Polysomnography beyond Sleep-disordered Breathing ...

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Overview of Seminar

- International classification of sleep disorders
- PSG in evaluation of hypersomnolence
- PSG in evaluation of sleep-related movement disorders
- PSG in evaluation of parasomnias
- PSG in evaluation of insomnia disorders
- PSG in evaluation of sleep-related movement disorders
- Take home message

International Classification of Sleep Disorders (ICSD)- 3rd Edition

Seven major categories:

- Sleep-related breathing disorders (SDBs)
- Central disorders of hypersomnolence
- Sleep-related movement disorders
- Parasomnias
- Insomnia disorders
- Circadian rhythm sleep-wake disorders
- Other sleep disorders

Classification of sleep disorders. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014

Evaluation of Hypersomnolence

CASE:

- 20 years/male
- BMI- 33.4 kg/m2
- C/o Excessive day time sleepiness
- Also reported to have uncontrollable "sleep attacks" during day time (reading, watching television, etc)
- Gave history of sudden loss of posture (buckling of knees) while awake, however, there was no history of sleep paralysis or hallucinations during onset or offset of sleep
- No history snoring and choking episodes
- No other comorbidities

Evaluation of Hypersomnolence

ICSD-3 defines excessive daytime sleepiness (EDS):

- Inability to maintain wakefulness and alertness during major waking episodes of day, with sleep occurring unintentionally or at inappropriate times almost daily for at least three months

HISTORY:

- Sleepiness in sedentary situations as driving, desk work, reading, or watching television

- Patient complain of drowsiness that interferes with daytime activities, unavoidable napping, or both

- Falling asleep while driving or at other particularly inappropriate or dangerous times is often the impetus that brings the patient to clinician

- Other symptoms: Lack of energy, tiredness, fatigue

Classification of sleep disorders. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014

Table 1. Differential Diagnosis of Chronic Daytime Sleepiness.*

Diagnosis	Distinguishing Characteristics
Insufficient sleep	Sleepiness decreases with more sleep on weekends and holidays
Obstructive sleep apnea	Snoring, witnessed episodes of apnea, large tonsils, large tongue, long uvula, obesity
Narcolepsy	Cataplexy, hypnagogic and hypnopompic hallucinations, sleep paralysis, fragmented sleep
Delayed sleep phase disorder	Sleepiness in the morning, alertness at night
Periodic limb movement disorder	Sleep disrupted by kicking movements; often occurs with the restless legs syndrome, iron deficiency, uremia, and neuropathy
Shift-work sleep disorder	Sleepiness when working at night, insufficient sleep during the day
Use of sedating medications	Insomnia medications, opiates, anxiolytics, anticonvulsants, antipsychotics, antidepressants, antihistamines, among others
Idiopathic hypersomnia	Lengthy nighttime sleep and long naps, difficulty waking from sleep
Depression	Increased time in bed but little functional sleepiness on the multiple sleep latency test
Other medical disorders	Symptoms of hypothyroidism, Parkinson's disease, the Prader–Willi syndrome, myotonic dystrophy, among others

* With most of these disorders, people do not feel rested when arising in the morning; however, most people with narcolepsy feel alert on awakening.

Central disorders of hypersomnolence

Disorder
Narcolepsy type 1
Narcolepsy type 2
Idiopathic hypersomnia
Kleine-Levin syndrome
Hypersomnia due to a medical disorder
Hypersomnia due to a medication or substance
Hypersomnia associated with a psychiatric disorder
Insufficient sleep syndrome

Classification of sleep disorders. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014

Epworth Sleepiness Scale

- Scores >10 considered abnormal and supportive of complaint of EDS
- Easy to administer
- High score raises the likelihood of true EDS as opposed to fatigue or low energy
- Assess of degree of functional impairment due to excessive sleep

Table 88-2 Epworth Sleepiness Scale	
Situation	**Chance of Dozing**
Sitting and reading	
Watching TV	
Sitting inactive in a public place (such as a theater or meeting)	
Riding as a passenger in a car for an hour without a break	
Lying down in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after a lunch without alcohol	
In a car, while stopped for a few minutes in traffic	
	Score = total (normal < 11)

Instructions to patient:

"What is the chance that you would doze off or fall asleep (not just "feel tired") in each of the following situations? Rate the chance for each situation. If you are never or rarely in the situation, please give your best guess for that situation."

Chance of dozing: 0, never; 1, slight chance; 2, moderate chance; 3, high chance.

Evaluation of hypersomnolence

- Assess sleep duration and timing: Rule out insufficient sleep syndrome or circadian rhythm sleep-wake disorders

- Sleep logs and actigraphy: Valuable to track sleep patterns over days to weeks, ensure adequate sleep duration before objective assessment of hypersomnolence with MSLT

Actigram:

- Agreement between actigraphy and PSG in detection of sleep is approximately 90%

- Accepted as valid method to evaluate sleep patterns

- ICSD-3 recommends documentation of sleep duration for 7 days on sleep log and, whenever possible, actigraphy in conjunction with the sleep log, before MSLT

Marino M. et al. Sleep 2013;36(11):1747–55
Classification of sleep disorders. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014

Nocturnal PSG

- Many patients referred for EDS have nocturnal sleep disorders→ nocturnal PSG can diagnose and rule out sleep apnea, delayed sleep phase disorder, and periodic limb movement disorder

- PSG may show fragmented, light sleep and an early transition into REM sleep

- Mean nocturnal sleep latency: Single variable that best reflects sleepiness

Nocturnal PSG

- Short latency to REM sleep on overnight PSG can provide valuable clue to the presence of narcolepsy

- REM onset latency < 15 minutes on nocturnal PSG had poor sensitivity (approx. 40%) but excellent specificity (99.6%) for type 1 narcolepsy

- ICSD-3 allows a sleep-onset REM period, on overnight PSG, to account for one of the two REM periods necessary to diagnose narcolepsy

Multiple sleep latency test (MSLT)

- Standard investigation for assessing daytime sleepiness objectively

- After monitoring amount and quality of previous night's sleep (overnight PSG)➔ Patient is given 4 or 5 nap opportunities at 2 hourly intervals

- Subject rests in quiet darkened room and the latency to sleep is determined

- Average latency from lying down to stage 1 sleep noted

Multiple Sleep Latency Test- An American Sleep Disorders Association Report. Thorpy et al

MSLT

- Mean sleep latency on MSLT: Most commonly used objective measure in assessment of daytime sleepiness

- Mean sleep latencies < 8 minutes on properly conducted MSLT are considered abnormal

- Latencies < 5 minutes often indicate severe excessive daytime sleepiness

- If REM sleep latency is within 15 min in at least two of the naps, along with mean sleep latency across the naps is 8 min or less→ fulfils criteria for narcolepsy

Multiple Sleep Latency Test- An American Sleep Disorders Association Report. Thorpy et al

MSLT

- For diagnosis of narcolepsy—2 or more sleep-onset REM periods (SOREMPs) and short mean sleep latency needed

- PPV of two or more SOREMPs for diagnosis of narcolepsy was 98%, and the NPV was 89%   *Amira SA et al. Sleep 1985;8:325–31*

- PPV of two or more SOREMPs was 57% and the NPV was 98%   *Aldrich MS. Et al. Sleep 1997;20:620–9*

- Presence of SOREMPs must be interpreted in conjunction with other clinical and polysomnographic findings

- Criterion of two or more SOREMPs cannot be used to diagnose narcolepsy when the patient has untreated OSA

MSLT considerations

- Results may be misleading if they are affected by noise, anxiety, or atypical sleep on the previous night

- Medications that suppress REM sleep should be discontinued well in advance of test (e.g., 3 weeks for antidepressants with a long half-life), and any other psychoactive medications, (especially stimulants) should be discontinued 1 week in advance

