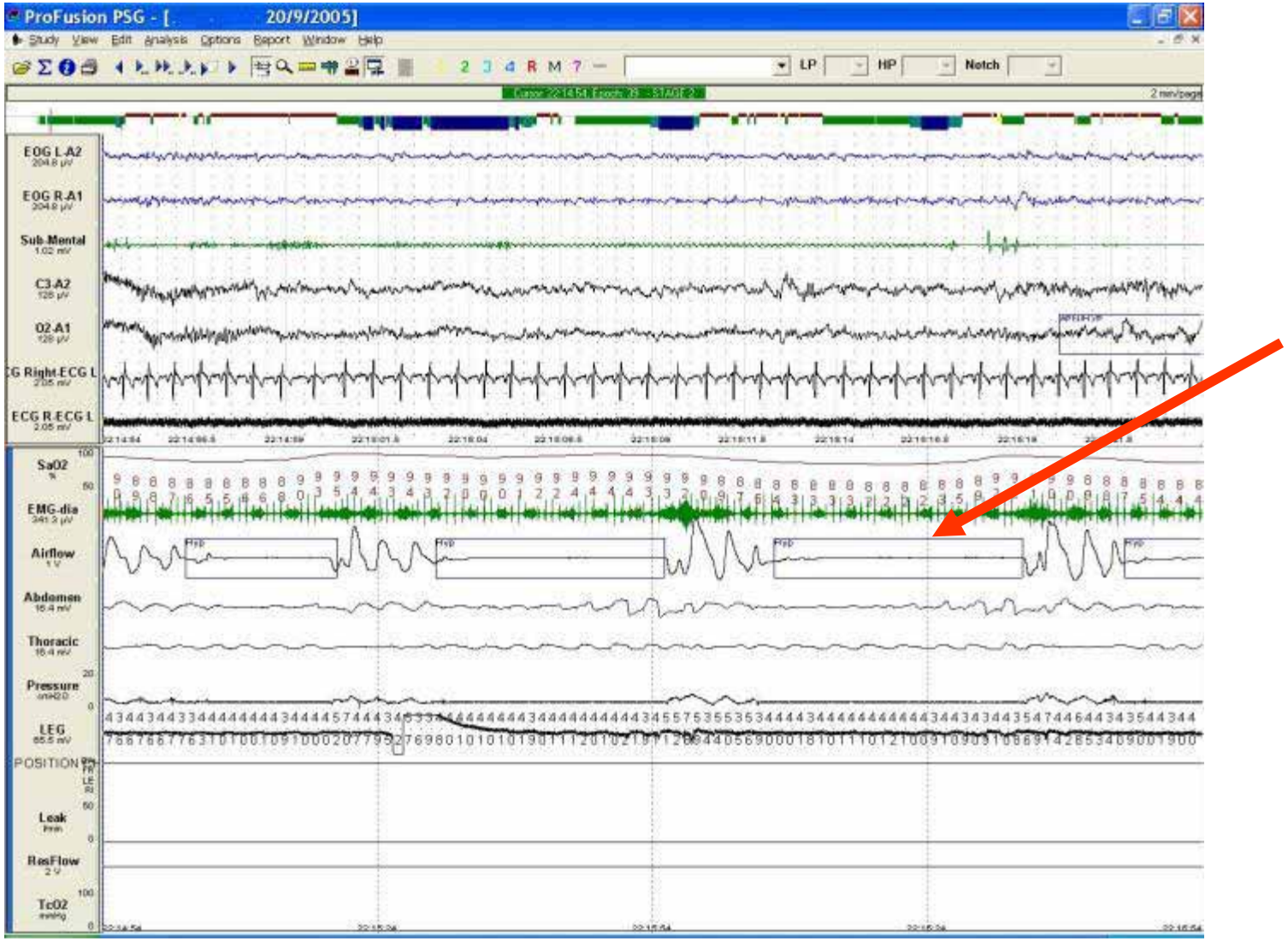


CPAP – Continuous Positive Airway Pressure

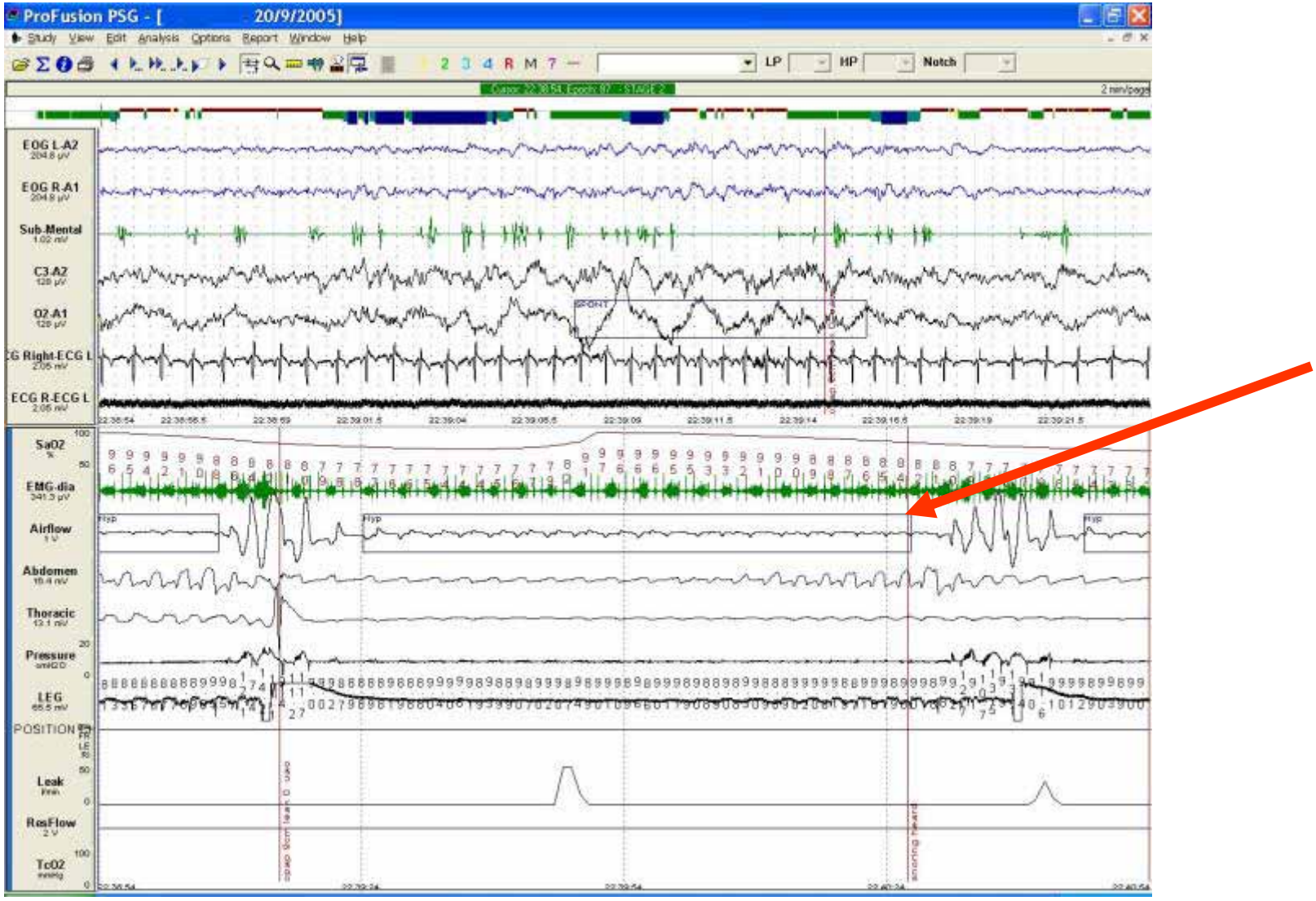
- Considered Gold Standard treatment for Obstructive Sleep Apnoea.
- Air passes through a mask into the patient's nose and/or mouth, and into the throat, where the slight pressure acts as a splint to keep the patient's airway open and prevent obstruction.

