Interpretation of PSG

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04Nov22

Polysomnography

- Continuous monitoring and simultaneous recording of physiologic activity during sleep
- Simultaneous recording :
    - Sleep staging
    - Eye movements
    - Electromyographic tone
    - Respiratory parameters
    - Electrocardiogram

Curr Sleep Med Rep.2020;6(4):309-321

Polysomnography

Routine indications
Diagnosis of sleep related breathing disorders(SRBDs)
PAP titration in patients with SRBDs
Assessment of treatment results
With MSLT in evaluation of suspected narcolepsy
Evaluating SRBDs that are violent or otherwise potentially injurious to patients or others
Atypical or unusual parasomnias

PAP- Positive airway pressure
MSLT- Multiple sleep latency test

Sleep. 2005 Apr;28(4):499-521

Polysomnography

Other indications
Neuromuscular disorders and sleep related symptoms
Assists in diagnosis of paroxysmal arousals or other sleep disturbances(seizure related)
Presumed parasomnia or sleep related seizure disorders not responding to conventional therapy
Strong clinical suspicion of periodic limb movement sleep disorder

Sleep. 2005 Apr;28(4):499-521

Polysomnography

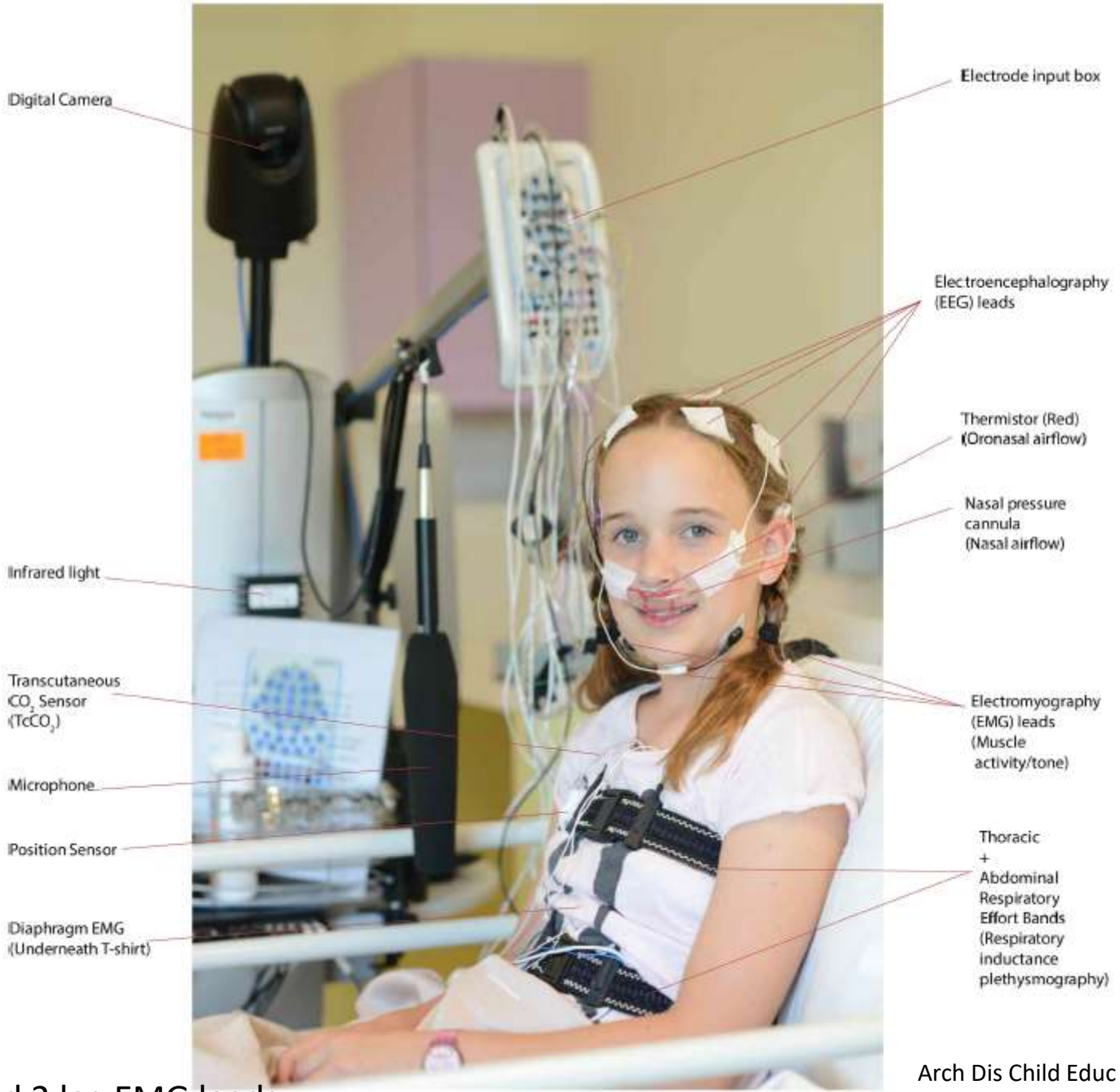
Not routinely indicated
Diagnose chronic lung disease
Typical, uncomplicated, and non injurious parasomnias when the diagnosis is clearly delineated
Patients with seizures who have no specific complaints consistent with sleep disorder
To diagnose or treat restless leg syndrome
To diagnose circadian rhythm sleep disorders
To establish diagnosis of depression

Sleep. 2005 Apr;28(4):499-521

Types of monitors

Type I	**In-laboratory, technologist attending, polysomnography Usual channels: EEG, EOG, chin EMG, ECG, airflow, respiratory effort and SpO2 (minimum of 7 channels as per AASM criteria)**
Type II	Unattended polysomnography(minimum of 7 channels, as above)
Type III	Portable monitoring with three or more channels, including pulse oximetry and heart rate (minimum of 4 channels, including respiratory movement, airflow, heart rate, SpO2)
Type IV	Portable monitoring with only one or two channels, including pulse oximetry

Can J Anaesth. 2018 Jan;65(1):60-75

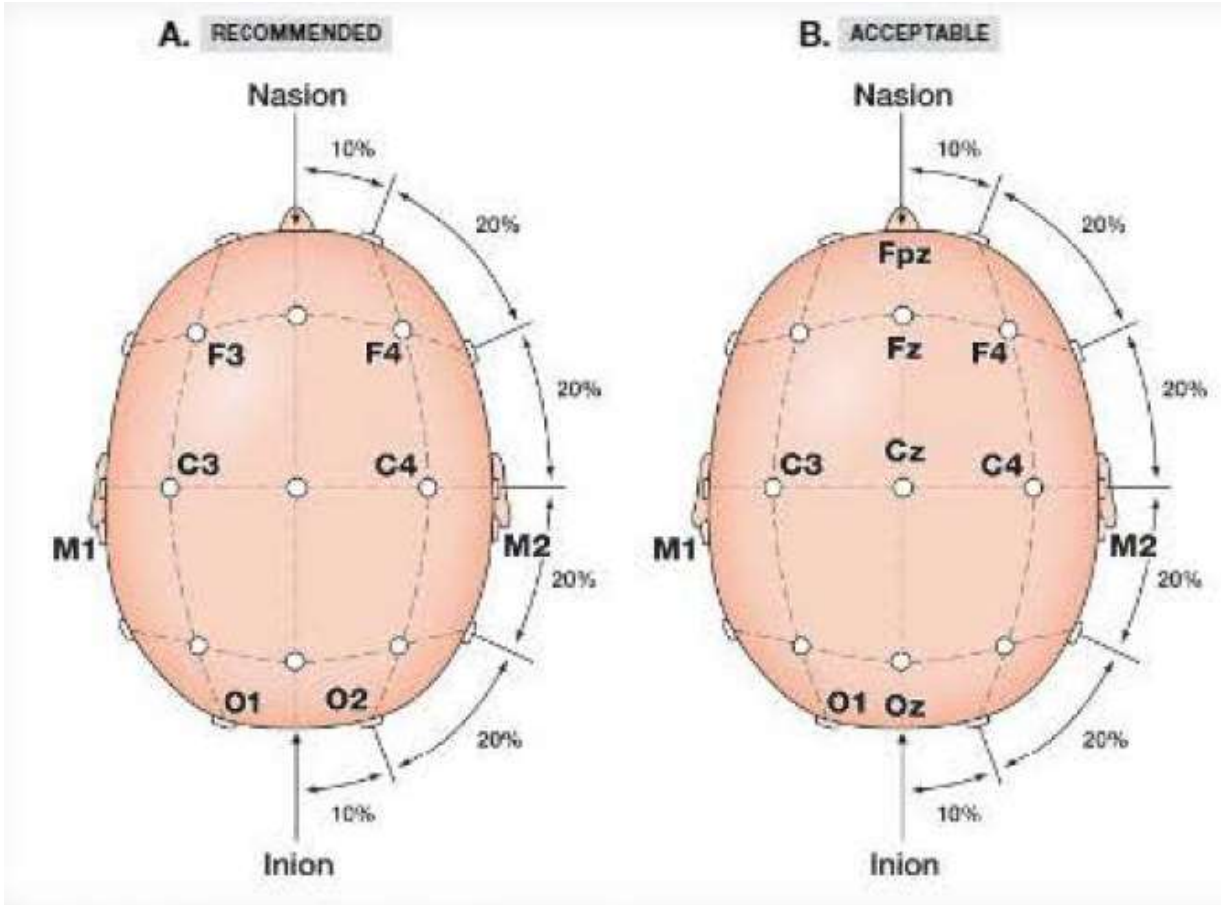


Arch Dis Child Educ Pract Ed. 2020 Jun;105(3):130-135

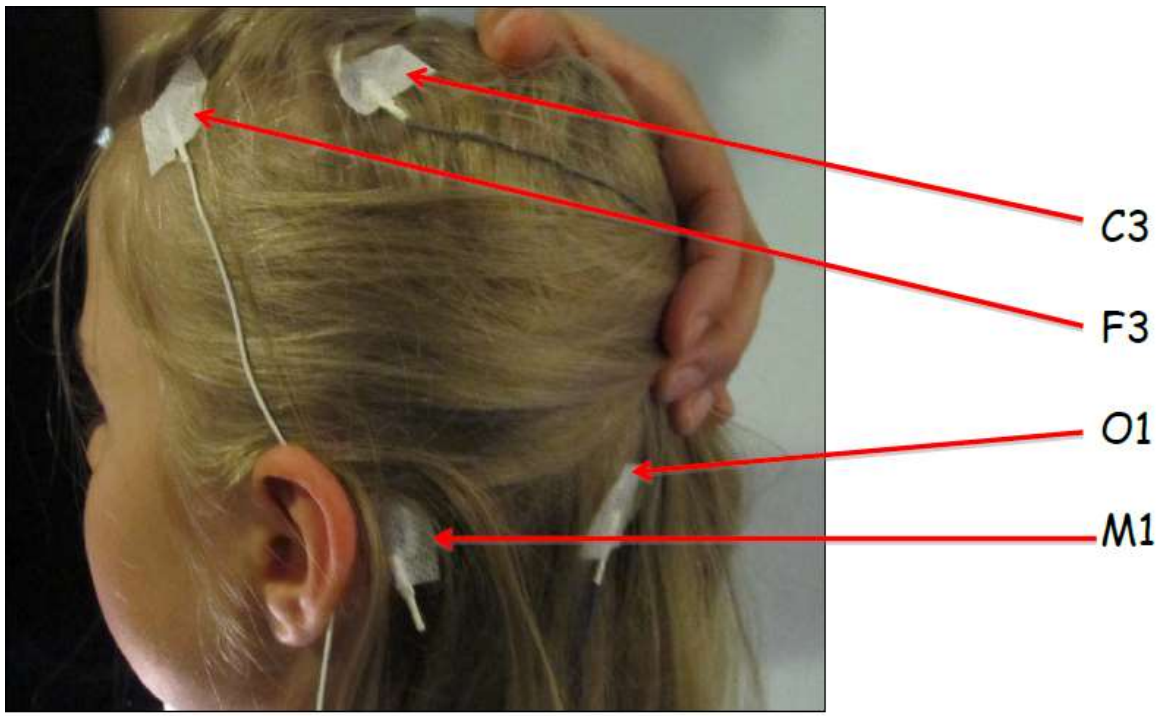
Not shown - SpO2 lead and 2 leg EMG leads

Parameter	Sensors	Purpose
Electroencephalography	Frontal, central, occipital leads with mastoid process reference lead	Stage sleep, detect epileptiform activity
Electrooculography	Outer canthi leads with mastoid process reference lead	Stage sleep (specifically stage R)
Electromyography	Submental surface electrodes, Anterior tibial surface electrodes	Stage sleep (specifically stage R), detect REM without atonia, detect periodic limb movements and other movement abnormalities
Airflow	Nasal cannula pressure transducer Oronasal thermal sensor PAP device (titration study)	Detection of hypopneas and RERAs Detection of apneas, Detection of apneas, hypopneas, and RERAs
Snoring	Microphone, piezoelectric sensor	Detect snoring
Respiratory effort	Chest and abdomen respiratory inductance plethysmography belts	Classify respiratory events as obstructive, central, or mixed
Arterial oxygen saturation	Pulse oximetry	Detect hypoxemia
Ventilation	End-tidal PCO2 or transcutaneous PCO2 monitoring	Detect hypoventilation
Electrocardiogram	Modified lead II	Monitor cardiac rate and rhythm
Position	Accelerometer, video monitors	Detect position
Behaviour	Audio, video monitors	Detect parasomnias, abnormal behaviors, seizures