- Documentation with sleep log an adequate amount of sleep each night in the week before the MSLT necessary

- During the overnight sleep study preceding the test, adults should get at least 6 hours of sleep

Indications for the MSLT

Narcolepsy: Indicated for all patients suspected of narcolepsy to confirm the diagnosis and to determine the severity of sleepiness and should be performed before commencing treatment with stimulant medications

Obstructive sleep apnea syndrome:

(a) Indicated in patients with mild to moderate OSA who complain of moderate to severe sleepiness

(b) May be indicated in patients with moderate to severe OSA syndrome, especially if severe sleepiness is unappreciated or denied

Other causes of excessive sleepiness: Evaluation of patients suspected of having idiopathic hypersomnia, periodic limb movement disorder or when cause of excessive sleepiness is unknown

Multiple Sleep Latency Test- An American Sleep Disorders Association Report. Thorpy et al

Indications for the MSLT…

Assessment of treatment effects: Indicated to assess the response to treatment following effective therapy for disorders that cause sleepiness when an additional sleep disorder that produces sleepiness is suspected, or if confirmation of relief of sleepiness is required to ensure occupational safety

Repeat MSLT testing: Repeat MSLT testing is indicated :

(a)   when the initial test is believed to be an invalid representation of the patient's status

(b)   when ambiguous or uninterpretable MSLT findings occur

(c)   when the response to treatment needs to be ascertained

(d)   when more than one sleep disorder is suspected

Multiple Sleep Latency Test- An American Sleep Disorders Association Report. Thorpy et al

Maintenance of wakefulness test (MWT)

- A variation of the MSLT, the Maintenance of Wakefulness Test (MWT): Performed under identical conditions as the MSLT but with the patient semi-reclining and instructed to attempt to remain awake

- Subjects instructed to stay awake, usually in four 40 min sessions, in monotonous isolated environment→ monitored for drowsiness and sleep onset

- Used less commonly than the MSLT and mainly used to assess improved alertness following therapeutic interventions

MWT

- More important safety question for work and driving
- Indicated in assessment of individuals in whom the inability to remain awake constitutes safety issue, or in patients with narcolepsy or idiopathic hypersomnia to assess response to treatment with medications
- Total of 97.5% of normal sleepers stay awake for an average of eight minutes or more during the MWT
- Falling asleep in < 8 minutes during the test would be considered abnormal
- Results show that from 40% to 59% of people with normal sleep stay awake for entire 40 minutes of all four trials

MWT

- The MWT results may better reflect improvement with treatment as compared to MSLT results

- Shorter sleep latencies on MWTs correlate with increased errors on driving simulation tests

- The Federal Aviation Administration and other agencies at times request or require an MWT

- Because of dearth of proven real-life predictive value, the role of this test or the MSLT in predicting workplace safety remains controversial

24-hour PSG

- About 40% of patients with idiopathic hypersomnia demonstrate mean sleep latencies >8 minutes on the MSLT despite severe subjective sleepiness

- Finding is more common in patients with long nocturnal sleep durations

- In these individuals, prolonged PSG reveals total sleep duration near 700 minutes over 24 hours

- 24-hour: Total sleep time of at least 660 minutes can be used to diagnose idiopathic hypersomnia in patients with symptoms consistent with the disorder but mean sleep latency >8 minutes

Classification of sleep disorders. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014

Narcolepsy type 1 Diagnosis

- Subjective complaint of sleepiness

- Demonstration of CSF hypocretin-1 deficiency (<110 pg/mL or < one-third of the normal values with the same standardized assay) or

- Mean latency of < 8 min on MSLT, with evidence of sleep-onset rapid eye movement periods (SOREMPs) and

- Clear cataplexy (defied as ">1episode of generally brief [<2 min], usually bilaterally symmetrical, sudden loss of muscle tone with retained consciousness")

- A SOREMP (<15 min) on preceding overnight PSG is highly specific for a diagnosis of narcolepsy and shows significant positive predictive value

- MSLT criteria of ICSD-3 for both types of narcolepsy include a requirement of either 2 SOREMPs on MLST, or a SOREMP on the PSG coupled with at least one SOREMP on the MSLT

Andlauer O. et al JAMA Neurol . 2013 ;70 (7): 891-902
Classification of sleep disorders. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014

Narcolepsy type 2 Diagnosis

- Subjective complaint of sleepiness

- MSLT requirements of a mean latency < 8 min and two SOREMPs (or one SOREMP on PSG and one or more on MSLT)

- Cataplexy must be absent and

- Cerebrospinal fluid hypocretin-1 levels, if measured, must not meet the narcolepsy type 1 criterion

Classification of sleep disorders. 3rd ed. Darien, IL:American Academy of Sleep Medicine; 2014

Idiopathic Hypersomnolence Diagnosis

- Report of subjective sleepiness
- MSLT showing a mean latency of <8 min with
  - Fewer that two SOREMPs (including any SOREMP on the PSG from the preceding night),
  - Absence of cataplexy and hypocretin deficiency (if measured), and
  - No other identifiable cause
- Who do not meet the objective MSLT criterion for sleepiness, 24-h PSG or 1-week actigraphy/sleep logs with unrestricted sleep→ Demonstration of ≥ 660 min average daily sleep time in adults satisfies the criterion for objective sleepiness along with the MSLT findings

Workup of the case....

Nocturnal PSG

Sleep Stages
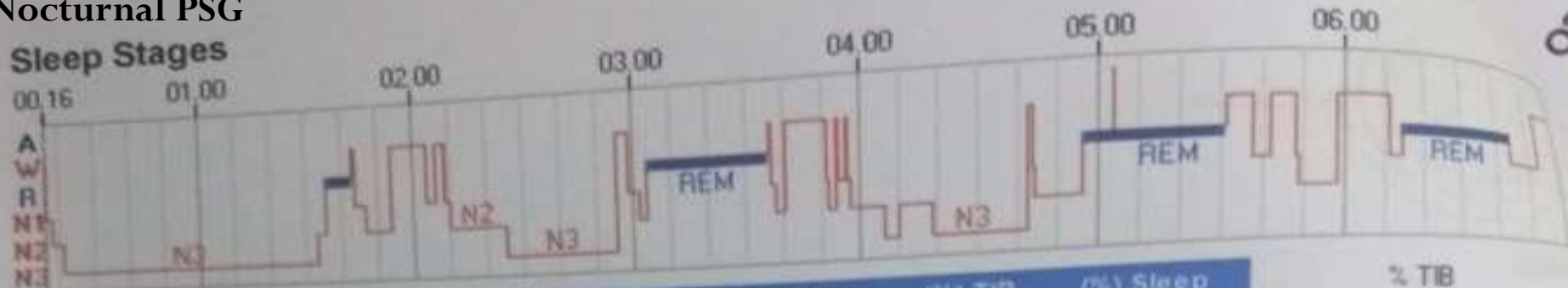
Total Sleep Time (TST)	05.39.08
Sleep Efficiency [%]	84.1
Sustained Sleep Eff. [%]	84.1
Sleep Latency [m]	0.5
Sleep Latency N1 [m]	0.5
Sleep Latency N2 [m]	2.5
Deep Sleep Latency [m]	6.5
REM latency [m]	79.0
Total Sleep Period (SPT)	06.36.30
Sleep Stage Change (Index)	47 (7.0)
# Wake (Index)	12 (2.1)
#Wake respiratory (Index)	0 (0.0)