CPAP – Continuous Positive Airway Pressure Titration PSG

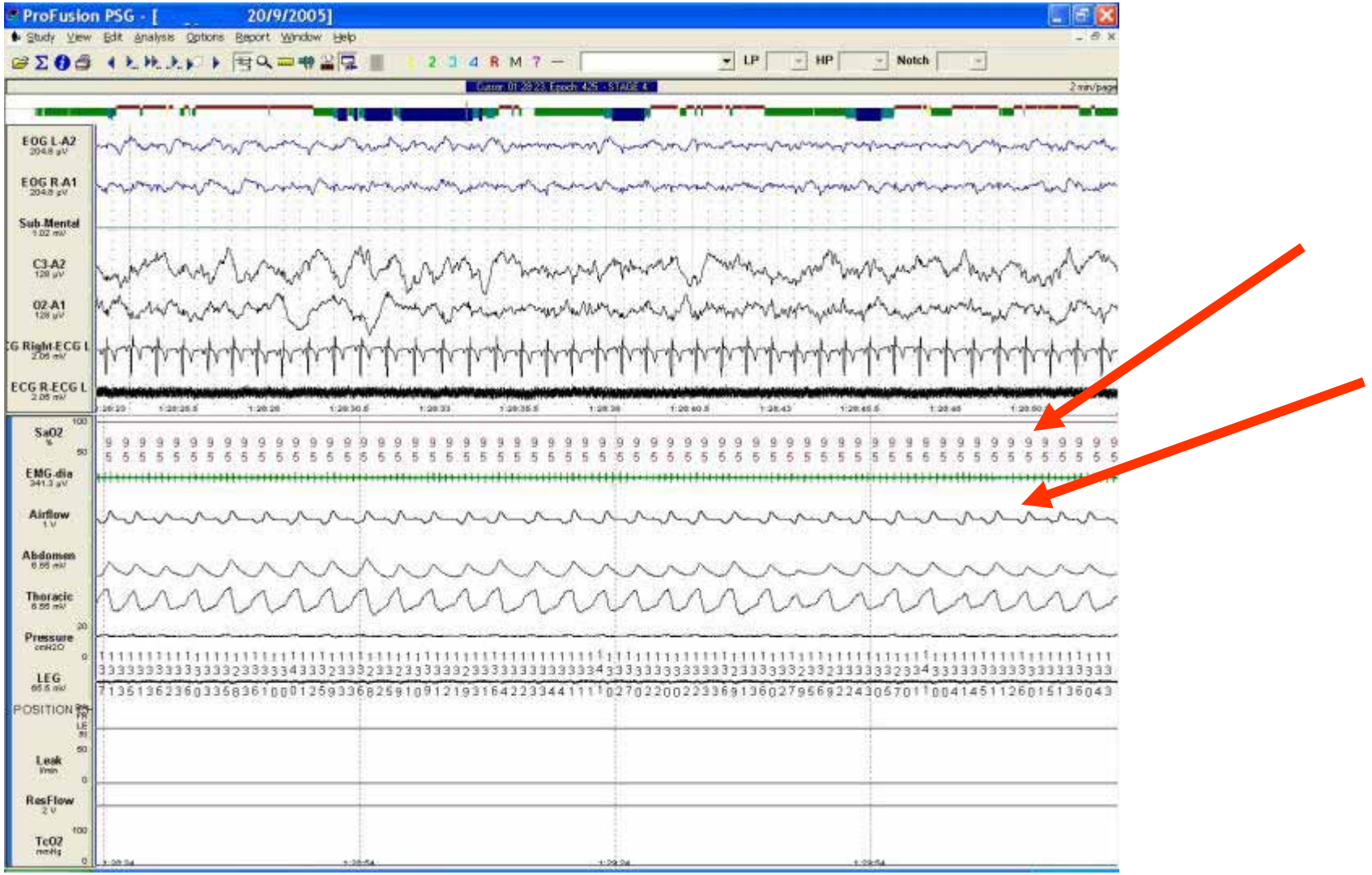
CPAP pressure titration PSG: At 2214hrs the patient is obstructing on 4cm.