Otolaryngol Clin North Am. 2020 Jun;53(3):367-383



Electroencephalogram



The AASM manual for the scoring of sleep and associated events,2018

Electroencephalogram

F4-M1 – best for slow waves

0.5-2.0hz

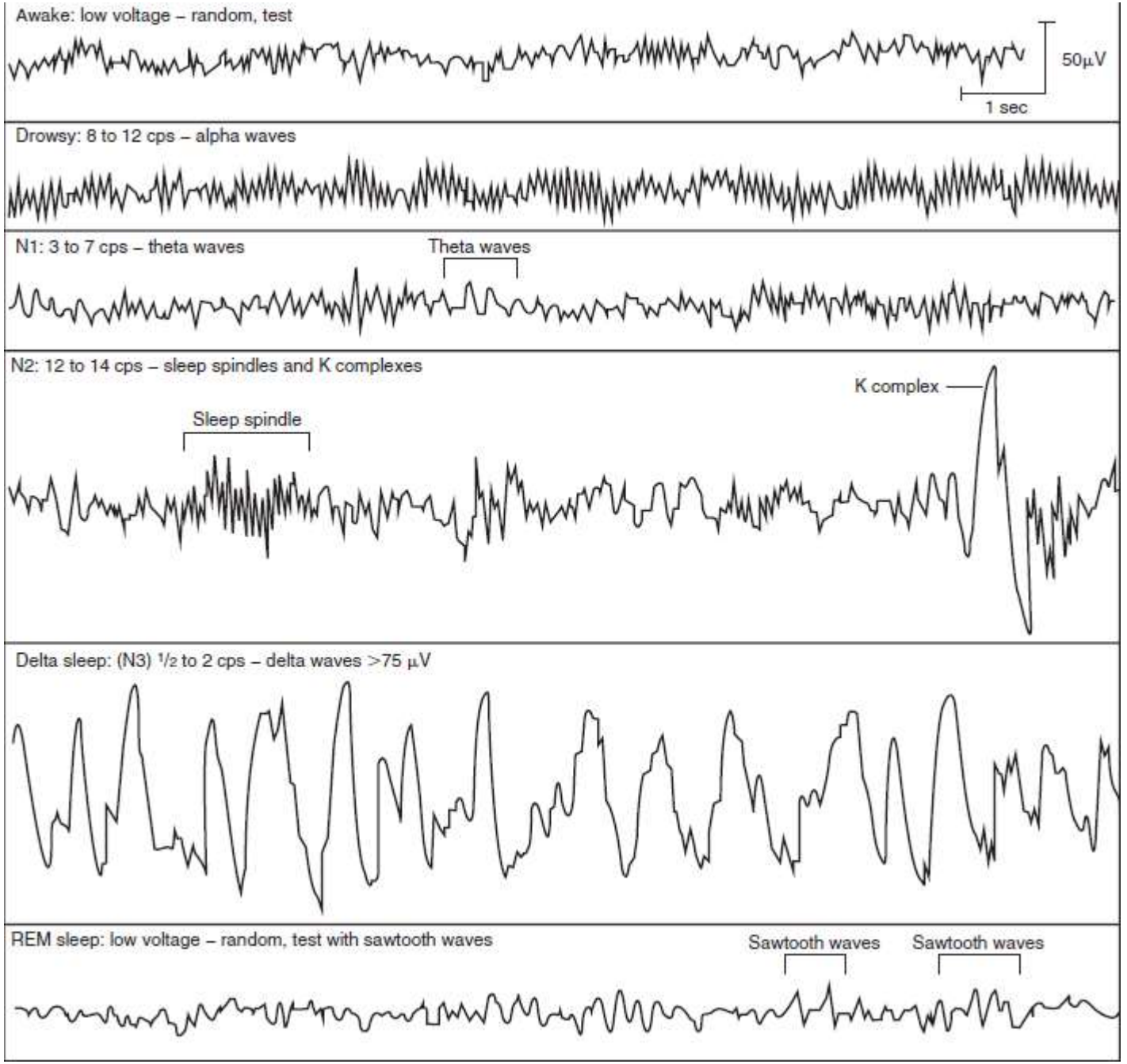
C4-M1 – best for spindles

11-16hz (most common 12-14hz)

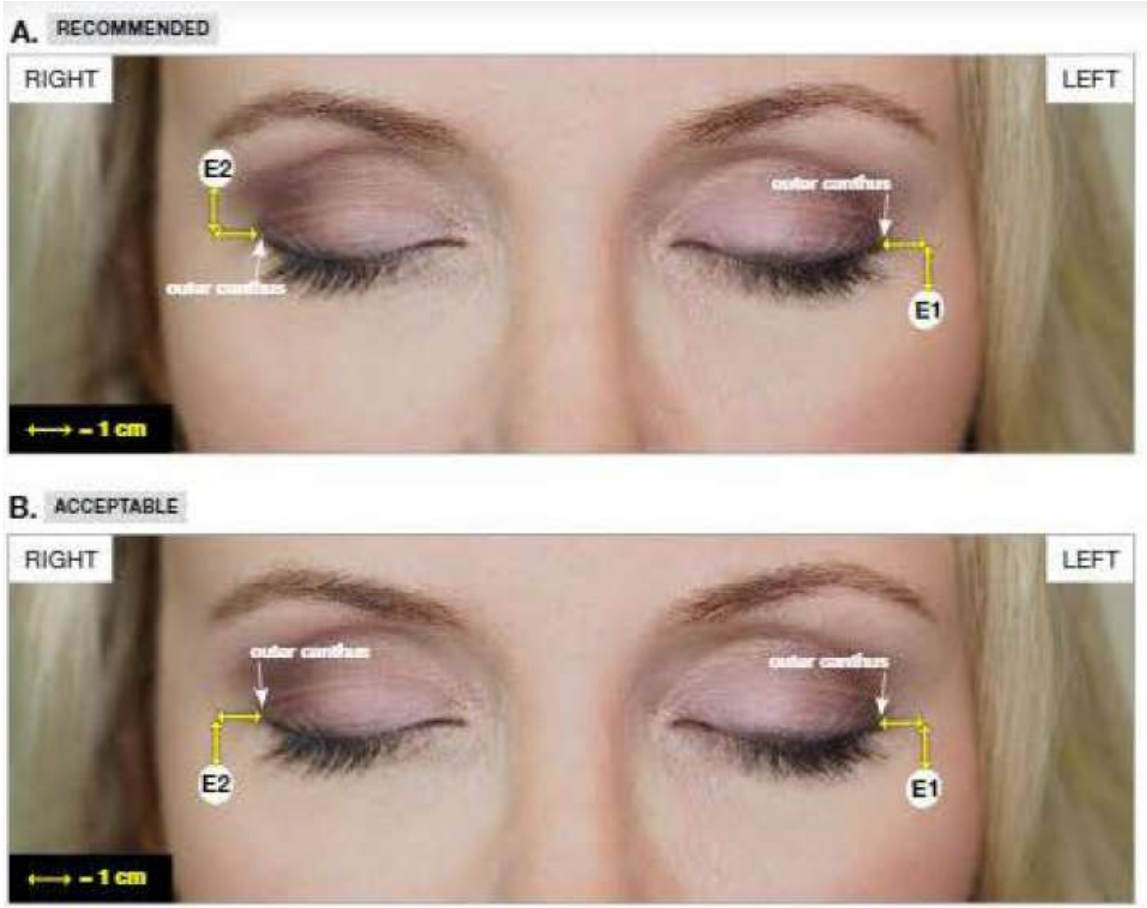
O2-M1 – best for alpha rhythm

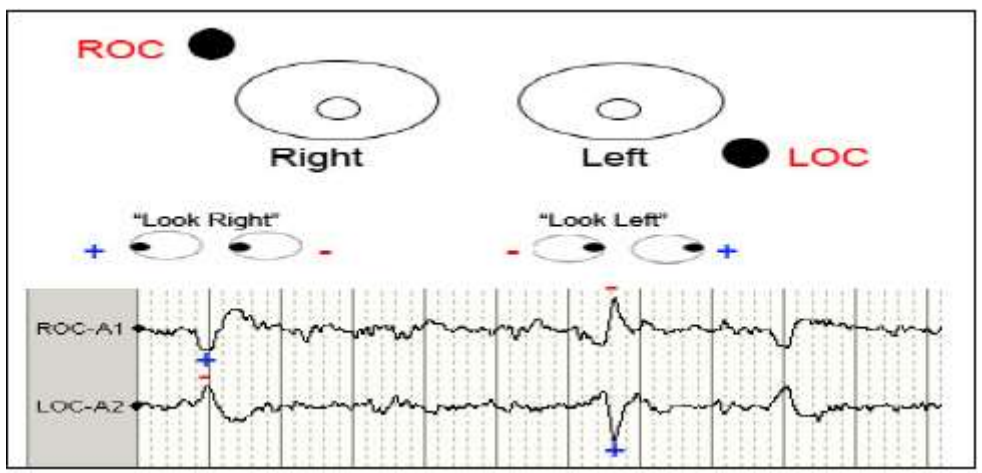
(8-13hz)

Features of sleep-stage electroencephalogram frequencies



Atlas of clinical sleep medicine





Electro-oculogram

Recording of the movement of the **corneo-retinal potential difference**, not the movement of eye muscle.

Electrodes are placed at outer canthus of eyes offset 1cm above/below the horizontal

Right out and up / Left out and down

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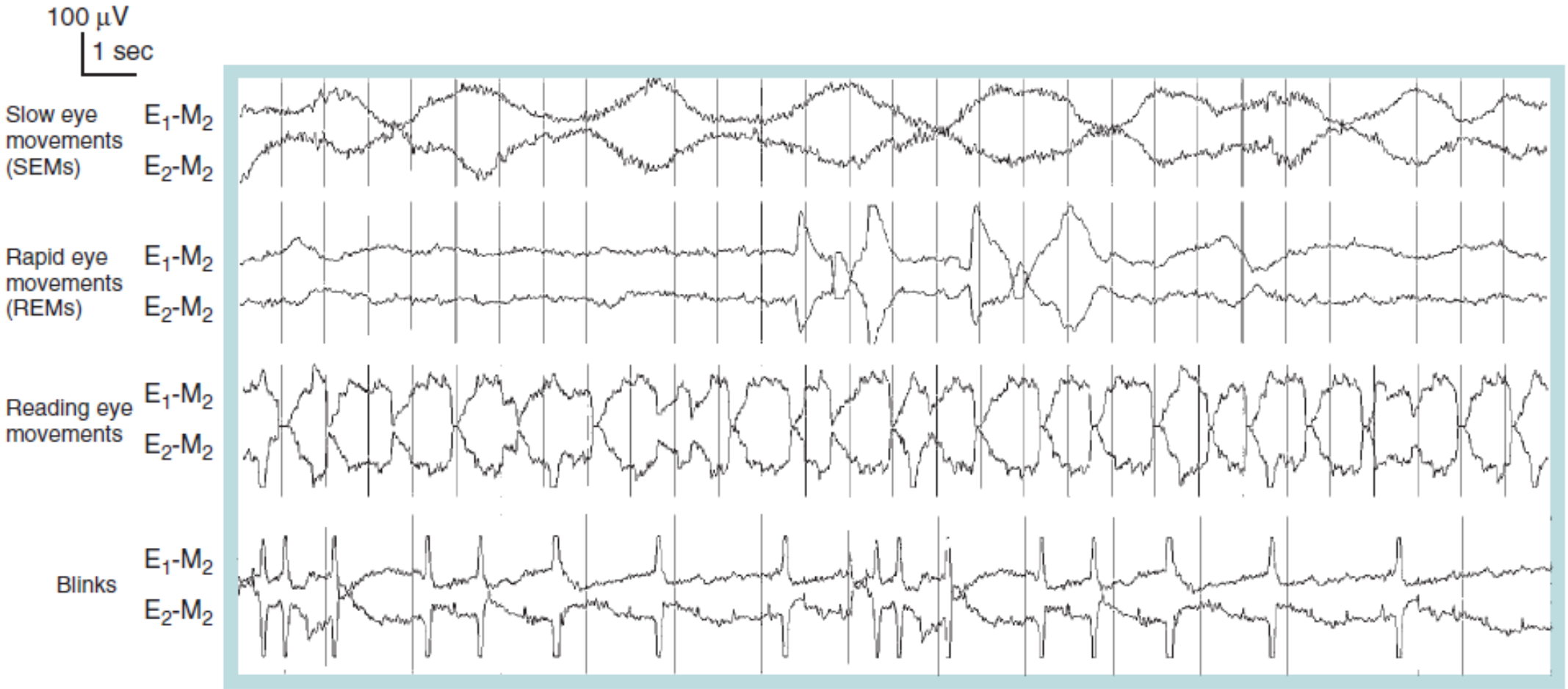
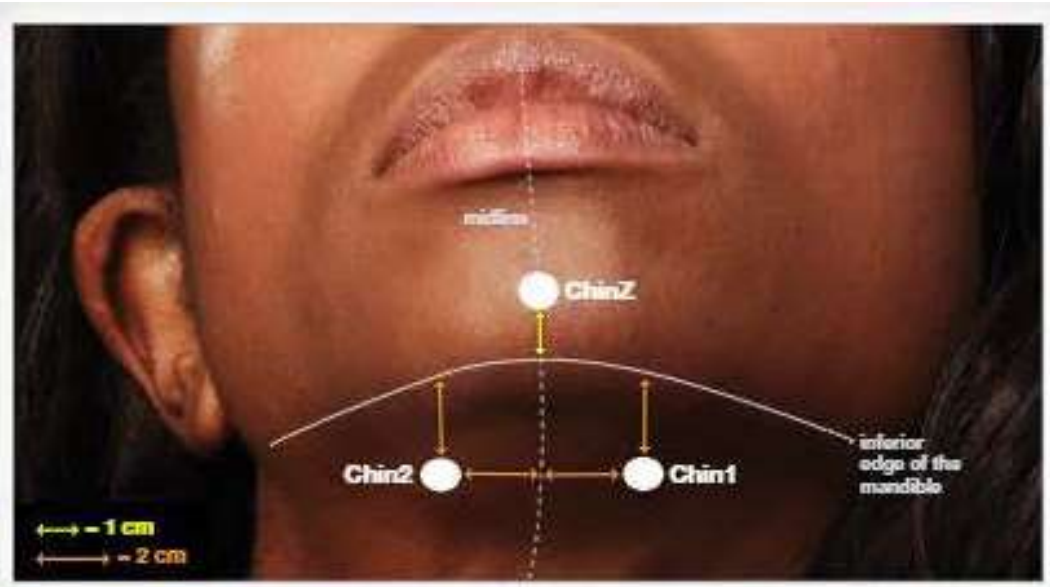
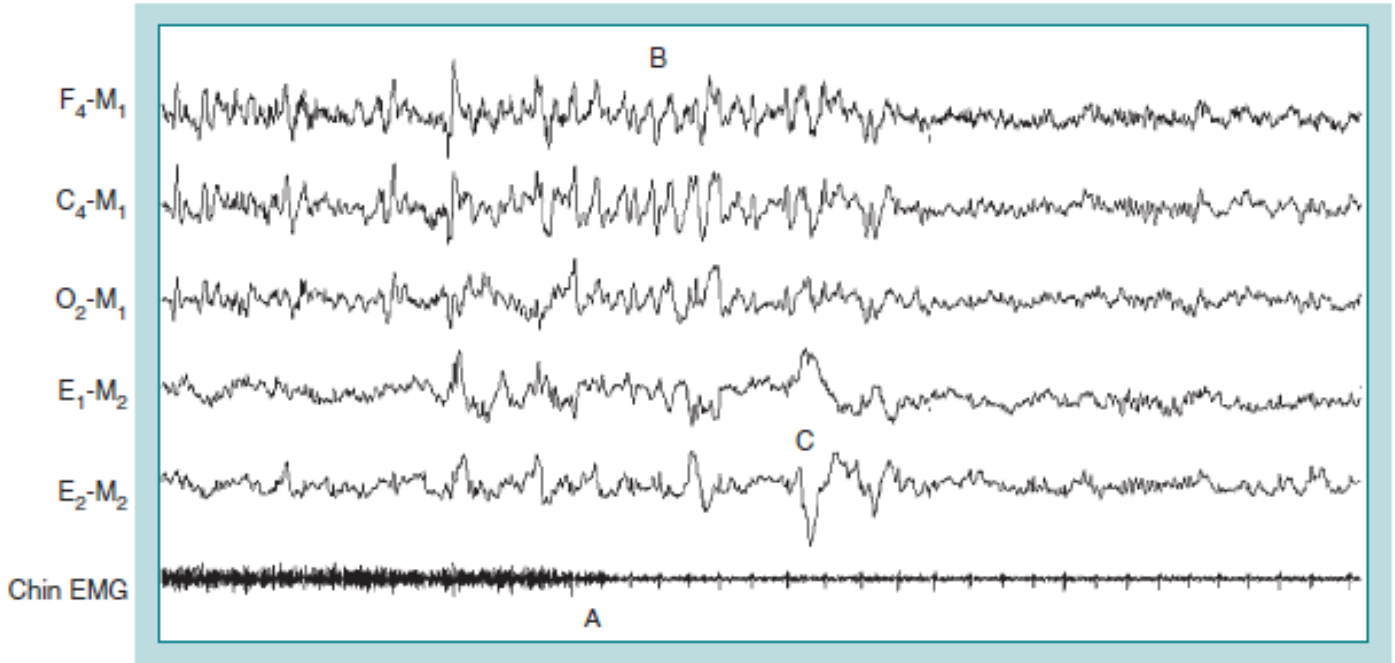