Sleep Stage	Duration	(%) TIB	(%) Sleep
Artefact	00.00.27	0.1	-
Wake	01.03.29	15.7	-
REM	01.44.30	25.9	30.8
N1	00.34.47	8.6	10.3
N2	01.10.58	17.6	20.9
N3	02.08.52	31.9	38.0
Light Sleep	01.45.46	26.2	31.2
Deep Sleep	02.08.52	31.9	38.0
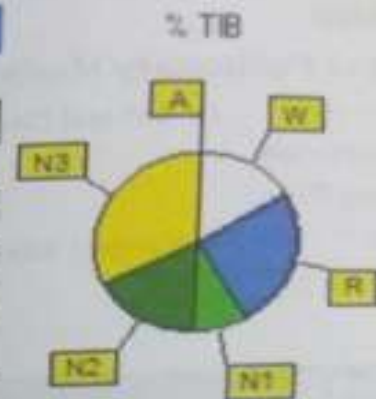
Respiratory Analysis

Number (Index)	
Obstructive	4 (0.7)
Mixed	-
Central	-
Undef Ap.	-
Total Ap.	4 (0.7)
Hypopnea	15 (2.7)
A+H	19 (3.4)
Limitation	2 (0.4)
RERAs	-
RDI	21 (3.7)

	REM	Non-REM	Sleep
Apnea (Index)	2 (1.1)	2 (0.5)	4 (0.7)
Hypopnea (Index)	9 (5.2)	6 (1.5)	15 (2.7)
AHI / RDI [/h]	6.3 / 7.5	2.0 / 2.0	3.4 / 3.7
Flow Limitation (Index)	2 (1.1)	-	2 (0.4)
RERAs (Index)	-	-	-
Max. Apnea Duration [s]	54	11	54
Max. Hypopnea Duration [s]	72	46	72
Average Apnea Dur. [s]	36.9	11.1	24.0
Average Hypopnea Dur. [s]	25.7	34.9	29.4
Artefact [min]	-	0.4 (0.2%)	0.4 (0.1%)

Hypopnea-rules 1: Desaturation 3 %, Ratio 70 %

MSLT Nap 1

	from	to	Artefact	Duration
Recorded Time	07-08-2018 11.09.00 A	07-08-2018 11.55.00 A		00.46.00
TIB	07-08-2018 11.19.20 A	07-08-2018 11.53.56 A	-	00.34.36

Sleep Stages
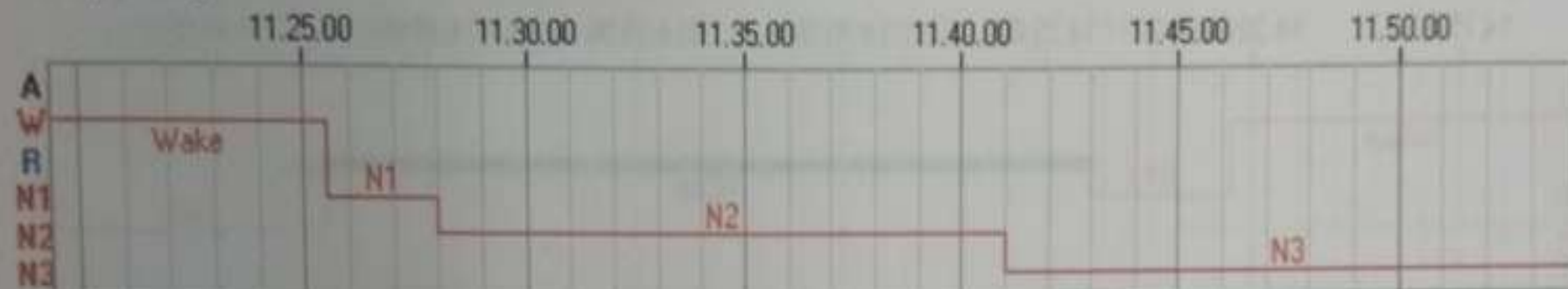
		Sleep Stage	Duration	(%) TIB	(%) Sleep
Total Sleep Time (TST)	00.28.26				
Sleep Efficiency [%]	82.2				
Sustained Sleep Eff. [%]	100.0	Artefact	-	-	-
Sleep Latency [m]	6.2				
Sleep Latency N1 [m]	6.2	Wake	00.06.09	17.8	-
Sleep Latency N2 [m]	8.7	REM	-	-	-
Deep Sleep Latency [m]	21.7	N1	00.02.30	7.2	8.8
REM latency [m]	-	N2	00.13.00	37.6	45.7
Total Sleep Period (SPT)	00.28.26	N3	00.12.56	37.4	45.5
Sleep Stage Change (Index)	3 (5.2)				
# Wake (Index)	-	Light Sleep	00.15.30	44.8	54.5
#Wake respiratory (Index)	0 (0.0)	Deep Sleep	00.12.56	37.4	45.5
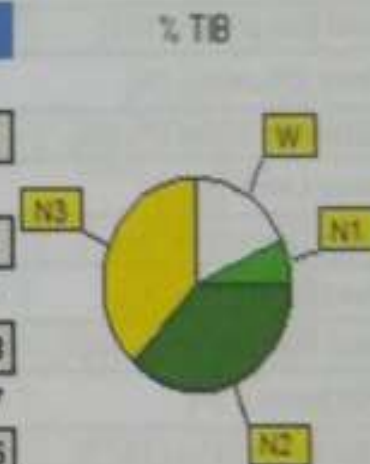
MSLT Nap 2

Description: MSLT Nap 2

	from	to	Artefact	Duration
				00.38.00
Recorded Time	07-08-2018 2.12.00 PM	07-08-2018 2.50.00 PM		
			-	00.36.39
TIB	07-08-2018 2.12.33 PM	07-08-2018 2.49.12 PM		
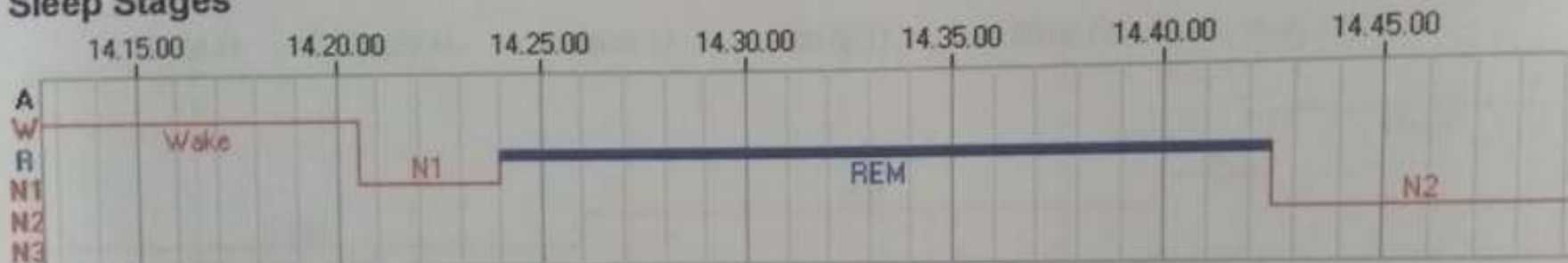
Sleep Stages

Total Sleep Time (TST)	00.28.42
Sleep Efficiency [%]	78.3
Sustained Sleep Eff. [%]	100.0
Sleep Latency [m]	7.9
Sleep Latency N1 [m]	7.9
Sleep Latency N2 [m]	29.9
Deep Sleep Latency [m]	-
REM latency [m]	3.5
Total Sleep Period (SPT)	00.28.42
Sleep Stage Change (Index)	3 (4.9)
# Wake (Index)	-
#Wake respiratory (Index)	0 (0.0)

Sleep Stage	Duration	(%) TIB	(%) Sleep
Artefact	-	-	-
Wake	00.07.56	21.7	-
REM	00.18.30	50.5	64.4
N1	00.03.30	9.5	12.2
N2	00.06.42	18.3	23.4
N3	-	-	-
Light Sleep	00.10.12	27.9	35.6
Deep Sleep	-	-	-