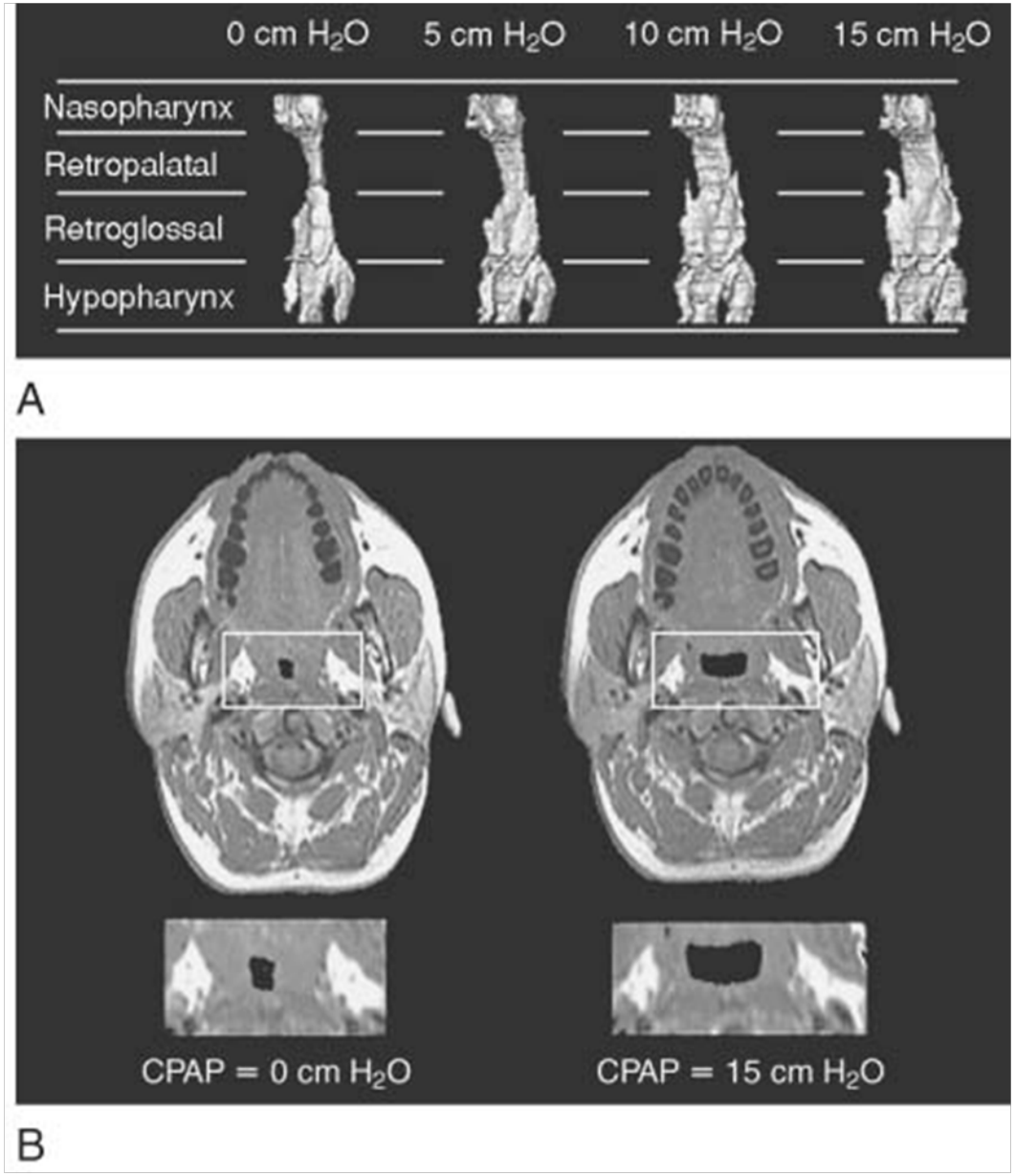
CPAP pressure titration PSG:
At 2238hrs patient continues to obstruct, pressure is increased to 8cm and then 9cm.



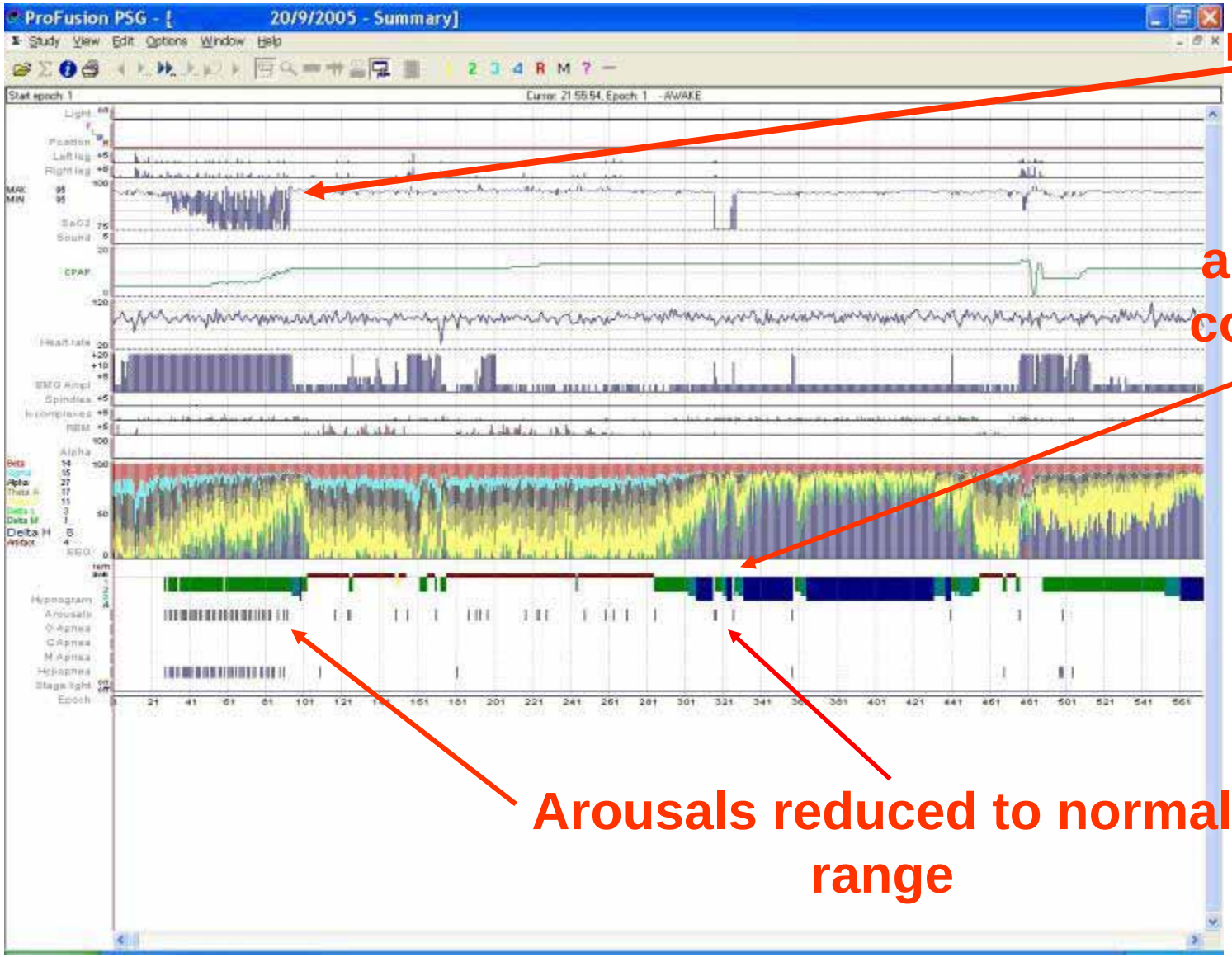
CPAP pressure titration PSG:
At 0128hrs on 13cm in SWS, consistent airflow shape and normal oxygen level.