Eye movement patterns

Fundamentals of sleep medicine

Electromyogram





A- reduction in chin EMG
B - saw tooth wave
C-rapid eye movements

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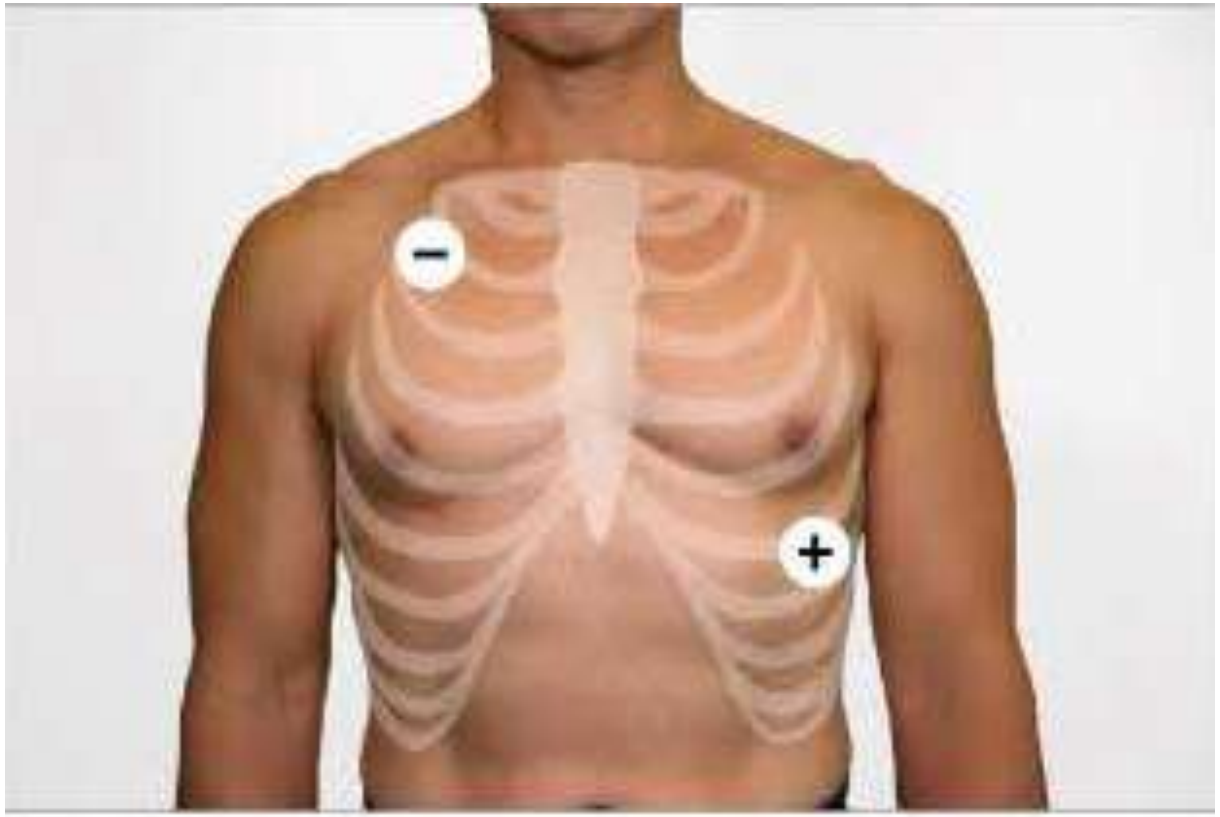
ECG



Single modified lead II electrode and torso electrode

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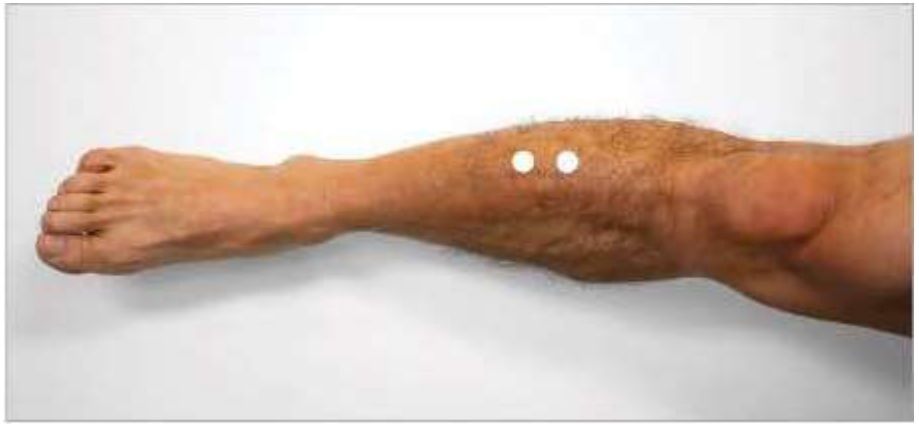
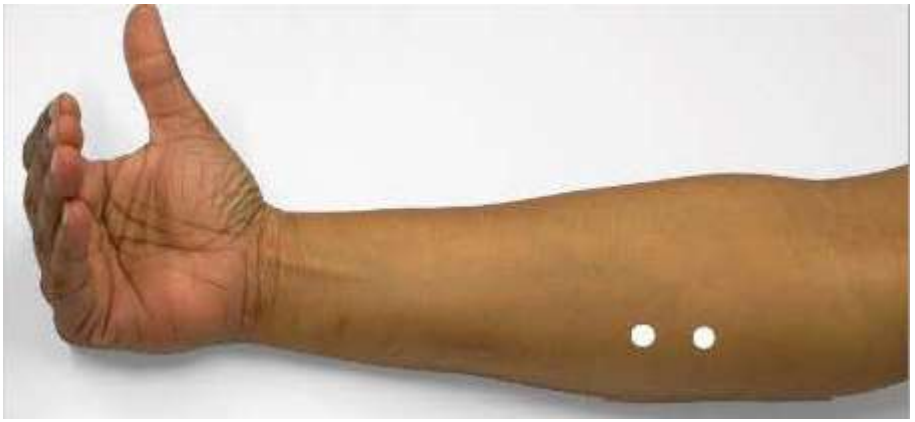
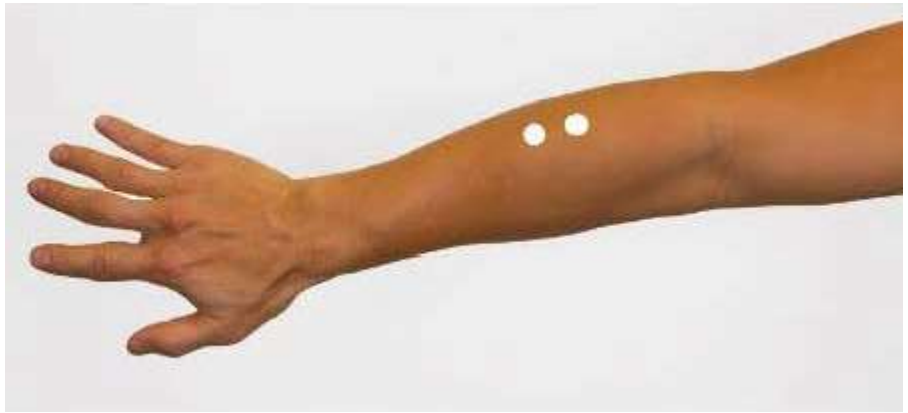
Limb movements



Tibialis anterior



Extensor digitorum superficialis



Extensor digitorum communis

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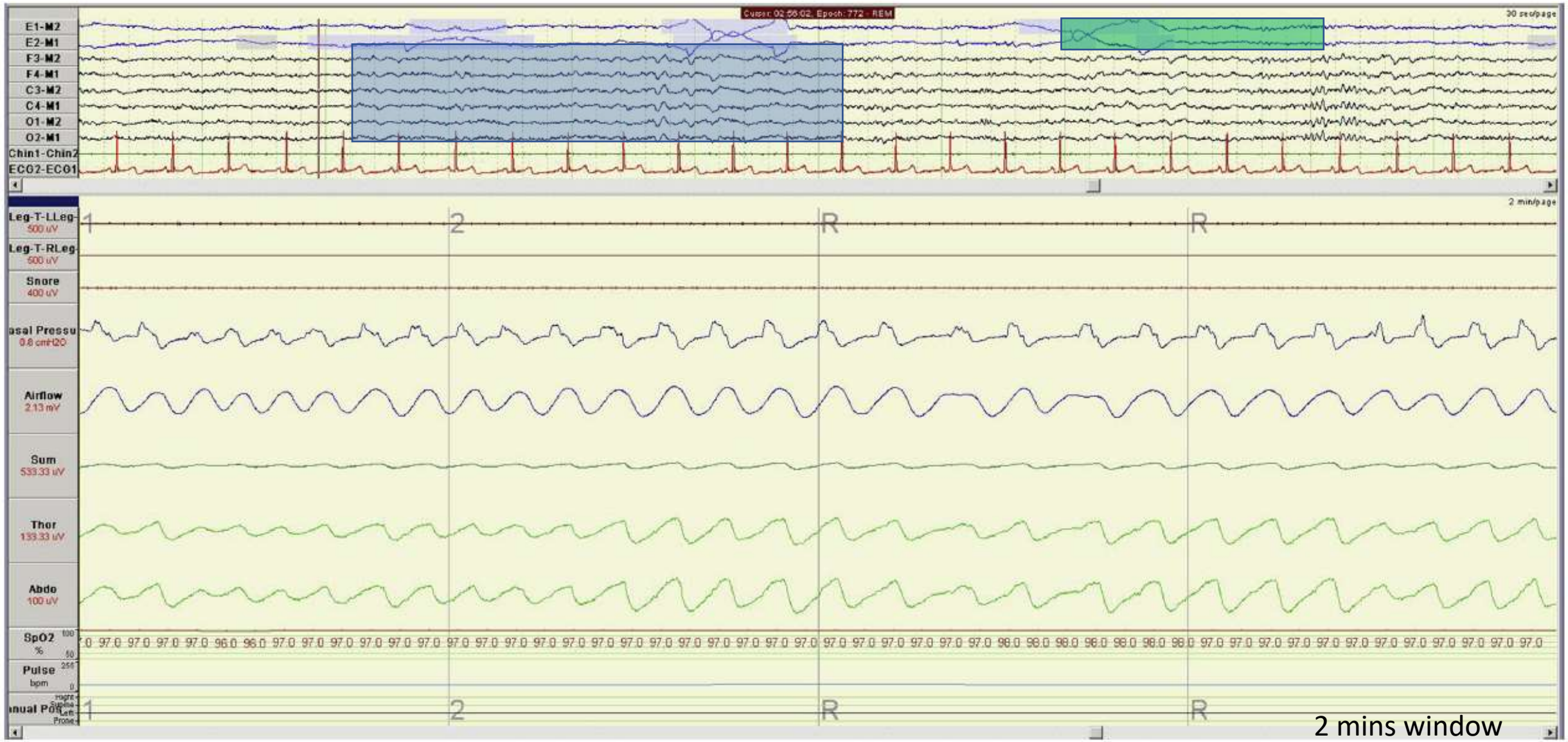
Sleep staging- 30s epoch

EEG arousals- 30s epoch

Respiratory events- 2min / 5min epoch

30 secs window



2 mins window

Otolaryngol Clin North Am. 2016 Dec;49(6):1307-1329

Stage W(Wakefulness)

- More than 50% of epoch has alpha rhythm over occipital region or
- Any of the following are present:
    - Eye blink at a frequency of 0.5 -2 Hz
    - Reading eye movement
    - Irregular conjugate rapid eye movements associated with normal or high chin muscle tone