% TIB
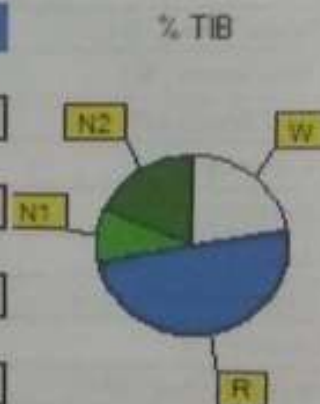
MSLT Nap 3

Description: MSLT Nap 3

	from	to	Artefact	Duration
Recorded Time	07-08-2018 4.48.00 PM	07-08-2018 5.19.00 PM		00.31.00
TIB	07-08-2018 4.48.24 PM	07-08-2018 5.18.53 PM	-	00.30.29

Sleep Stages
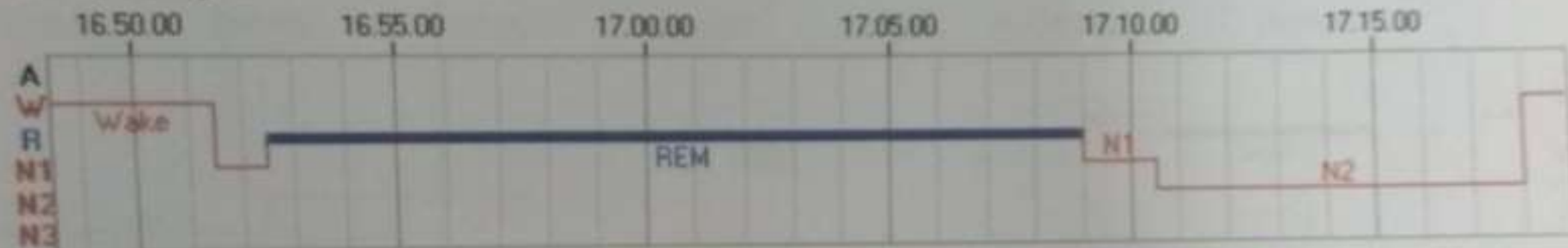
		Sleep Stage	Duration	(%) TIB	(%) Sleep
Total Sleep Time (TST)	00.26.30				
Sleep Efficiency [%]	86.9				
Sustained Sleep Eff. [%]	96.7	Artefact	-	0.0	-
Sleep Latency [m]	3.1				
Sleep Latency N1 [m]	3.1	Wake	00.03.59	13.1	-
Sleep Latency N2 [m]	22.1	REM	00.16.30	54.1	62.3
Deep Sleep Latency [m]	-	N1	00.02.30	8.2	9.4
REM latency [m]	1.0	N2	00.07.30	24.6	28.3
Total Sleep Period (SPT)	00.26.30	N3	-	-	-
Sleep Stage Change (Index)	5 (9.8)				
# Wake (Index)	1 (2.3)	Light Sleep	00.10.00	32.8	37.7
#Wake respiratory (Index)	0 (0.0)	Deep Sleep	-	-	-
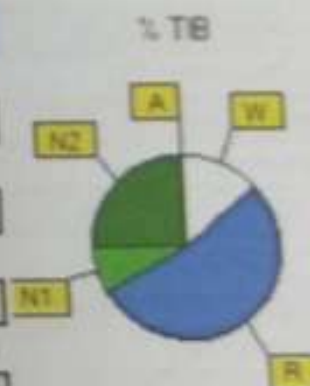
MSLT Nap 4

Description: MSLT Nap 4

	from	to	Artefact	Duration
Recorded Time	07-08-2018 7.52.00 PM	07-08-2018 8.30.00 PM		00.38.00
TIB	07-08-2018 7.54.05 PM	07-08-2018 8.29.56 PM	-	00.35.51

Sleep Stages
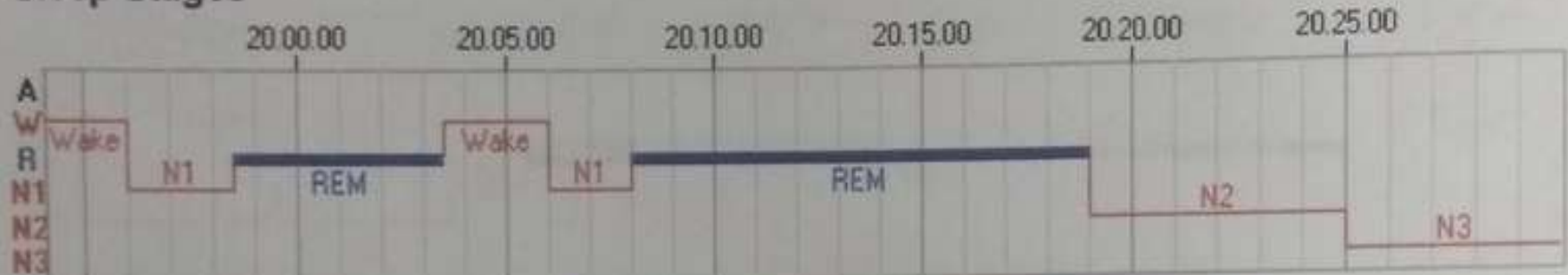
		Sleep Stage	Duration	(%) TIB	(%) Sleep
Total Sleep Time (TST)	00.31.26				
Sleep Efficiency [%]	87.7				
Sustained Sleep Eff. [%]	92.6	Artefact	-	-	-
Sleep Latency [m]	1.9				
Sleep Latency N1 [m]	1.9	Wake	00.04.24	12.3	-
Sleep Latency N2 [m]	24.9	REM	00.16.00	44.6	50.9
Deep Sleep Latency [m]	30.9	N1	00.04.30	12.6	14.3
REM latency [m]	2.5	N2	00.06.00	16.7	19.1
Total Sleep Period (SPT)	00.33.56	N3	00.04.56	13.8	15.7
Sleep Stage Change (Index)	7 (11.7)				
# Wake (Index)	1 (1.9)	Light Sleep	00.10.30	29.3	33.4
#Wake respiratory (Index)	0 (0.0)	Deep Sleep	00.04.56	13.8	15.7
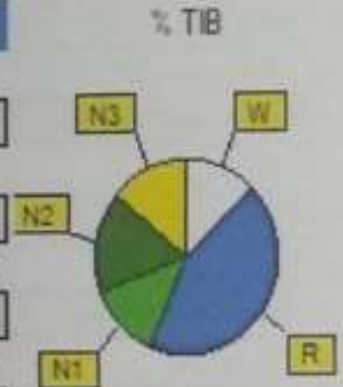
MSLT Nap 5

Description: MSLT Nap 5

	from	to	Artefact	Duration
Recorded Time	07-08-2018 10.25.00 P	07-08-2018 10.48.00 P		00.23.00
TIB	07-08-2018 10.25.35 P	07-08-2018 10.47.40 P	-	00.22.04

Sleep Stages
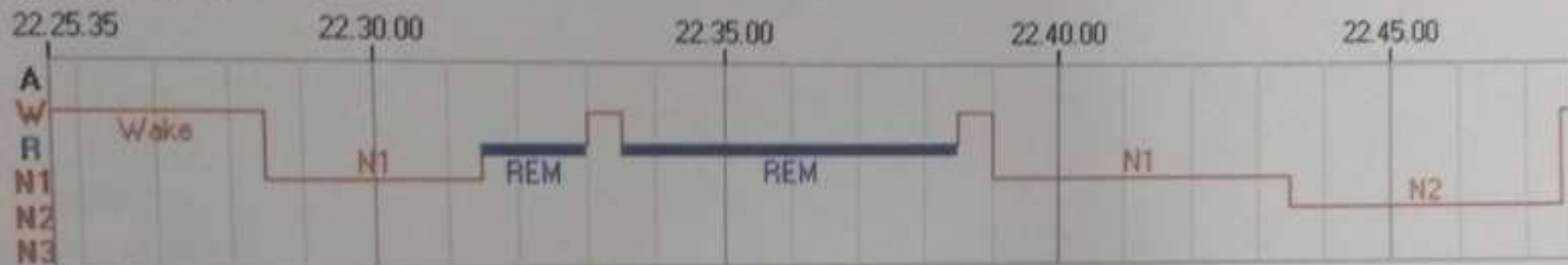
Total Sleep Time (TST)	00.18.00
Sleep Efficiency [%]	81.5
Sustained Sleep Eff. [%]	93.9
Sleep Latency [m]	2.9
Sleep Latency N1 [m]	2.9
Sleep Latency N2 [m]	17.9
Deep Sleep Latency [m]	-
REM latency [m]	3.0
Total Sleep Period (SPT)	00.19.00
Sleep Stage Change (Index)	8 (21.7)
# Wake (Index)	3 (10.0)
#Wake respiratory (Index)	0 (0.0)