CPAP Works - Airway CT Scan



CPAP pressure titration PSG: Entire night summary

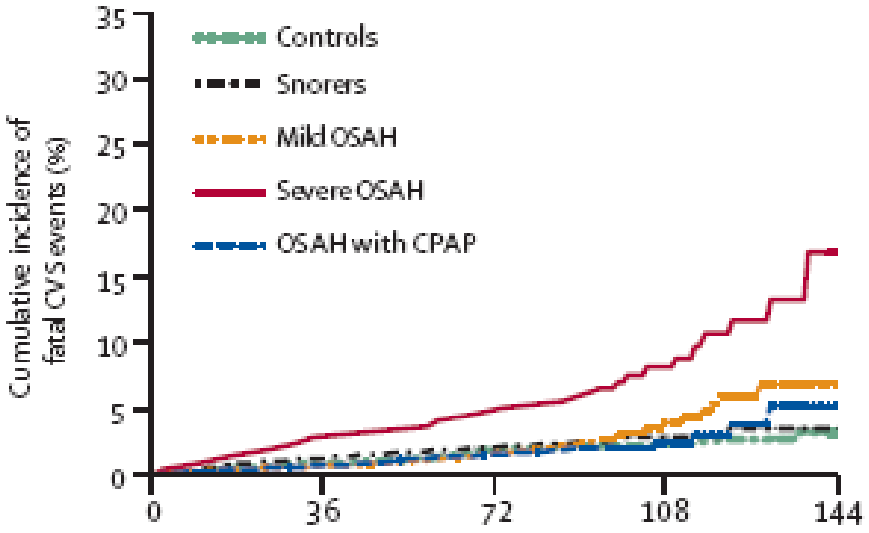


Optimal oxygenation maintained

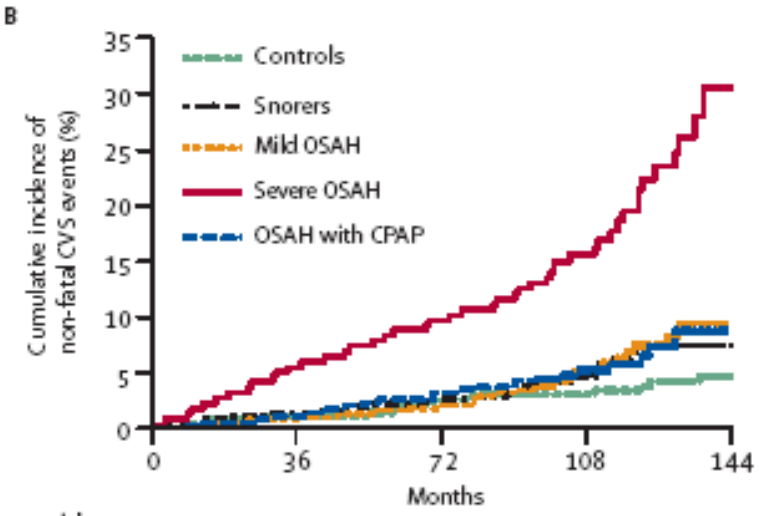
Sleep architecture consolidated

Arousals reduced to normal range

Effects of OSA and CPAP



Marin et al, Lancet 2005

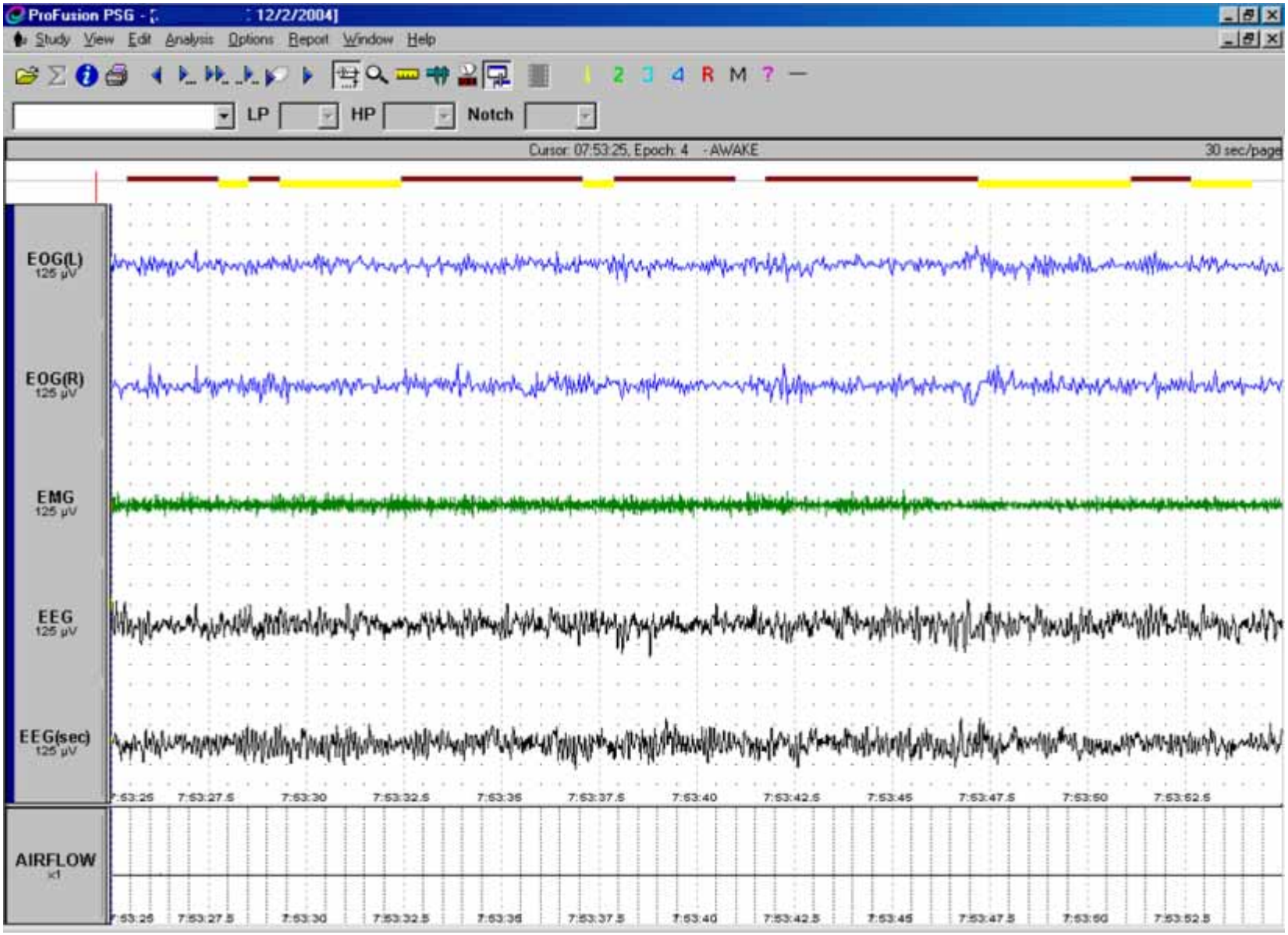


Numbers at risk				
Controls	264	262	259	258
Snorers	377	372	361	232
Mild OSAH	403	401	392	264
Severe OSAH	235	229	221	167
OSAH with CPAP	372	364	361	229