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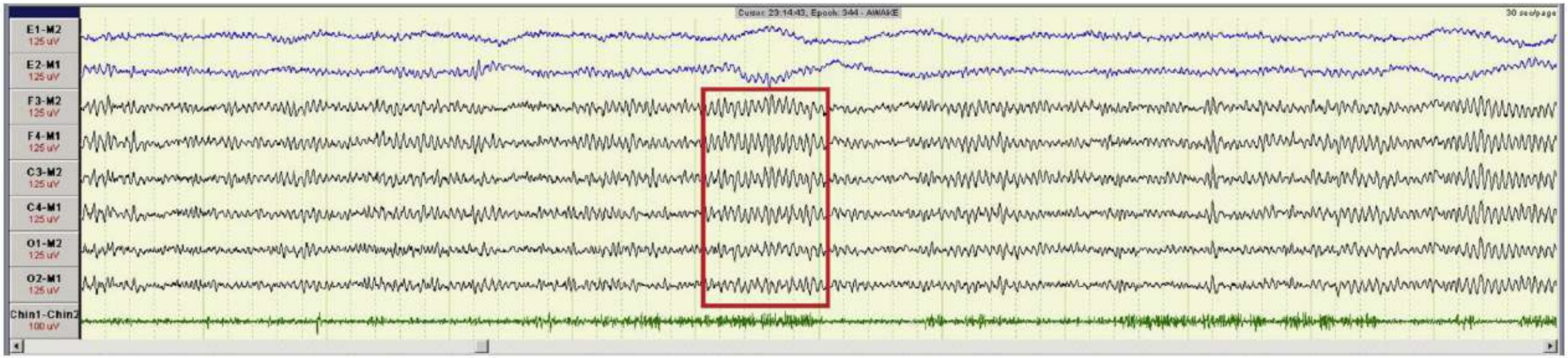
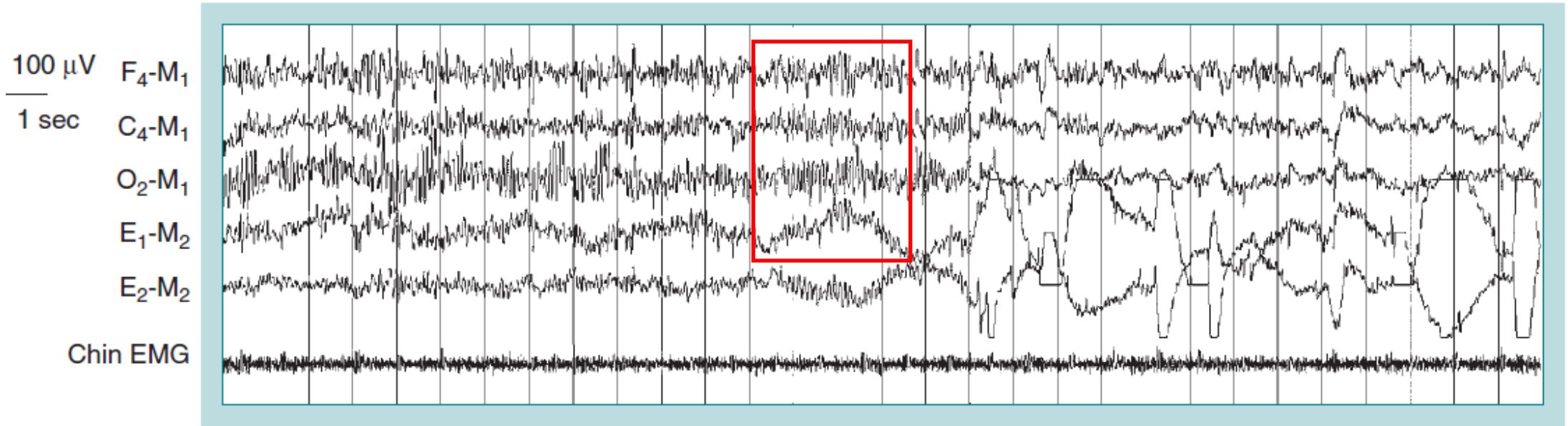
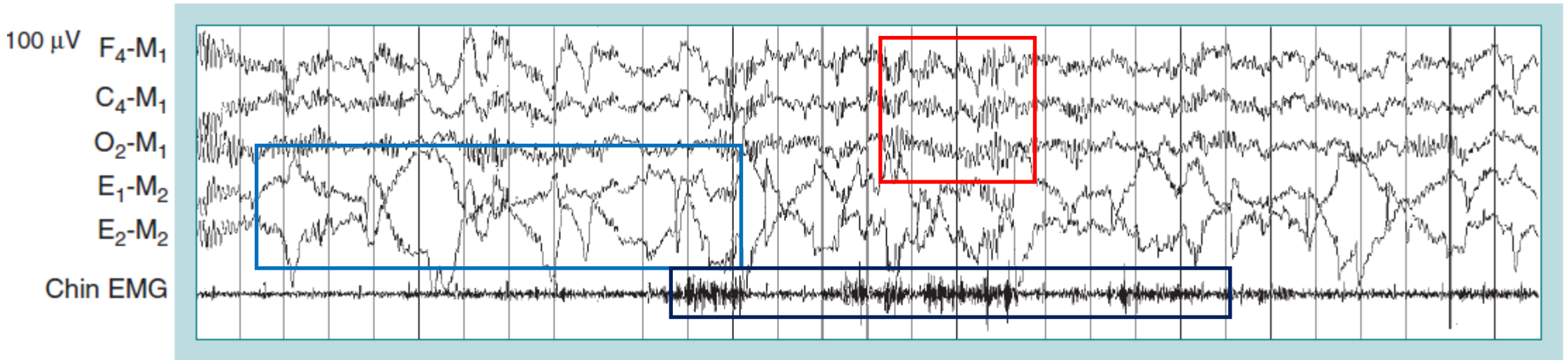


Drowsy (before sleep onset) alpha waves, seen in EEG leads (red rectangle), occupy greater than 50% of the 30-second epoch

Otolaryngol Clin North Am. 2016 Dec;49(6):1307-1329



Increased Alpha activity



Alpha activity
Rapid eye movements
Chin EMG

Fundamentals of sleep medicine

Stage N1

- If individual is generating alpha rhythm, score stage as N1 if alpha rhythm is attenuated and replaced by low amplitude mixed frequency activity for more than 50% of epoch
- In individual who do not generate alpha rhythm, score stage N1 commencing with the earliest of any of the following phenomenon:
  - EEG activity in range of 4- 7 Hz with slowing of background frequencies by >1 Hz from those of stage W
  - Vertex shaped waves
  - Slow eye movements

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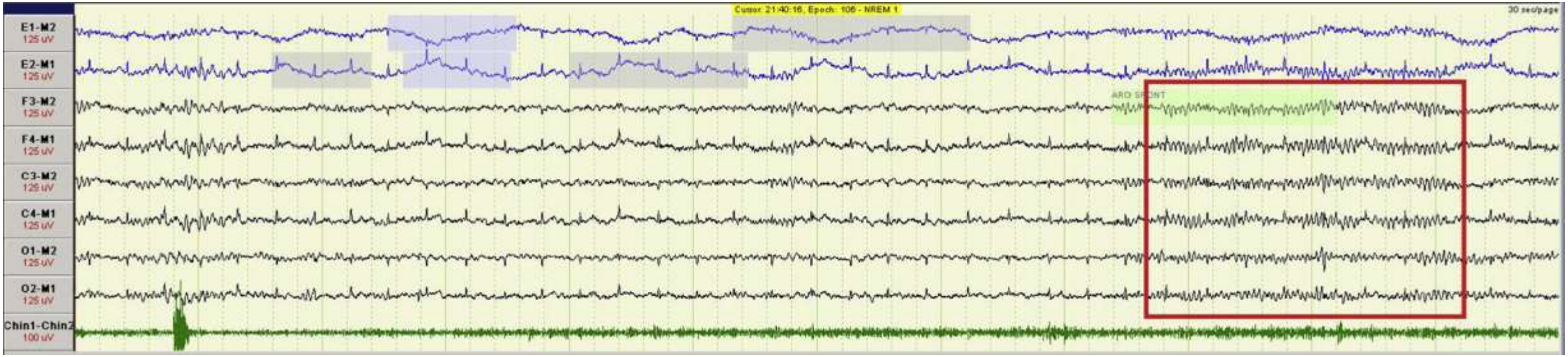
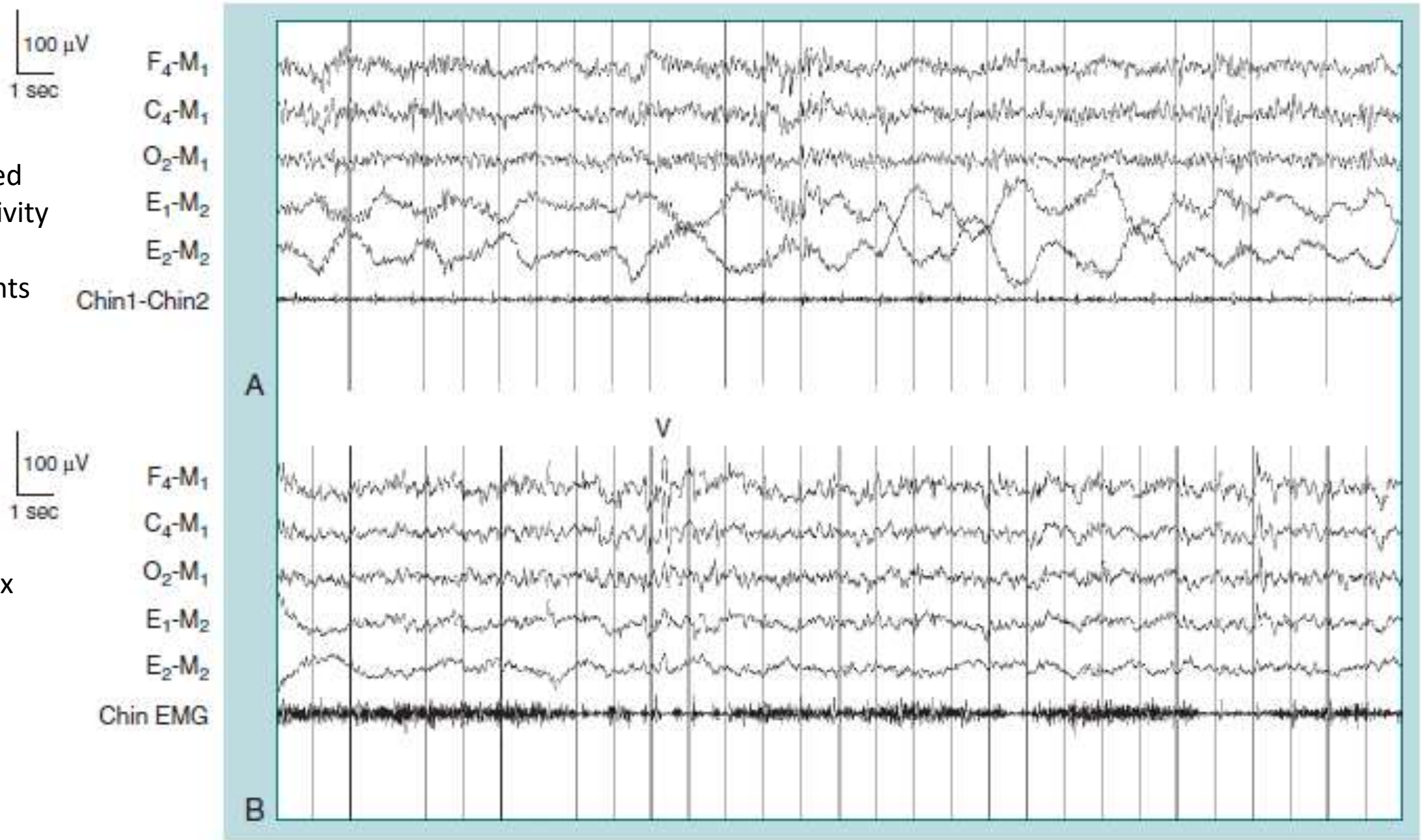


Stage N1, sleep onset. Alpha waves (red rectangle) are less than 50% of the 30-second epoch

Otolaryngol Clin North Am. 2016 Dec;49(6):1307-1329

Attenuated alpha activity
Slow eye movements

V-Vertex waves



Fundamentals of sleep medicine

Stage N2

Score N2 (in absence of criteria for N3) if one or both occur in first half of epoch or last half of the previous epoch :

- One or more k complexes unassociated with arousal
- One or more trains of sleep spindles

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

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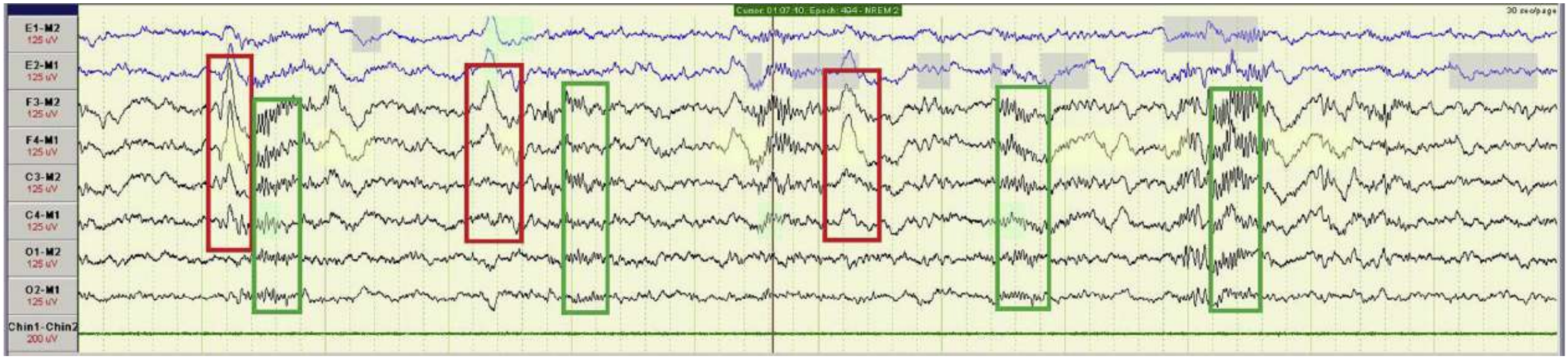
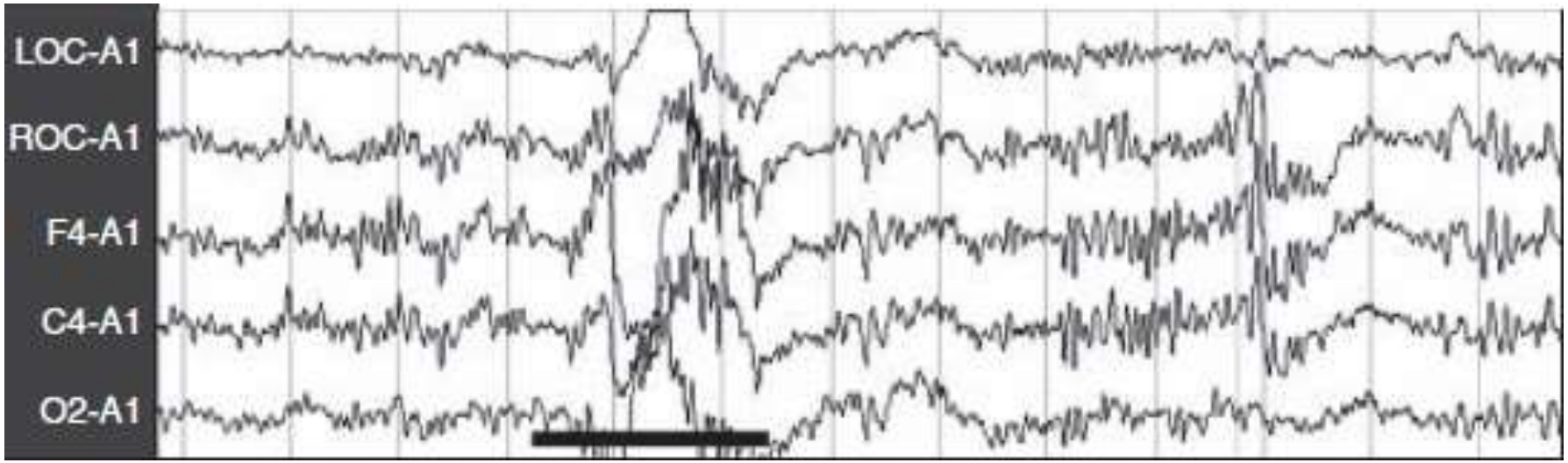


Stage N2: K complexes (red rectangles) and sleep spindles (green rectangles).