Sleep Stage	Duration	(%) TIB	(%) Sleep
Artefact	-	-	-
Wake	00.04.04	18.5	-
REM	00.06.30	29.4	36.1
N1	00.07.30	34.0	41.7
N2	00.04.00	18.1	22.2
N3	-	-	-
Light Sleep	00.11.30	52.1	63.9
Deep Sleep	-	-	-
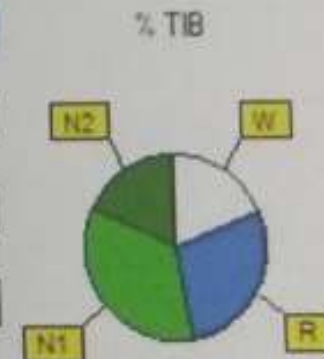
Name : Lachhman Kumar	Weight (Kg) : 107
CR No : 201603860371	Height (cm) : 179
Age/Sex : 20/M	BMI : 33.4
S No.717	Date : 07/8/18 and 08/8/18

Comorbidities: None

Epworth Sleepiness Scale: 20

STOP BANG: 2

AHI: 3.4

Summary: Mr Lachhman Kumar was evaluated in Pulmonology clinic for excessive day time sleepiness. He reported to have uncontrollable "sleep attacks" during day time. He also gave history of sudden loss of posture (buckling of knees) while awake (?partial cataplexy). He denied history of sleep paralysis or hypnagognic hallucinations.

He underwent Diagnostic Sleep study followed by MSLT. Diagnostic study was done on 7th Aug 2018 followed by MSLT on 8th Aug 2018. AHI in diagnostic component was 3.4/h. Sleep period time in the night's diagnostic study was 5h 39mins. SOREMP was observed in 4 out of 5 nap opportunities during MSLT. Mean time for sleep latency was 4.4 min. MSLT is consistent with a diagnosis of Narcolepsy.

Sleep-Related Movement Disorders

Disorder
Restless legs syndrome
Periodic limb movement disorder
Sleep-related leg cramps
Sleep-related bruxism
Sleep-related rhythmic movement disorder
Benign sleep myoclonus of infancy
Propriospinal myoclonus at sleep onset
Sleep-related movement disorder due to a medical disorder
Sleep-related movement disorder due to a medication or substance
Sleep-related movement disorder, unspecified

RESTLESS LEGS SYNDROME (RLS)

- Common sleep-related movement disorder characterized by unpleasant or uncomfortable urge to move the legs, sometimes accompanied by an uncomfortable sensation that
  - occurs primarily with rest/inactivity;
  - partially or totally relieved by movement, for as long as the movement occurs; and
  - occurs primarily in the evening or night

Birgit Hogl. et al. Movement Disorders,Vol. 32, No. 5, 2017

RLS

- The ICSD-3 criteria differ from the International Restless Legs Syndrome Study Group definition: distress, associated sleep disturbance, or impairment is required to establish the ICSD diagnosis

- During sleep, patients with RLS have characteristic limb movements, called periodic limb movements of sleep (PLMS), which may or may not be associated with arousal

RLS

- RLS associated with other neurologic diseases, such as neuropathy, spinal cord disease, multiple sclerosis, or Parkinson disease

- Assessment of affect and mood to identify psychiatric disorders is important→ mental health morbidity frequently coexists with RLS

- Low serum iron and ferritin levels: > 1/3 patient have low serum iron levels, and > 2/3 have ferritin values of 50 ng/mL or less

- Depression, fatigue, and increased severity of symptoms are associated with low serum iron levels in RLS patients

- Ferritin levels: inversely related to RLS severity

- Diagnosis of RLS requires specific interview and active exclusion of mimics

RLS

Nocturnal Polysomnography

- Not routinely indicated in evaluation of RLS

- Should be performed only if clinician suspects comorbid sleep disorder such as OSA

- Periodic limb movements during sleep found in up to 90% of patients with RLS

- Periodic limb movements during sleep are nonspecific→ they occur in approximately 25% of individuals without RLS

Periodic limb movements disorder (PLMD)

- Clinical sleep disturbance attributed to an increased number of periodic limb movements of sleep (PLMS), in the absence of alternative causes of the sleep complaints

- PLMS are repetitive, highly stereotyped limb movements that occur during sleep, typically involving dorsal extension of the big toe, often in combination with partial flexion of the ankle, the knee, and sometimes the hip

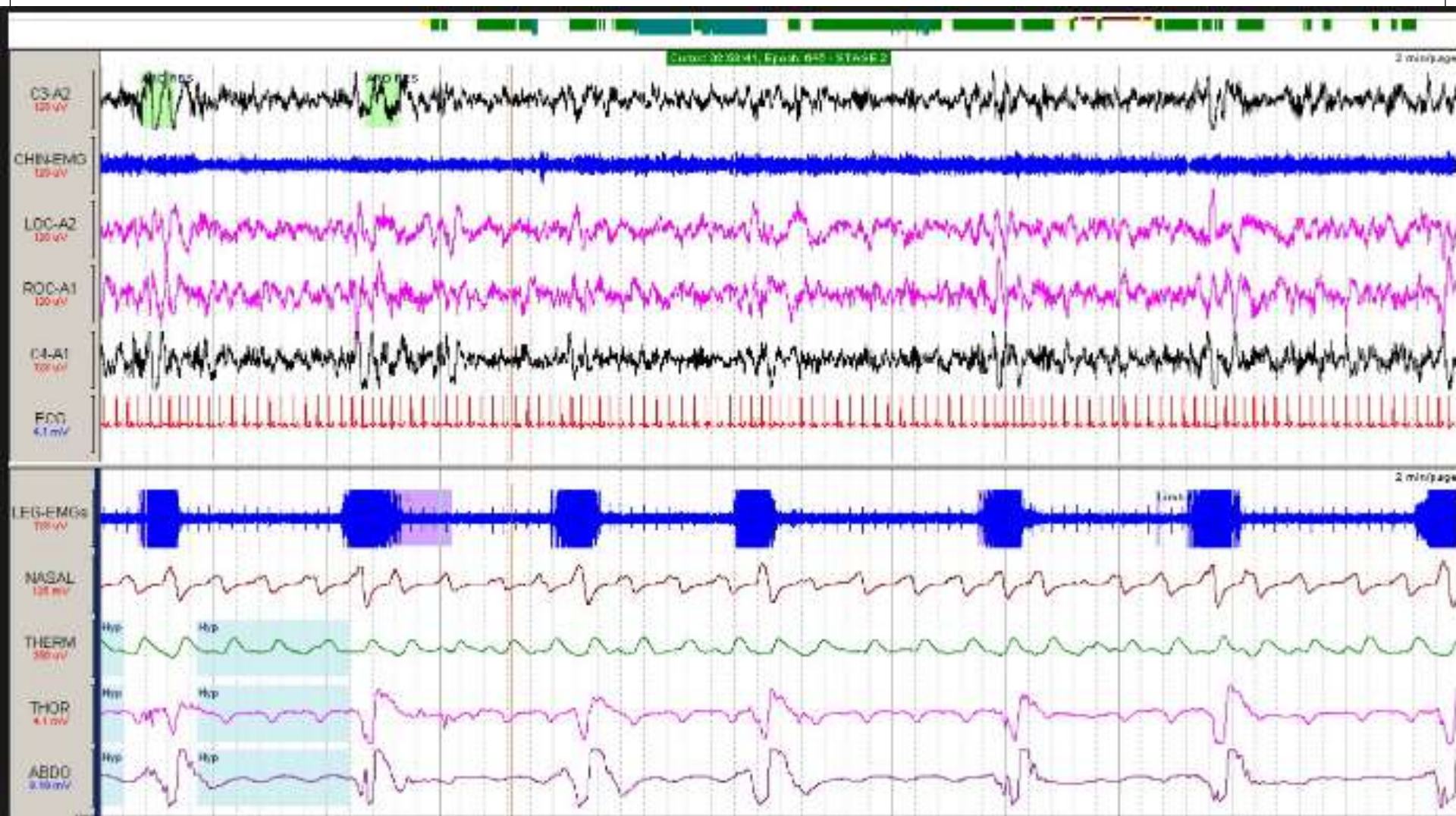- PLMD and RLS are distinct, mutually exclusive diagnoses