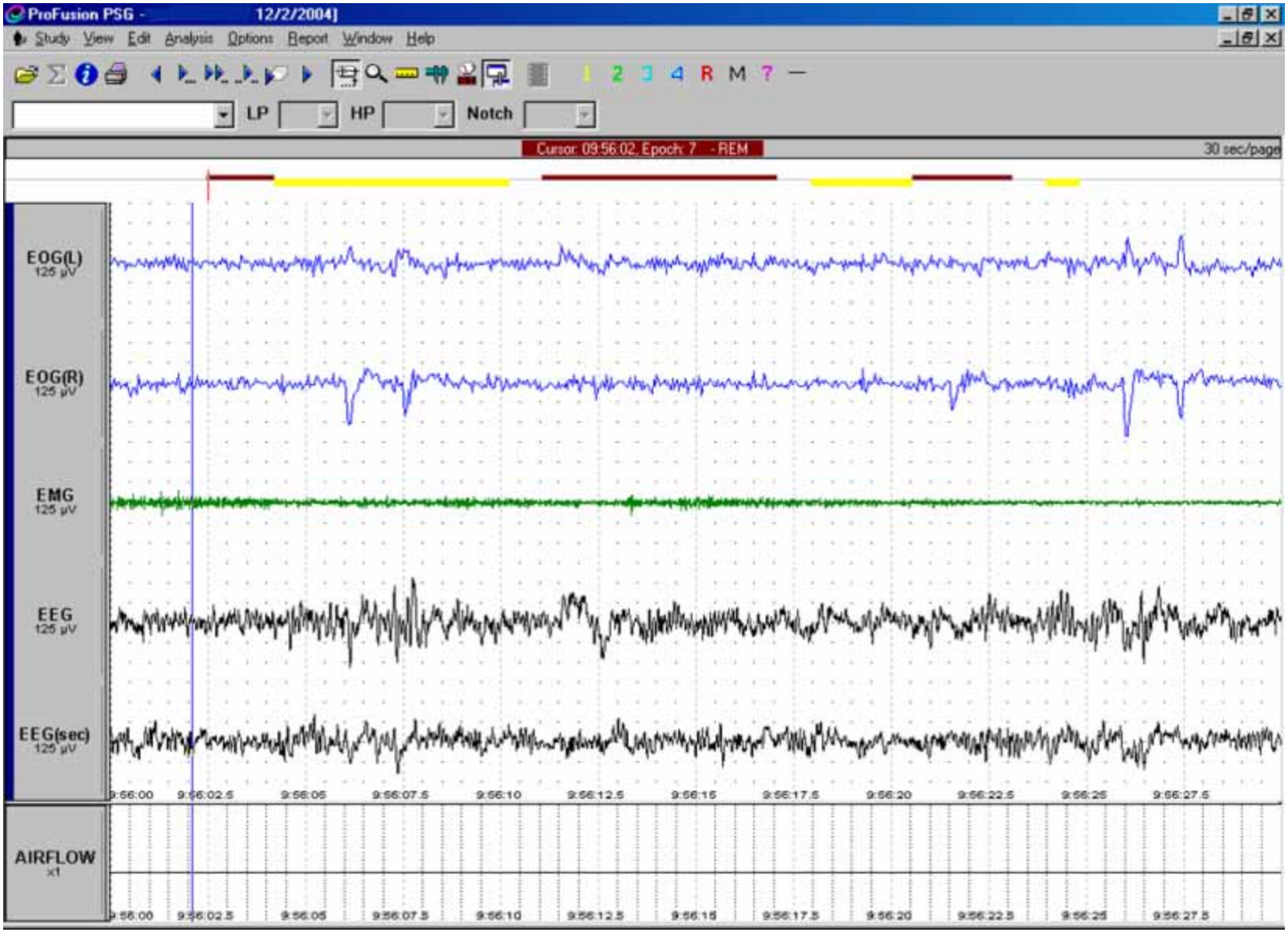
Daytime PSG – Multiple Sleep Latency Test (MSLT)

- Measures the rapidity of the patient falling asleep
- Conducted the day after a Diagnostic Study
- Subject while lying down is asked to sleep (20 minutes)
- If the patient falls asleep in 20 minutes, he is given another 15 minutes to get into REM stage
- Measures Sleep Latency (time taken to fall asleep) Measure REM Latency
- Important in the diagnosis and confirmation of Narcolepsy
- Repeated 5 times every 2 hours throughout the day