Otolaryngol Clin North Am. 2016 Dec;49(6):1307-1329

- K Complex: A well delineated negative sharp wave immediately followed by a positive component standing out from the background EEG, with total duration > or equal to 5 seconds, usually maximal in amplitude when recorded using frontal derivations



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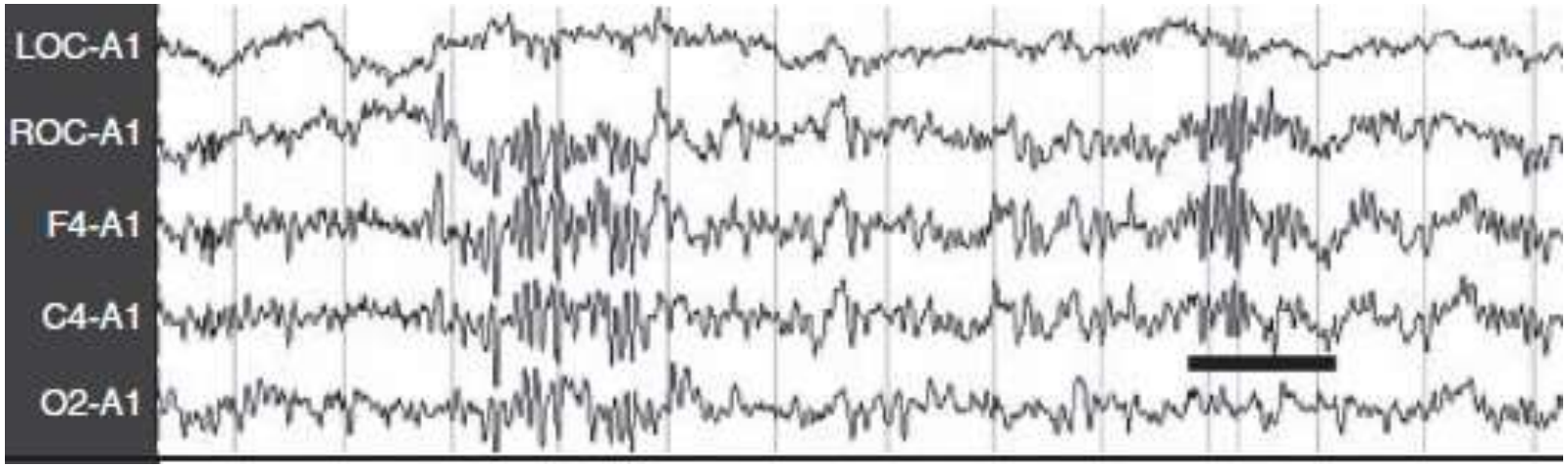
- Sleep Spindle: A train of distinct waves with frequency 11-16 Hz with a duration of > and equal to 0.5 seconds usually maximal in amplitude using central derivations



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Stage N2

End scoring stage N2:

- Transition to stage W or N3 or R
- An arousal followed by low amplitude ,mixed frequency EEG
- Major body movement followed by slow eye movements and low amplitude mixed frequency EEG without non arousal associated K complexes or sleep spindles

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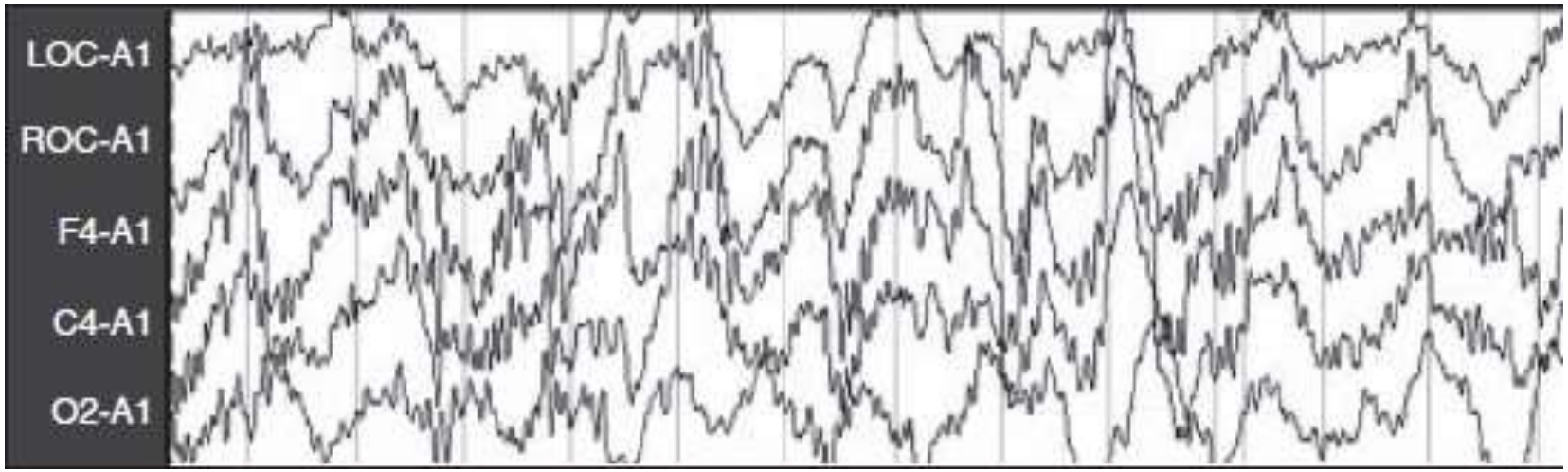
Stage N3

- Score stage N3 when >20 % of an epoch consists of slow wave activity, irrespective of age
- Slow wave activity: waves of frequency 0.5 – 2Hz and peak to peak amplitude of >75µV, measured over frontal region referenced to contralateral ear or mastoid



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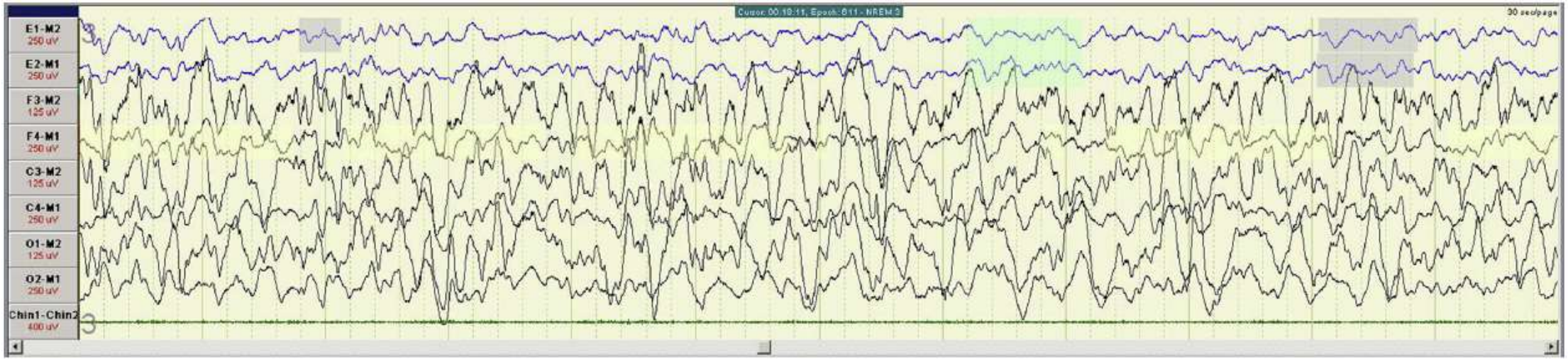

Stage N3 or slow-wave sleep: numerous delta waves.

Otolaryngol Clin North Am. 2016 Dec;49(6):1307-1329

Stage R

- Definite stage R(if all are present):
    - Low amplitude mixed frequency(LAMF) EEG activity without K complexes or sleep spindles
    - Low chin EMG tone for majority of the epoch and concurrent with REMs
    - REMs at any position within the epoch
- Score segments of sleep preceding and contiguous with an epoch of definite R ,in absence of rapid eye movements, as stage R if all of the following are present:
        - The EEG shows LMAF activity without K complex and sleep spindles
        - The chin EMG tone is low
        - There is no intervening arousal
        - Slow eye movement following an arousal or stage W is present

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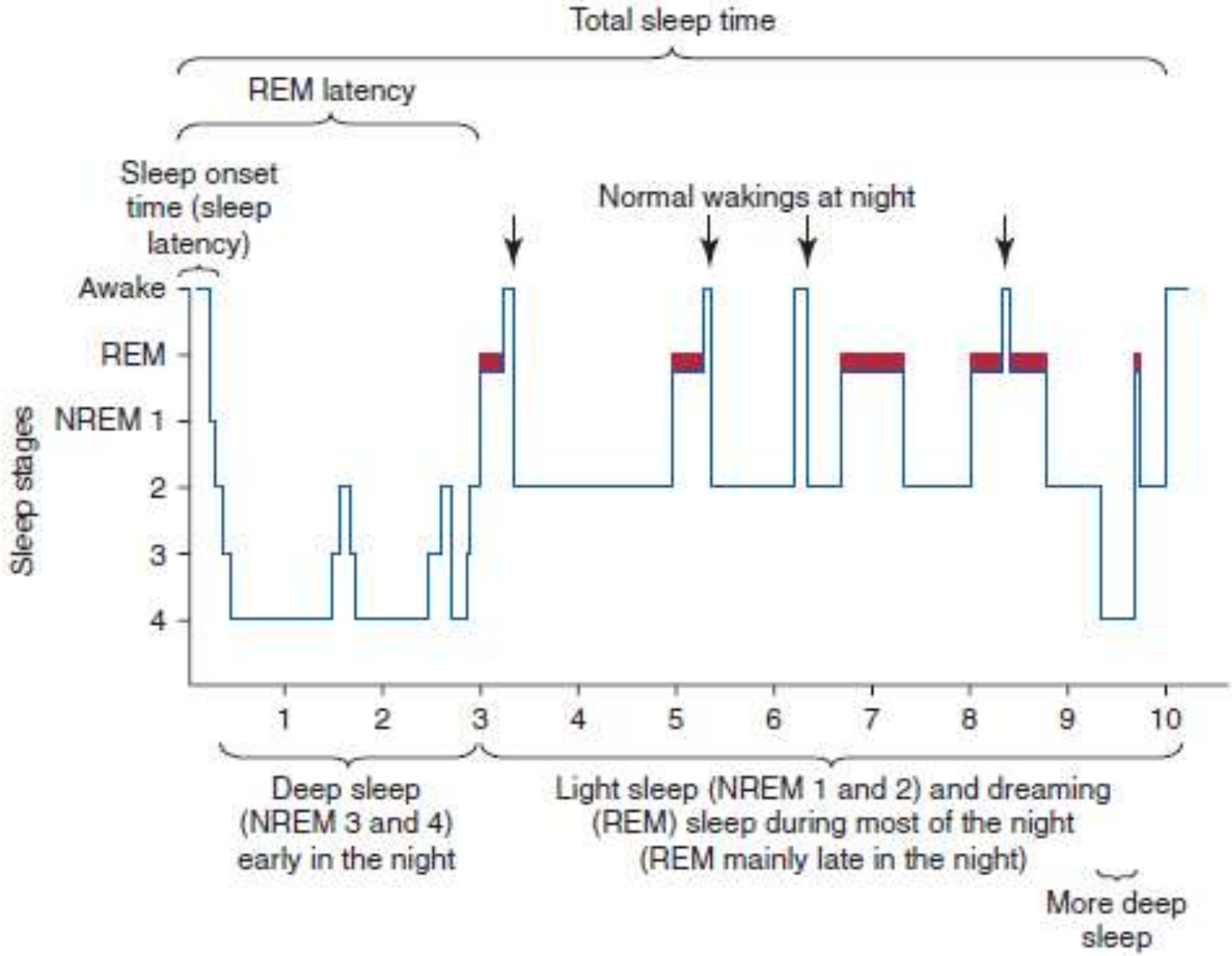
Stage REM.REMs on the top 2 lines and low tone on chin EMG on the bottom line

Otolaryngol Clin North Am. 2016 Dec;49(6):1307-1329

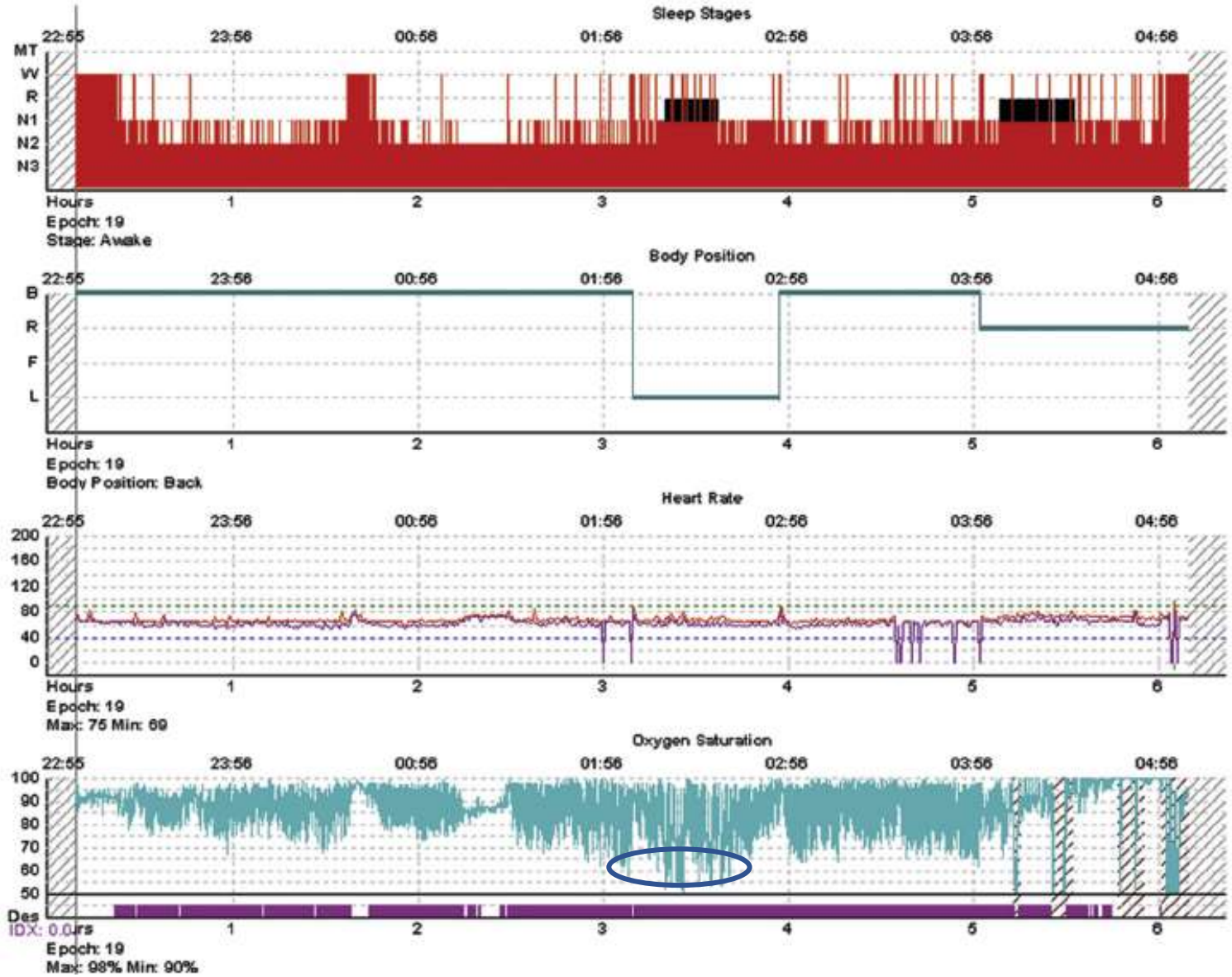
Hypnogram

- Compressed graphic summary of entire sleep study
- Representation of multiple variables :
    - Sleep stages
    - Respiratory events
    - Positive airway pressure (if used)
    - Motor movements
    - Oximetry
    - End-tidal or transcutaneous CO2,
    - Heart rate variability measures
    - Electroencephalographic power spectrum
    - Body position

Atlas of sleep medicine



Arch Dis Child 2009; 94:63–69.