PLMS

Criteria for PLMS developed by American Academy of Sleep Medicine (AASM) include:

- Minimum number of consecutive limb movement (LM) events needed to define PLMS series is 4 LMs

- Minimum period length between LM (defined as the time between the onsets of consecutive LMs) to include them as part of a PLMS series is 5 seconds

- Maximum period length between LMs to include them as part of a PLMS series is 90 seconds

- LMs on two different legs separated by <5 seconds between movement onsets are counted as a single movement

Classification of sleep disorders. 3rd ed. Darien, IL:American Academy of Sleep Medicine; 2014

PLMS

- PSG demonstrates repetitive movements of 0.5 to 10 seconds duration, separated by interval of 20 to 40 seconds (range 5 to 90 seconds)

- PLMS can occur simultaneously in both legs, alternate between legs, or occur unilaterally

- Duration of leg movement is typically between 1.5 and 2.5 seconds

- Intensity and anatomic distribution vary from slight extension of the great toe to a prominent triple flexion of the entire leg

- Movements are most pronounced in stage N1 and stage N2 of sleep, often accompanied by K-complexes on PSG and an increase in pulse and BP

- PLMS may result in arousals but are not generally associated with insomnia

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PLMD

- PLMS accompany most cases of RLS but are not specific to RLS

- Most people with RLS have PLMS, but many people with PLMS do not have RLS

- One study found that only 17 % of subjects with PLMS on PSG had symptoms of RLS→ Presence of PLMS in PSG in patient without RLS may indicate genetic risk for RLS

- ICSD-3 states that PLMD cannot be diagnosed in the context of RLS, narcolepsy, untreated obstructive sleep apnea, or RBD

- Diagnosis of RLS takes precedence over that of PLMD when potentially sleep-disrupting PLMS occur in context of RLS

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PLMD diagnosis

- Based on clinical history of sleep disturbance or daytime fatigue, combined with polysomnography (PSG) showing an excessive number of PLMS

- Exclusion of alternative causes as RLS, obstructive sleep apnea, and narcolepsy

- Diagnostic criteria for PLMD:

  - PLMS of > 15 periodic limb movements per hour of sleep time in adults (> 5 in children)

  - Causing clinically significant sleep disturbance or impairment in mental, physical, social, occupational, educational, or behavioral wellbeing not explained by some other entity

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Periodic limb movement disorder (PLMD)

Severity Criteria:

- *Mild*: Mild insomnia or mild sleepiness, and typically associated with a PLM index of 5 or more but less than 25

- *Moderate*: Moderate insomnia or moderate sleepiness, and typically associated with a PLM index of 25 or more but less than 50

- *Severe*: Severe insomnia or severe sleepiness, and typically associated with a PLM index of 50 or more or a PLM–arousal index of greater than 25

PARASOMNIAS

NREM-related parasomnias

    Confusional arousals

    Sleepwalking

    Sleep terrors

    Sleep-related eating disorder

REM-related parasomnias

    REM sleep behavior disorder

    Recurrent isolated sleep paralysis

    Nightmare disorder

Other parasomnias

    Exploding head syndrome

    Sleep-related hallucinations

    Sleep enuresis

    Parasomnia due to a medical disorder

    Parasomnia due to a medication or substance

    Parasomnia, unspecified

PARASOMNIAS

- Parasomnias consist of clinical disorders that have **undesirable physical phenomena** that occur predominantly during sleep

- Include disorders of arousal, partial arousal, and sleep-stage transition

- Many of the parasomnias are manifestations of central nervous system activation

- Autonomic nervous system changes and skeletal muscle activity are the predominant features of this group of disorders

- Except REM sleep behavior disorder (RBD), parasomnias can be diagnosed by history alone

Role of PSG

- If the behavior in question occurs during the PSG: diagnostic value

- May effectively differentiate sleep-related epilepsy from parasomnias

- Appropriate additional recording devices, as extra EEG leads, extra surface electromyogram (EMG) leads, or video monitoring, used

- Besides chin EMG and anterior tibialis EMG, additional EMG electrodes on the bilateral upper extremities used

- Two electrodes can be placed in tandem in forearms, either on extensor digitorum communis muscle or on flexor digitorum superficialis muscle

PSG

- To stage sleep, minimum of three EEG derivations are required, recording the frontal, central, and occipital regions and referenced to the contralateral mastoid region

- Recommended derivations include referential montage with F4-M1, C4-M1, and O2-M1

- When PSG is used to evaluate for possible seizures during sleep, the montage should include extended EEG monitoring with ≥16 derivations

PSG

- For suspected parasomnias or nocturnal seizures, the PSG technologist is present throughout the study to provide documentation of events

- When nocturnal behaviors occur, the technologist should determine the patient's level of consciousness, response to verbal commands, and capacity to follow commands

- Patients should be given code phrase so that memory recall can be assessed after the event

- When patients wake up after an event, they should be asked to recall dream content