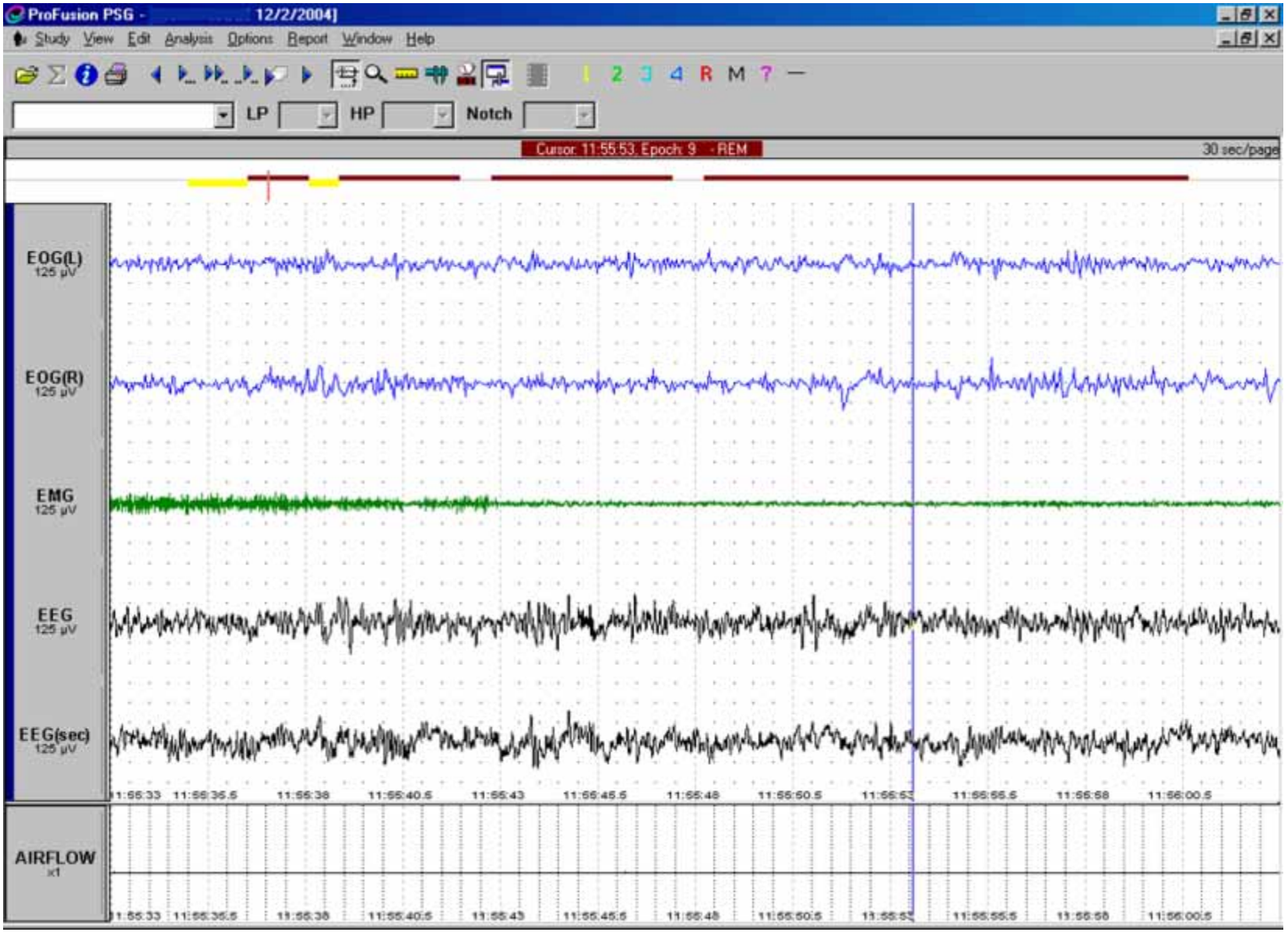
MSLT – Nap 1


ProFusion PSG - [: 12/2/2004]
Study View Edit Analysis Options Report Window Help
LP HP Notch
Cursor: 07:53:25, Epoch: 4 - AWAKE
30 sec/page
EOG(L)
125 µV
EOG(R)
125 µV
EMG
125 µV
EEG
125 µV
EEG(sec)
125 µV
AIRFLOW
x1
7:53:25 7:53:27.5 7:53:30 7:53:32.5 7:53:35 7:53:37.5 7:53:40 7:53:42.5 7:53:45 7:53:47.5 7:53:50 7:53:52.5