Obstructive sleep apnea

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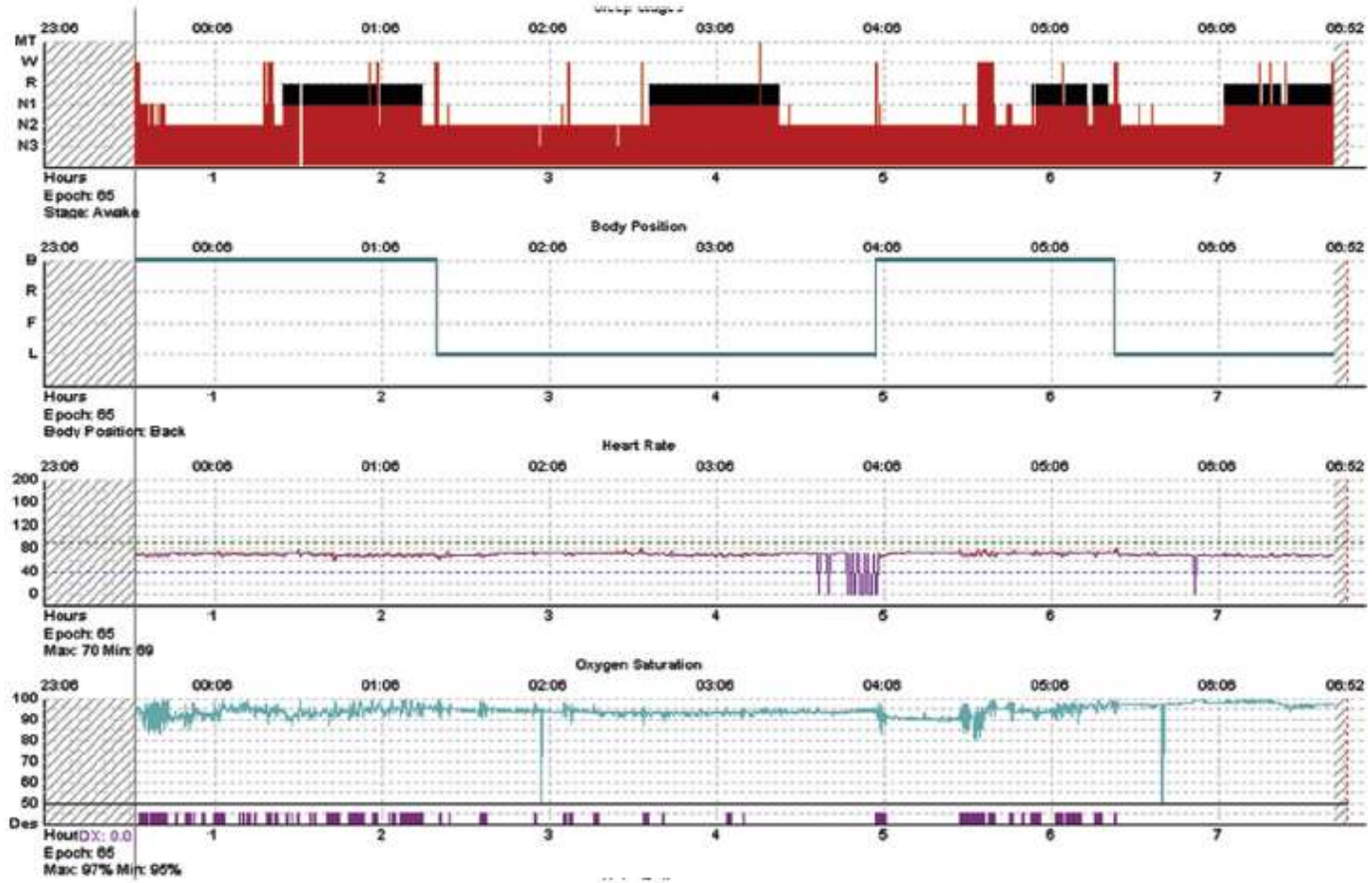

Obstructive sleep apnea on PAP

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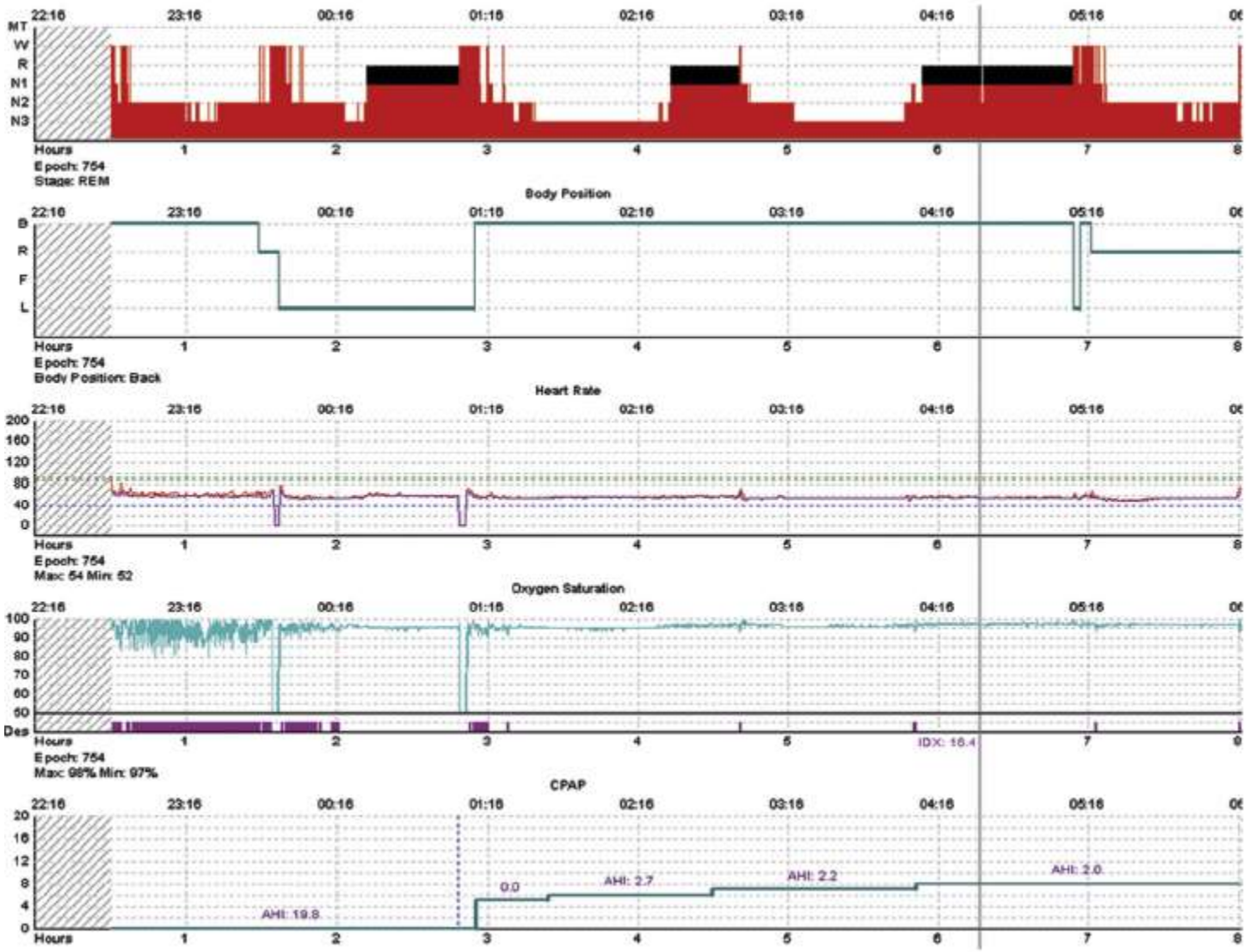

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Apnea

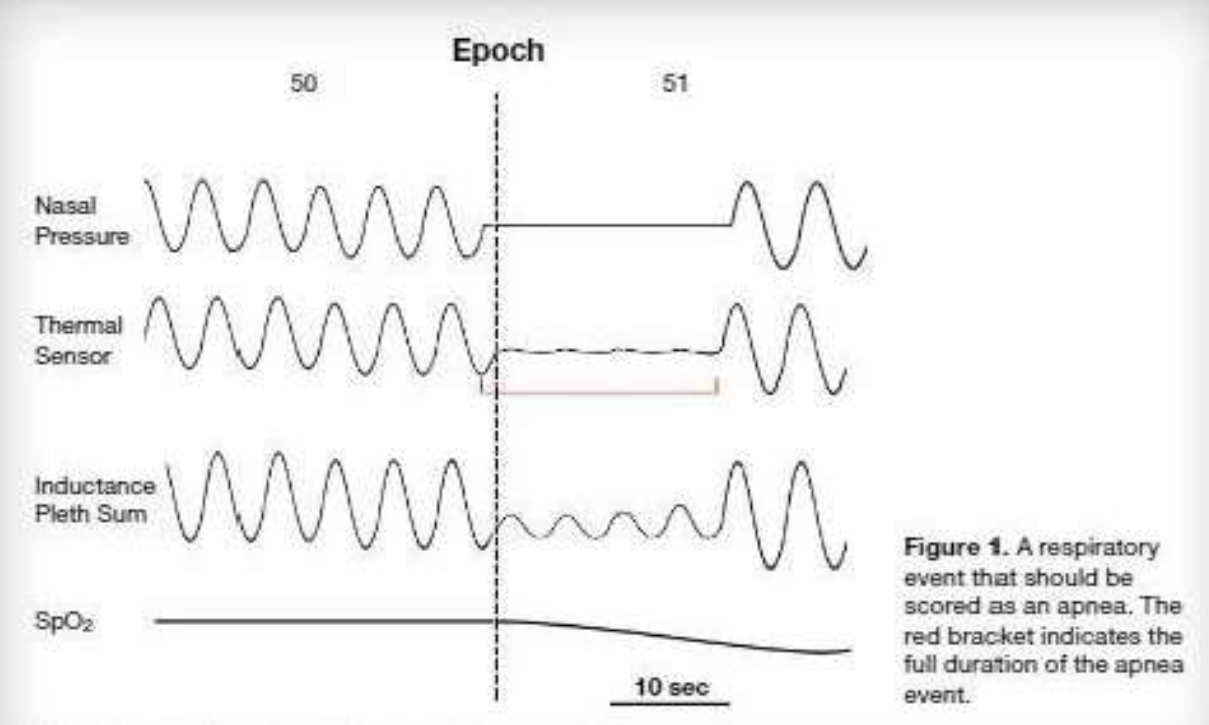

Figure 1. A respiratory event that should be scored as an apnea. The red bracket indicates the full duration of the apnea event.

- Drop in peak the signal excursion by ≥ 90% of pre event baseline using an oronasal thermal sensor
- Duration of ≥90% drop in sensor signal ≥10 seconds

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Apnea

Score an apnea as an **obstructive apnea** if:

- it meets apnea criteria and
- is associated with continued or increased inspiratory effort throughout the entire period of absent airflow.

Score an apnea as a **central apnea** if:

- it meets apnea criteria and
- is associated with absent inspiratory effort throughout the entire period of absent airflow.

Score an apnea as a **mixed apnea** if :

- it meets apnea criteria and
- is associated with absent inspiratory effort in the initial part of the event, followed by resumption of inspiratory effort in the second part of the event.