Timing of sleep-related movements and behaviors throughout the sleep period
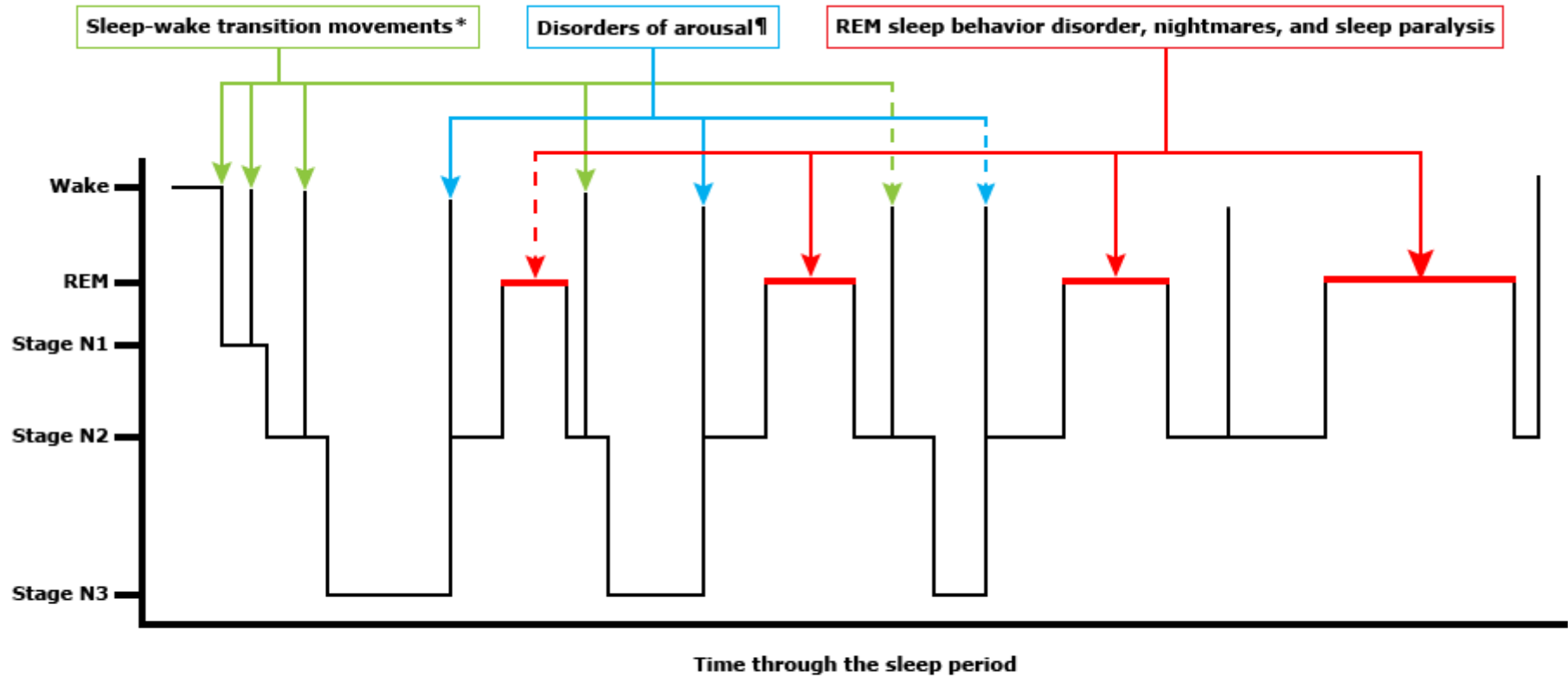

REM: rapid eye movement.

* Examples include hypnic jerks, hypnagogic foot tremor, periodic limb movements, and sleep-related rhythmic movement disorder.

¶ Disorders of arousal from non-REM sleep include confusional arousals, sleep-related abnormal sexual behavior, sleep terrors, sleepwalking, and sleep-related eating disorder.

NREM Parasomnias

- Arousal events typically occur in the **first half of the night from N3** or less commonly N2 sleep

- NREM parasomnias share common features on PSG: represent a **mixture of wake-like and sleep-like states** in different cortical regions, attributed to dissociation between mechanisms controlling NREM sleep and wake

- Onset of an NREM arousal parasomnia often marked by **tachycardia** during N3 sleep; maximum heart rates are observed with sleep terrors or distressed sleepwalking

- EEG during an arousal event demonstrates incomplete awakening, with intermixed slower alpha and theta frequencies

Onset of confusional arousal on electroencephalography
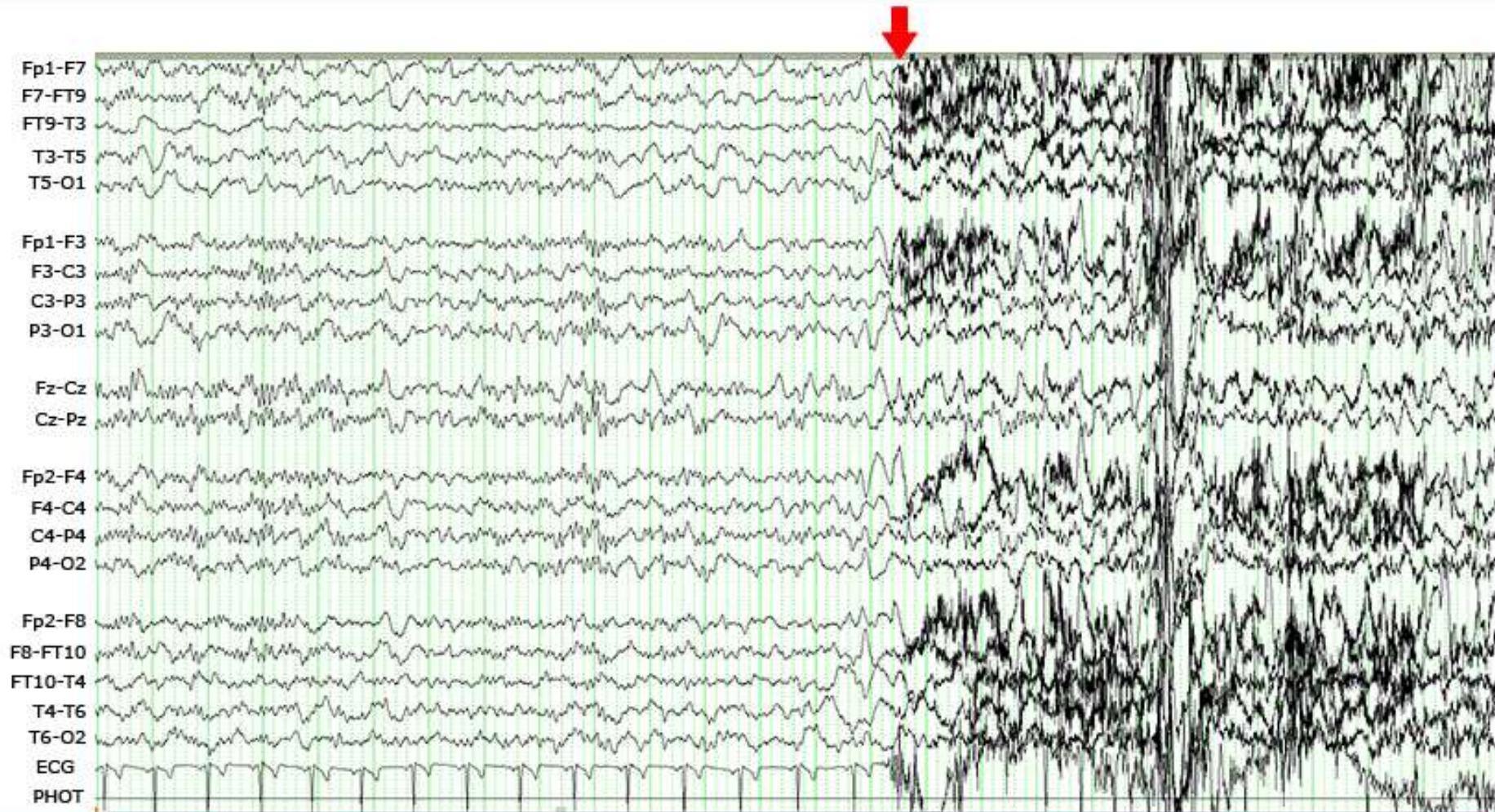
EEG 30-second epoch, longitudinal bipolar montage. This epoch shows a confusional arousal during N3 sleep, with increased beta/spindle activity due to benzodiazepine use. Arrow: Arousal when nurse entered the room. Patient quickly sat up in bed and appeared scared and confused.

EEG: electroencephalography; NREM: non-rapid eye movement.