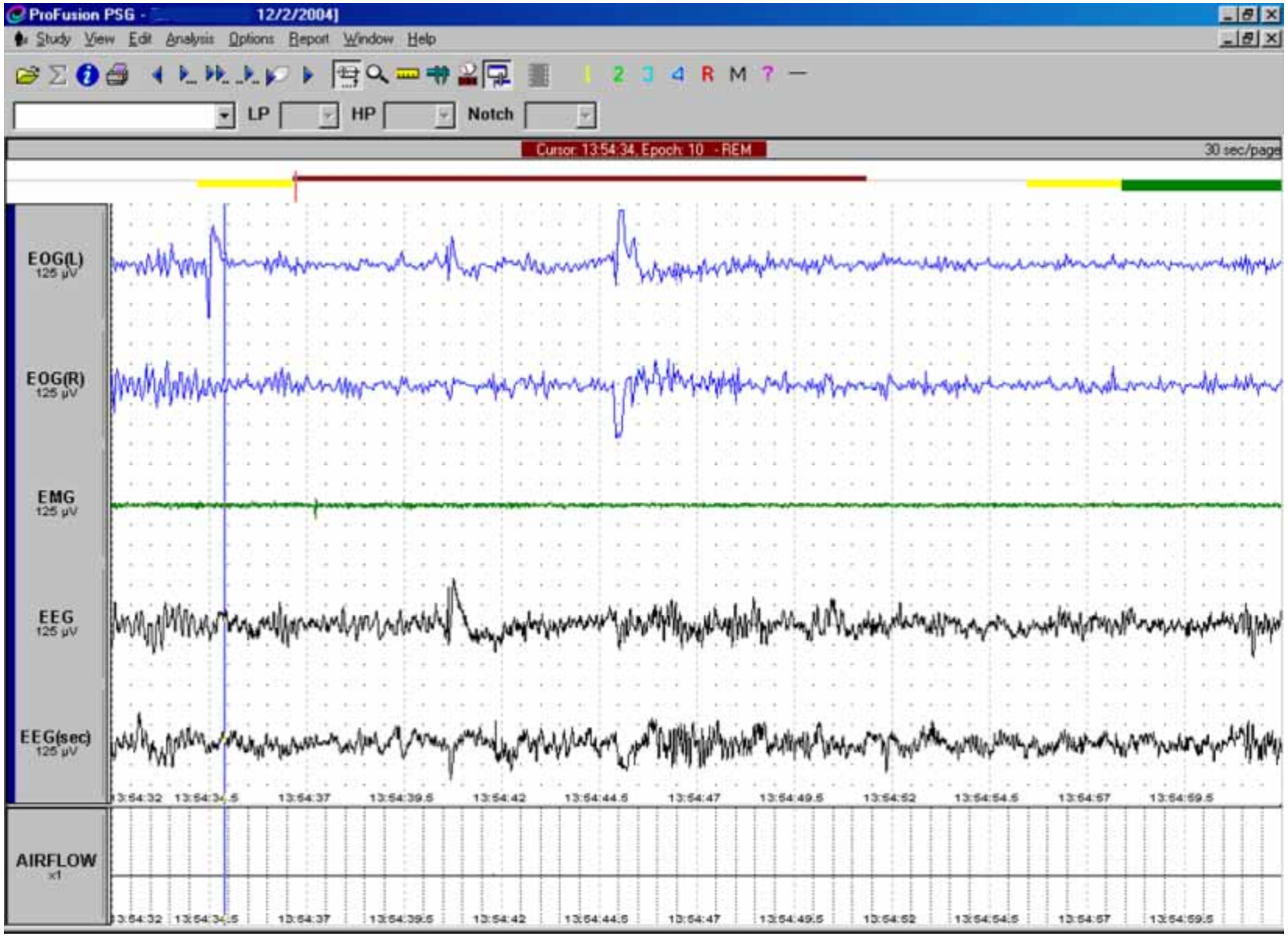
MSLT – Nap 2


ProFusion PSG - 12/2/2004]
Study View Edit Analysis Options Report Window Help
LP HP Notch
Cursor: 09:56:02, Epoch: 7 - REM
30 sec/page
EOG(L)
125 µV
EOG(R)
125 µV
EMG
125 µV
EEG
125 µV
EEG(sec)
125 µV
9:56:00 9:56:02.5 9:56:05 9:56:07.5 9:56:10 9:56:12.5 9:56:15 9:56:17.5 9:56:20 9:56:22.5 9:56:25 9:56:27.5
AIRFLOW
x1

MSLT – Nap 3


ProFusion PSG - 12/2/2004]
Study View Edit Analysis Options Report Window Help
LP HP Notch
Cursor 11:55:53 Epoch: 9 - REM
30 sec/page
EOG(L)
125 µV
EOG(R)
125 µV
EMG
125 µV
EEG
125 µV
EEG(sec)
125 µV
AIRFLOW
x1

MSLT – Nap 4


ProFusion PSG - 12/2/2004]
Study View Edit Analysis Options Report Window Help
LP HP Notch
Cursor 13:54:34, Epoch: 10 - REM
30 sec/page
EOG(L)
125 µV
EOG(R)
125 µV
EMG
125 µV
EEG
125 µV
EEG(sec)
125 µV
AIRFLOW
x1

Multiple Sleep Latency Test

MEAN SLEEP LATENCY	REM ONSETS (in 5 naps)
10-15 min MILD	0-1 NORMAL
5-10 min MODERATE	≥ 2 ABNORMAL
< 5 min SEVERE	

Diagnosis of Narcolepsy = mean sleep latency < 10 mins with 2 or more REM periods in any of the naps

Conclusion

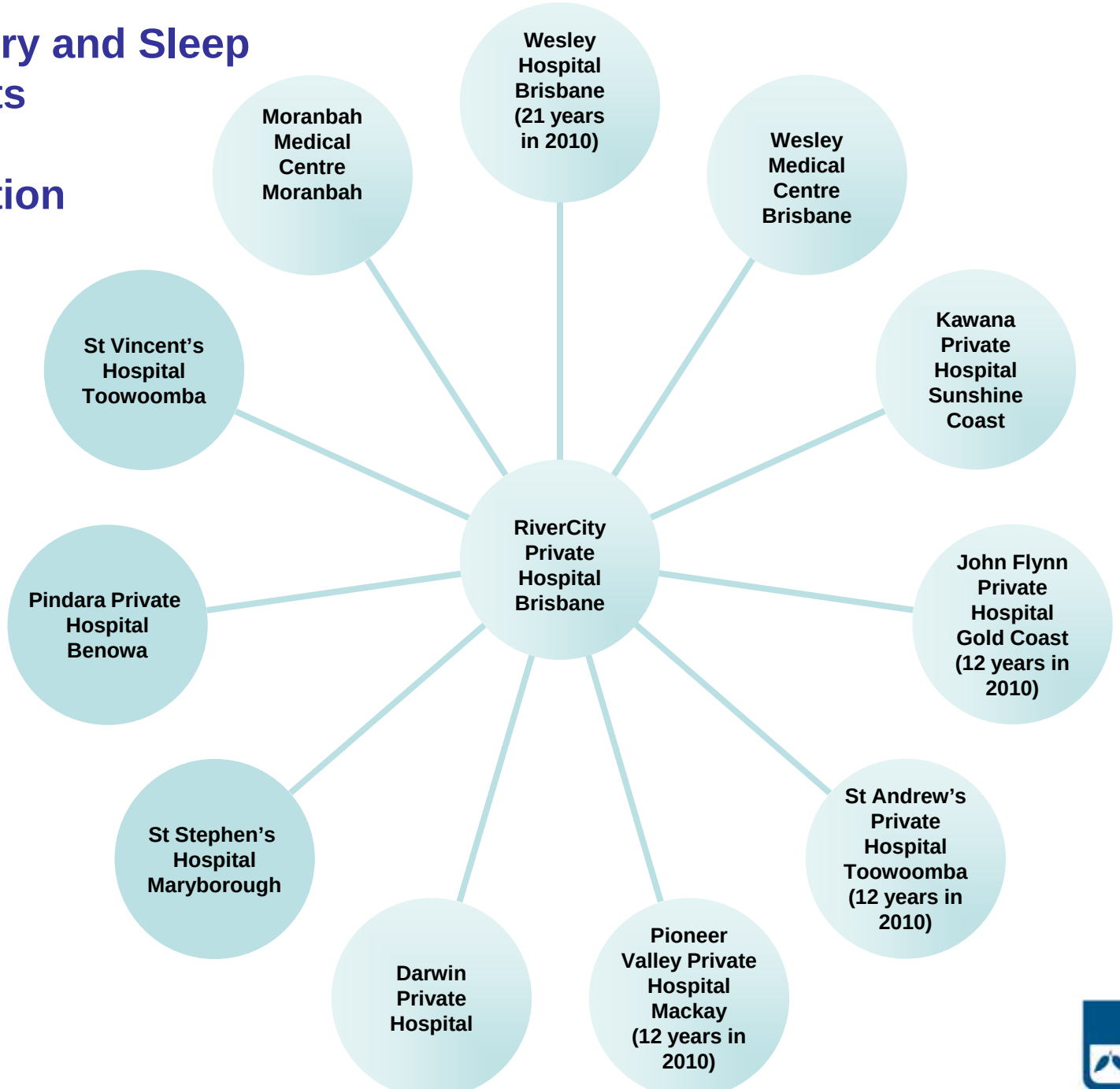
- **Polysomnography (PSG) can be viewed as an important adjunct to existing fatigue management training and subjective and other physiologic measures of sleepiness.**
- **PSG is an objective measure of sleepiness, sleep quality and sleep quantity in addition to other variables.**
- **PSG permits the medical diagnosis of an underlying sleep disorder.**