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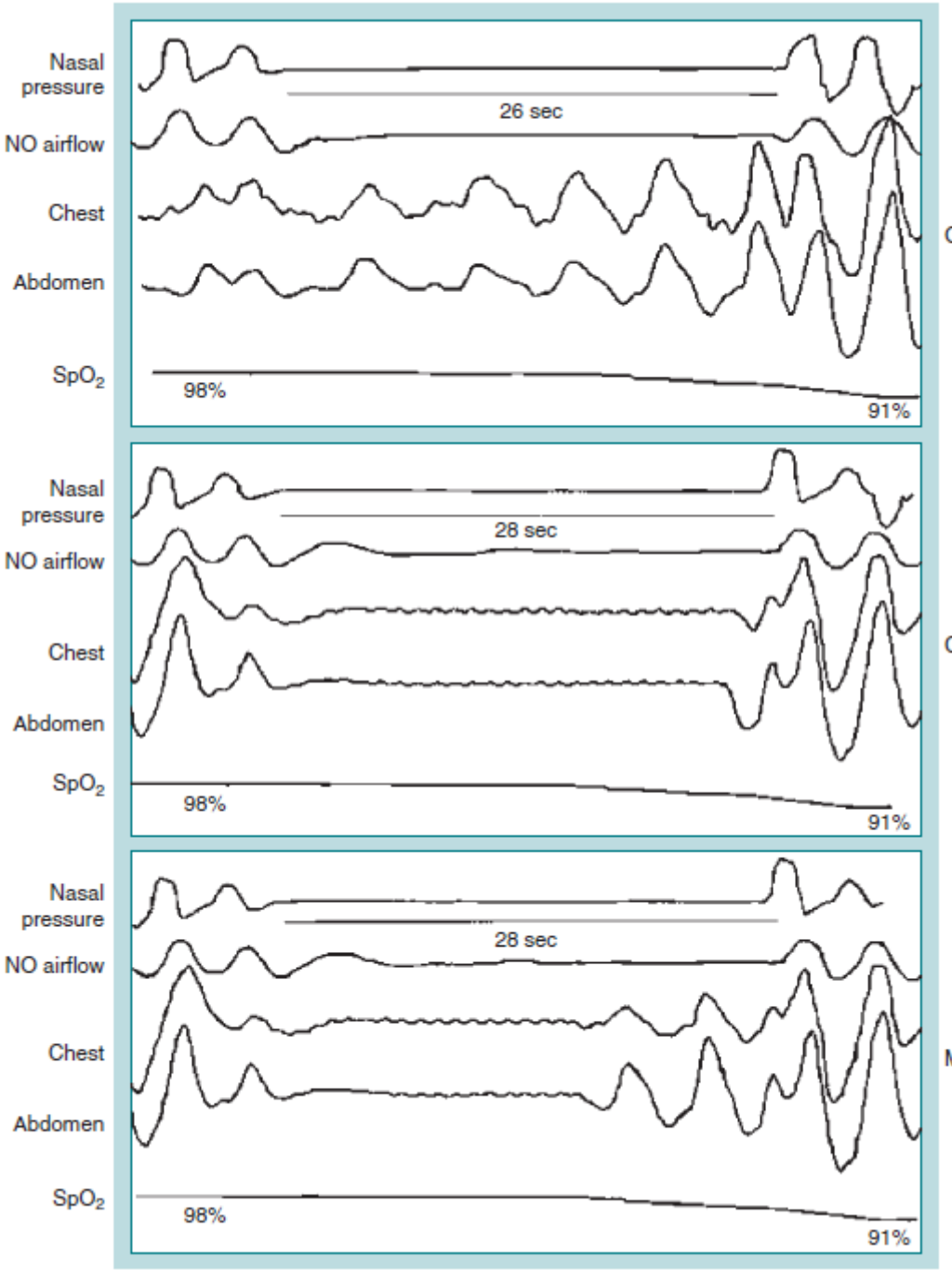
Apnea

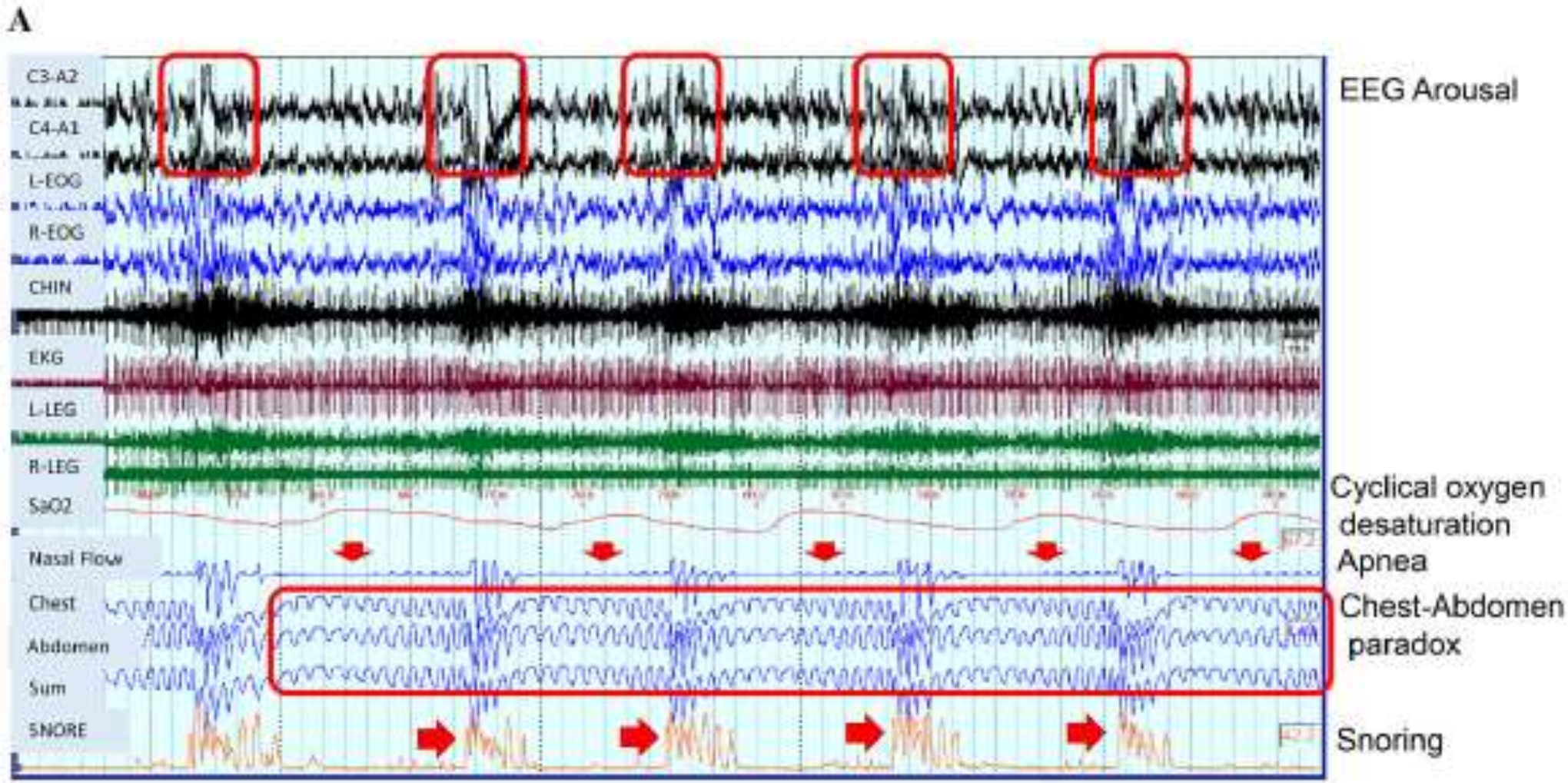


Obstructive sleep apnea

Central sleep apnea

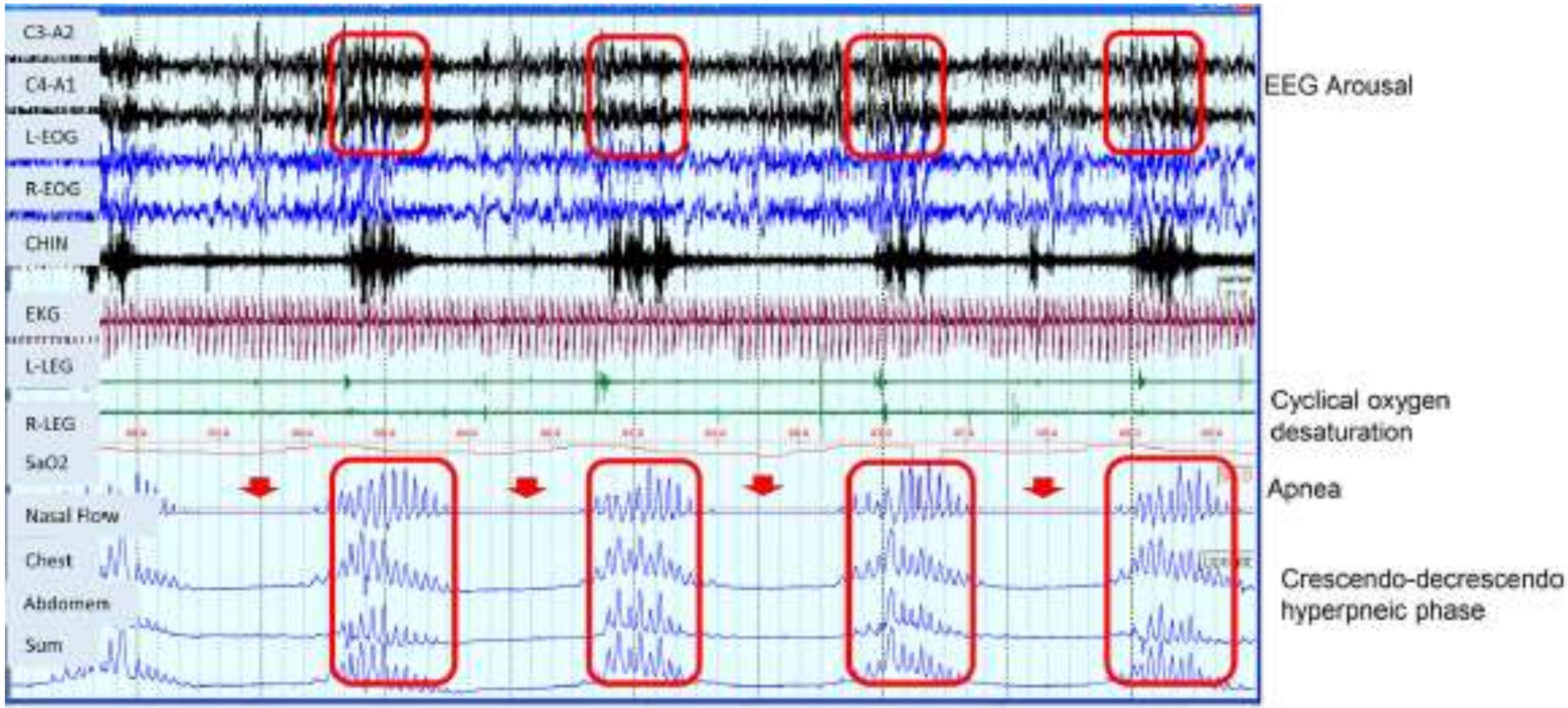
Mixed sleep apnea

Fundamentals of sleep medicine



OSA

Can J Anaesth. 2018 Jan;65(1):60-75



CSA

Can J Anaesth. 2018 Jan;65(1):60-75

Hypopnea

- Score a respiratory event as a hypopnea if all of the following criteria are met:
    - The peak signal excursions drop by ≥ 30% of pre-event baseline using nasal pressure
    - The duration of ≥30% drop in signal excursion is 10 seconds.
    - There is a ≥3% desaturation from the pre-event baseline or the event is associated with an arousal

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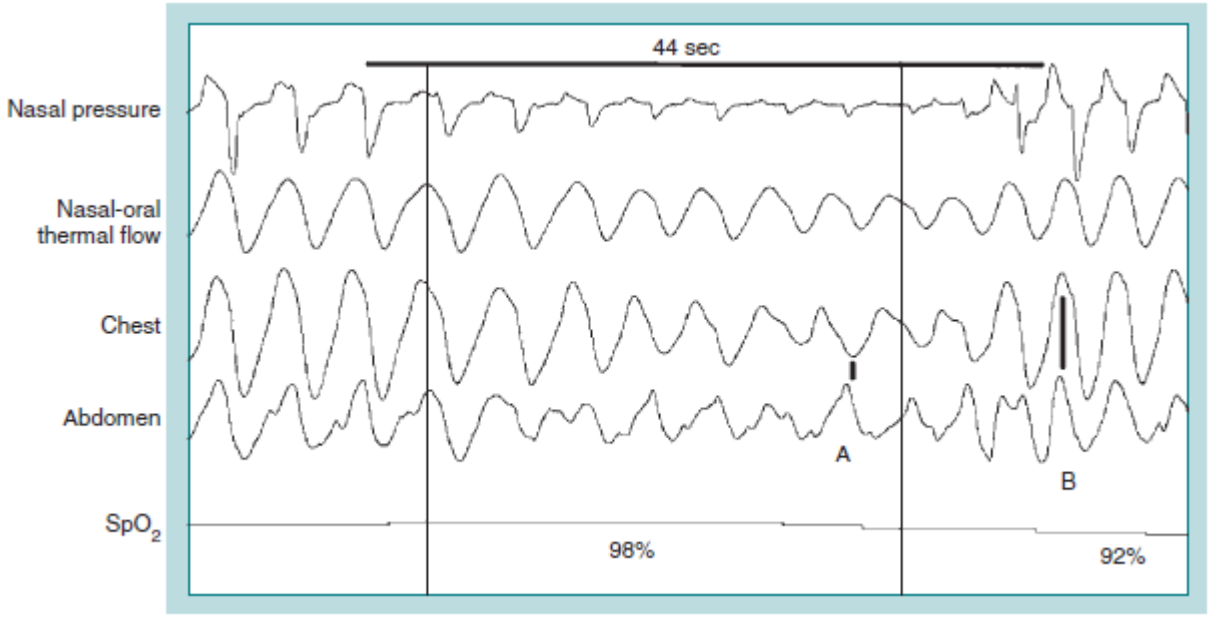
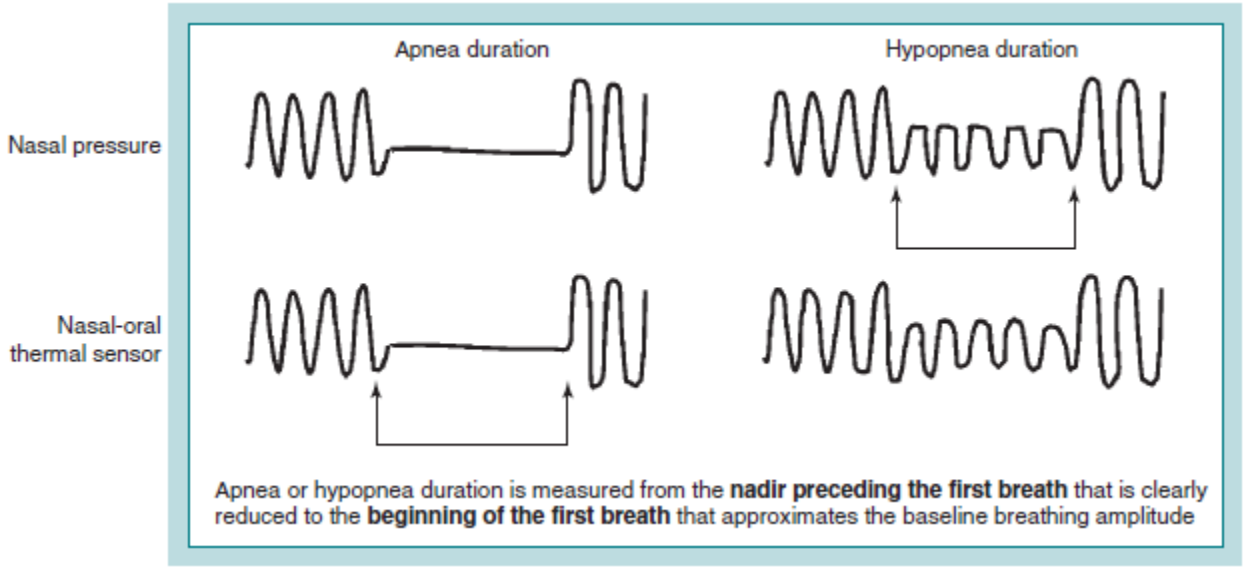
Hypopnea





Fundamentals of sleep medicine

RERA

Score a respiratory event as a respiratory effort related arousal if:

- there is a sequence of breaths lasting ≥ 10 seconds characterized by increasing respiratory effort or by flattening of inspiratory portion of nasal pressure(diagnostic study) waveform
- leading to arousal from sleep when the sequence of breath does not meet criteria for an apnea or hypopnea