Conclusion

- Not all Portable (Home) sleep study devices and sleep services in Australia meet current Medicare guidelines.
- Not all sleep services will provide local access to a Sleep Physician for consultation.
- Not all sleep services will be able to perform all of these tests.
- Not all sleep services will provide ongoing support for patients commencing treatment.

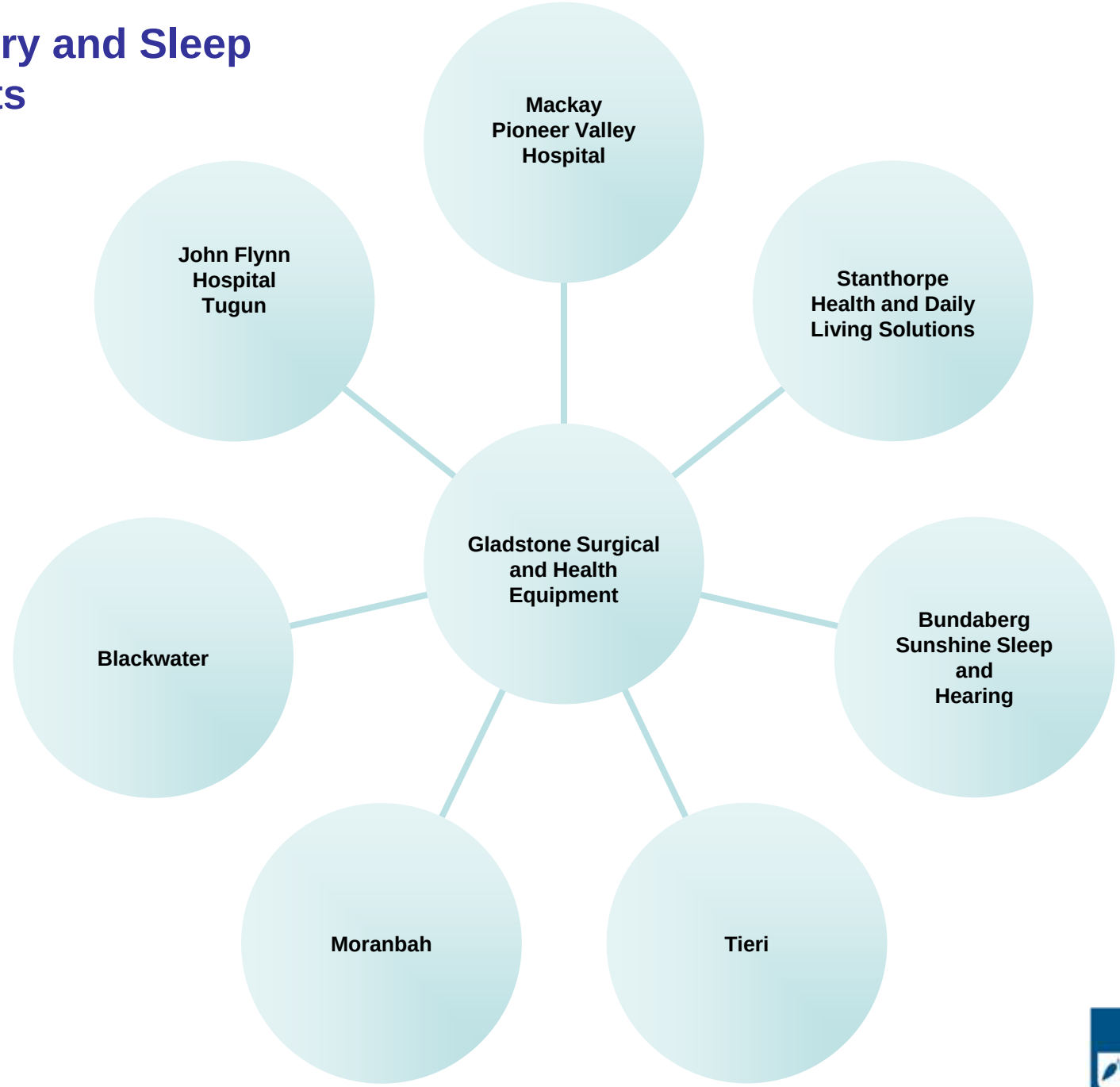
The onus is on each organisation to locate a sleep service that can meet the above criteria and provide optimal testing and treatment pathways.

Respiratory and Sleep Specialists Sleep Investigation Units



RESPIRATORY & SLEEP SPECIALISTS

Respiratory and Sleep Specialists Portable Sleep Services



RESPIRATORY & SLEEP SPECIALISTS

Experts in Sleep Health Management

RESPIRATORY
& SLEEP
SPECIALISTS

Sleep Investigation Unit
Bowen Basin Sleep Health Centre

20 years of excellence in Sleep Health Management

Australasian Sleep Association ASA ACCREDITED

RESPIRATORY & SLEEP SPECIALISTS
Experts in Sleep Health Care

Questions/Discussion?

RESPIRATORY & SLEEP SPECIALISTS

Experts in Sleep Health Management