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RERA

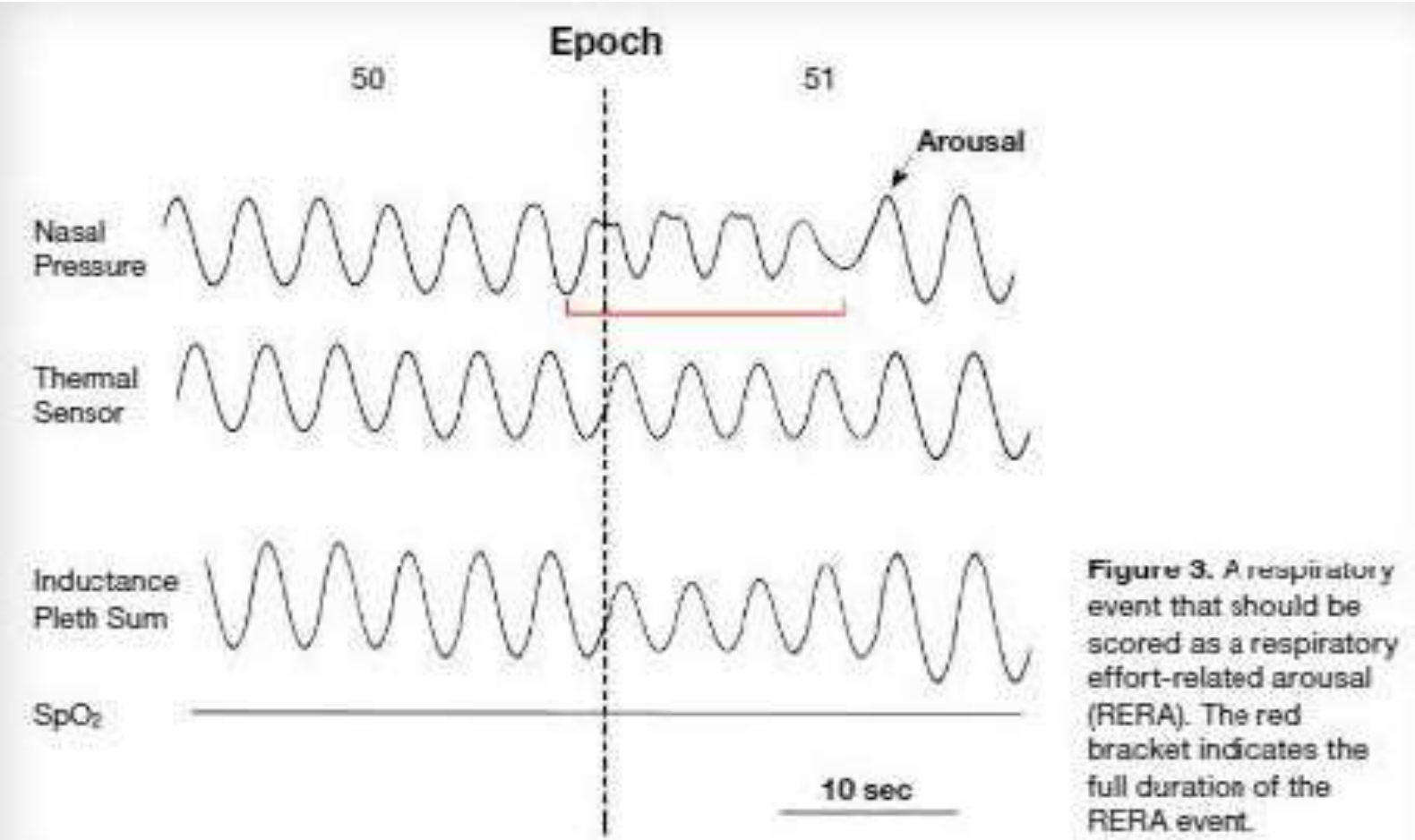

Figure 3. A respiratory event that should be scored as a respiratory effort-related arousal (RERA). The red bracket indicates the full duration of the RERA event.

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Hypoventilation

Score hypoventilation during sleep if either of the below occur:

- There is an increase in arterial pCO2 to a value >55mmHg for ≥ 10 minutes
- There is ≥ 10mmHg increase in arterial pCO2 during sleep(in comparison to an awake supine value) to a value exceeding 50mm Hg for ≥ 10 minutes

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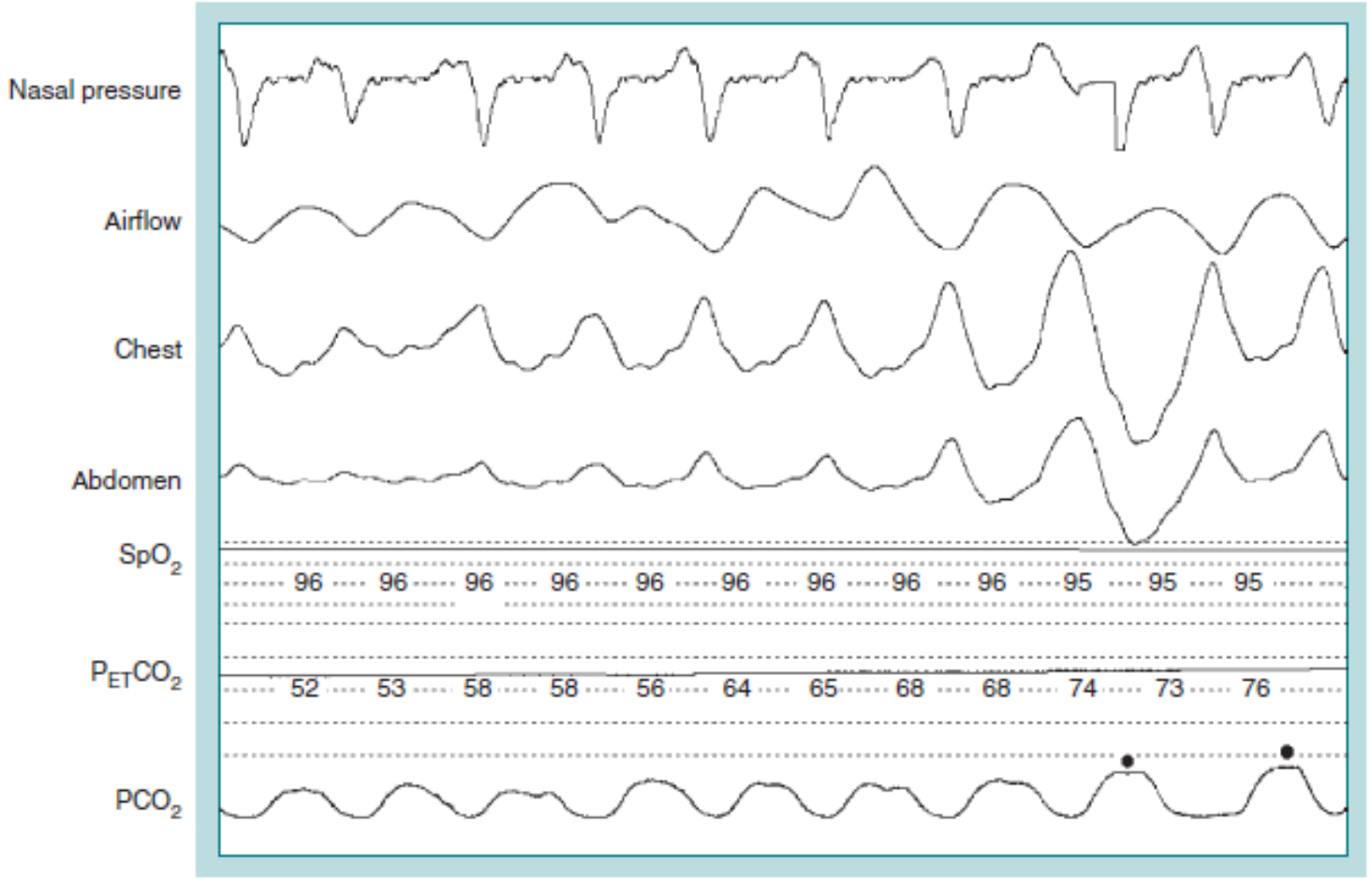
Hypoventilation



Fundamentals of sleep medicine

Cheyne-stokes breathing

Score a respiratory event as Cheyne-stokes breathing if both of the following are met :

- There are episodes of ≥ 3 consecutive central apneas and/or central hypopneas separated by crescendo and decrescendo change in breathing amplitude with a cycle length of ≥ 40 seconds
- There are ≥ 5 central apneas and /or hypopneas/hour of sleep associated with the crescendo/decrescendo breathing pattern recorded over ≥ 2hrs of monitoring

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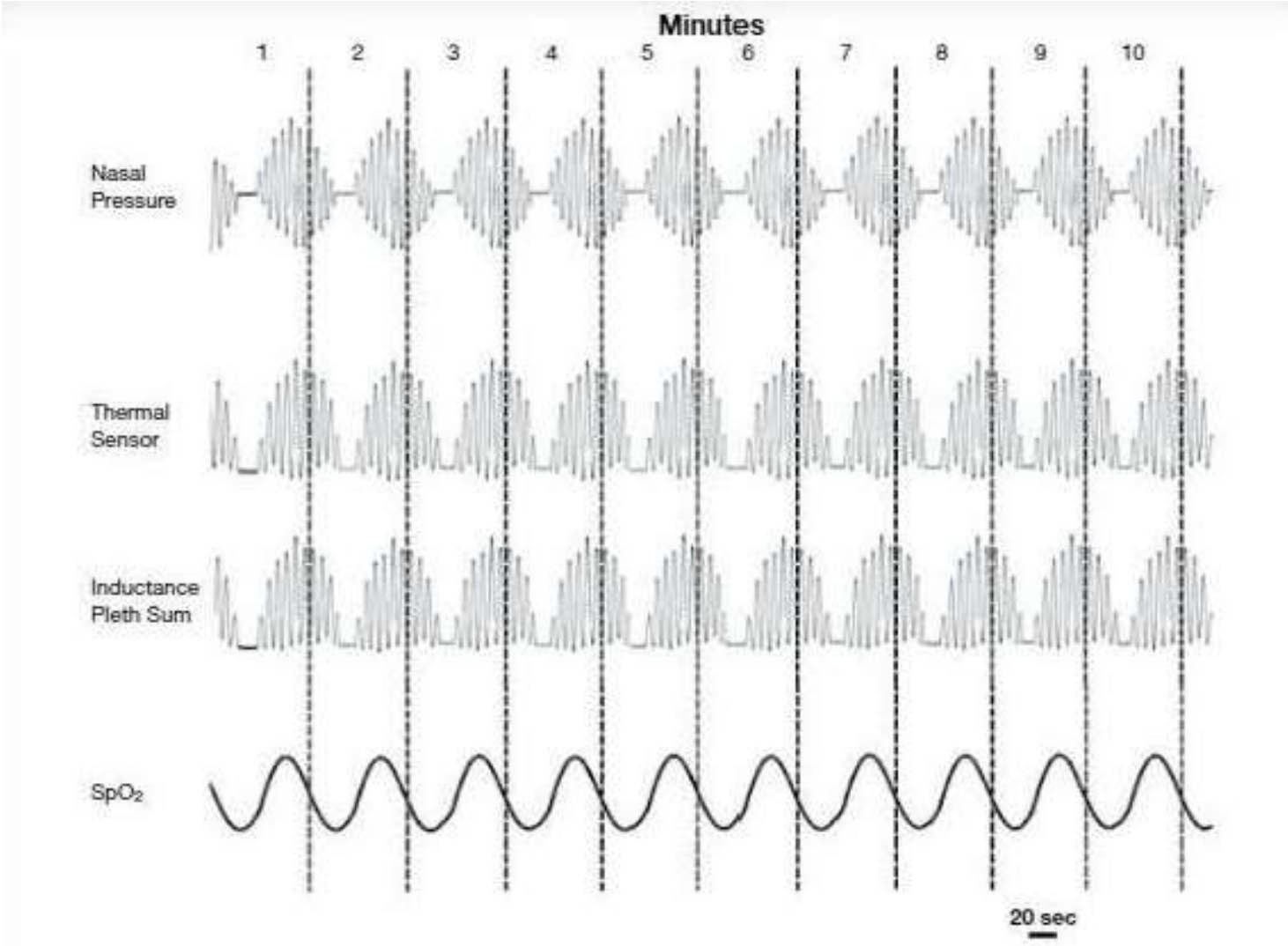

The AASM manual for the scoring of sleep and associated events,2018

Sleep summary

Lights out time:	22:18
Lights on time:	5:16
Total recording time (TRT):	418.5 min
Total sleep period (TSP):	402.5 min
Total sleep time (TST):	368.5 min
Wake after sleep onset (WASO):	34.0 min
Sleep latency:	16.1 min
REM latency:	142.0 min
Sleep efficiency:	88.0%

Position statistics

Position	Duration
Supine:	98.5 min
Left:	117.0 min
Right:	150.5 min
Prone:	2.5 min
Movement:	0.0 min
Total:	368.5 min

Sleep position

	Supine	Non-supine
Sleep duration:	98.5 min	270.0 min
% TST:	26.7%	73.3%
REM sleep time:	10.5 min	45.5 min

Sleep information

Sleep stage	Total time	% of TST
Wake:	50.1 min	
N1:	37.5 min	10.2
N2:	245.5 min	66.6
N3:	29.5 min	8.0
REM	56.0 min	15.2

Arousal summary

	NREM count (index)	REM count (index)	Total count	Total index
Total arousals:	181 (34.8)	29 (31.1)	210	34.2
Spontaneous arousals:	28 (5.4)	11 (11.8)	39	6.4
Respiratory arousals:	37 (7.1)	11 (11.8)	48	7.8
PLM arousals:	0 (0.0)	0 (0.0)	0	0.0
RERAs:	116 (22.3)	7 (7.5)	123	20.0

Apnea/hypopnea statistics

Respiration	Total number	Total index	Supine index	Non-supine index	NREM index	REM index	Supine REM index
AHI:	89	14.5	21.3	12.0	11.7	30.0	51.4
RDI:	212	34.5	40.2	32.4	34.0	37.5	68.6
Total apneas:	28	4.6	7.3	3.6	2.3	17.1	45.7
Obstructive:	27	4.4	7.3	3.3	2.3	16.1	45.7
Central:	1	0.2	0.0	0.2	0.0	1.1	0.0
Mixed:	0	0.0	0.0	0.0	0.0	0.0	0.0
Hypopnea:	61	9.9	14.0	8.4	9.4	12.9	5.7
RERA:	123	20.0	18.9	20.4	22.3	7.5	17.1

SpO2 statistics		Pulse statistics	
Baseline SpO2%:	95.2	Baseline pulse:	88.2
Minimum SpO2%:	88.0		
ODI 4%:	11.2	Mean pulse:	72.1
Saturation <90%:	0.2		

Sample PSG report