Continuation of confusional arousal on electroencephalography
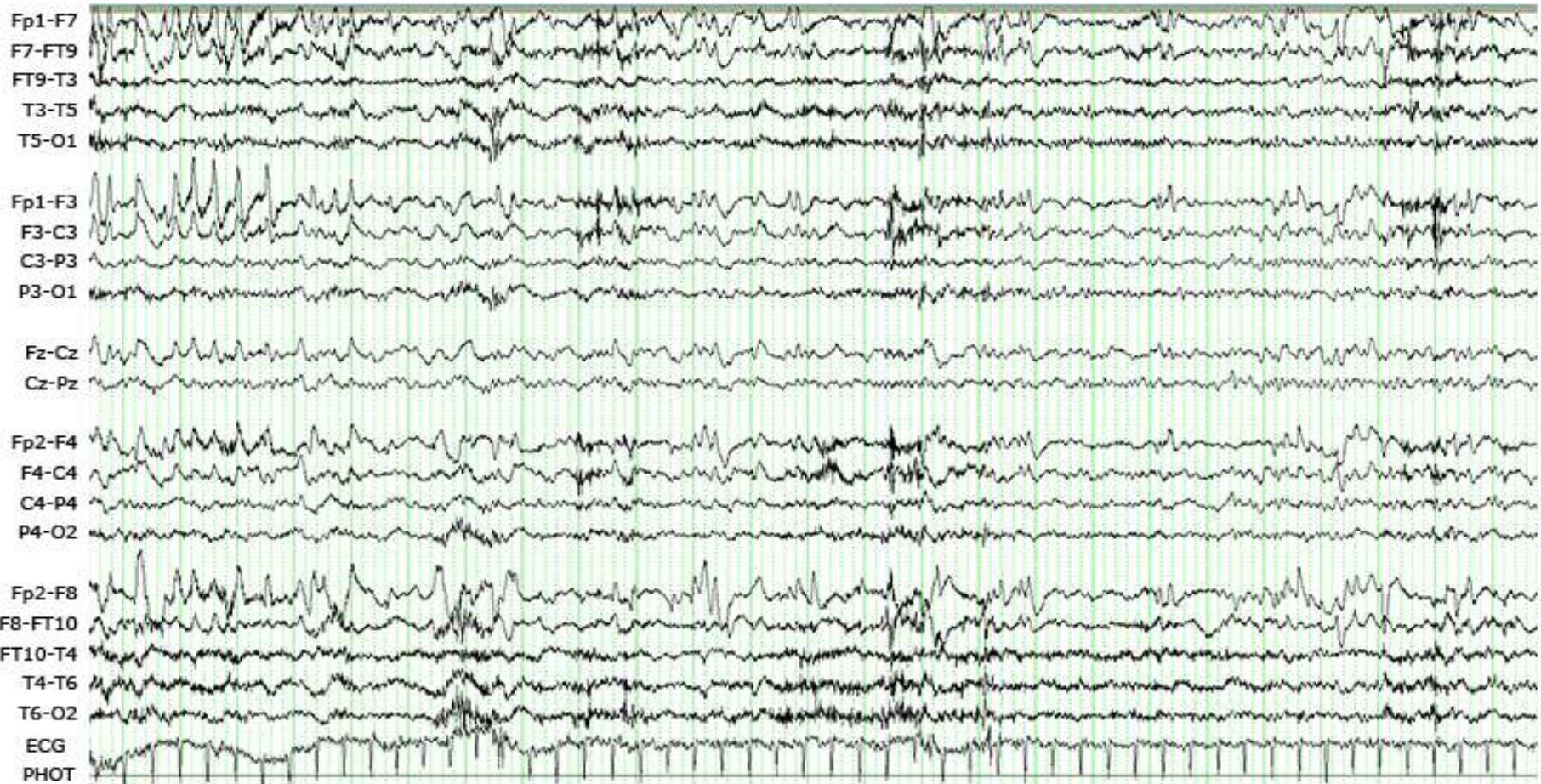
EEG 30-second epoch, longitudinal bipolar montage. When asked his location, the patient replied "We are on the ship," and continued to refer to the ship on subsequent questioning. EEG demonstrates incomplete awakening, with intermixed theta, alpha, and delta frequencies.

Electroencephalography after confusional arousal termination

EEG 30-second epoch, longitudinal bipolar montage, after confusional arousal termination. Within a few minutes, the patient returned to baseline, his responses became appropriate, and he remembered the code phrase given to him during the middle of the episode but was amnestic to conversations early in the spell. EEG demonstrates intermixed alpha and beta frequencies, his usual waking baseline.

NREM Parasomnias

- PSG findings during *sleep terror episode* typically include sudden, incomplete arousal from N3 sleep, often accompanied with a dramatic increase in electromyography (EMG) tone, respirations, and heart rate

- Arousal with inconsolable crying and screaming arising out of N3 sleep is often unique feature that can be observed on time-locked video recording

NREM Parasomnias

- Most *sleep-related eating disorder* events occur out of N2 or N3 sleep, but unlike confusional arousals and sleepwalking, episodes are sometimes associated with *partial awareness and memory of events upon awakening*

- Patients have increased comorbid periodic limb movements in sleep

- PSG findings during episodes: repetitive chewing movements, rhythmic masticatory muscle activity, and an awake pattern on EEG (persistent N2 sleep has also been reported)

NREM Parasomnias

- Inducing NREM arousal parasomnias: Sleep deprivation for > 24 hours and use of ascending 10 dB intensities of 1000 Hz auditory stimuli delivered for 3 seconds via earphones at one-minute intervals

- Stimulation is delivered during N3 sleep during first two NREM-REM sleep cycles

- Combination of auditory stimulation and sleep deprivation greatly enhances the chances of capturing an event in the sleep laboratory

Pilon M et al Neurology. 2008 Jun;70(24):2284-90

REM sleep behavior disorder (RBD)

- Manifest with *dream enactment* behavior during REM sleep, often associated with recall of dream content that mirrors observed behaviors

- Episodes typically occur more in the *latter half of the night*, when REM sleep predominates

- Finding of *REM sleep without atonia* on PSG is required to confirm diagnosis

RBD

American Academy of Sleep Medicine (AASM) sleep scoring manual:

- PSG in patients with RBD must show **increased tonic and/or phasic activity** during at least one 30-second epoch of REM sleep

- Sustained muscle activity (**tonic activity**): defined as chin EMG amplitude 50 percent or greater than the minimum amplitude during NREM sleep

- Excessive transient muscle activity (**phasic activity**): defined as chin or limb EMG amplitude at least four times higher than background EMG activity during 0.1- to 5.0-second bursts in at least 5 of 10 3-second mini-epochs

Classification of sleep disorders. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014

RBD

- History or video PSG observations via time-synchronized audio equipment of dream enactment behavior (which may disrupt sustained or excessive transient muscle activity): required to confirm the diagnosis
- Both upper and lower extremity EMG derivations should be used
- Alternate EMG derivations using muscles with highest rates of phase EMG activity in RBD may improve sensitivity (upper limb EMG)
- Degree of abnormal tonic and phasic activity during REM sleep can be quantified
  - *Visual* analysis or *Autodetection* software
  - Improved by viewing *video* when there is increased phasic EMG activity

Limitation

- Main limitation of PSG in the characterization of abnormal events during sleep is the chance that the individual does not have a typical event on the night of the study

- The so-called "*first-night*" effect, when sleeping in new environment, can alter normal sleep stages and, for example, lead to reduced REM sleep

- In part for this reason, some laboratories record for two consecutive nights in an assessment for a parasomnia

- For NREM parasomnias, sleep deprivation and/or auditory stimulation can improve diagnostic yield

RBD

- Even in the absence of abnormal behaviors on the night of the PSG, other findings can be valuable:
    - Excessive limb twitching during REM sleep characteristic of RBD and interictal spike and wave complexes that may represent an interictal expression of epilepsy
    - REM sleep without atonia (RSWA) is the PSG hallmark of RBD and is required to confirm the diagnosis

Insomnia

- Often diagnosed by history alone
- When history does not reveal cause of insomnia, PSG may be useful
- Considered if:
  - Patient's history and physical examination suggest: sleep-disordered breathing, periodic limb movement disorder, paradoxical insomnia, or uncertain causes
  - Indicated if insomnia fails to respond to treatment or in patients who have precipitous arousals with violent or injurious behavior
  - *MSLT*: Indicated in the evaluation of the complaint of insomnia when the presence of moderate to severe excessive sleepiness is suspected

Schutte-Rodin S et al. J Clin Sleep Med 2008;4(5):487–504

Circadian rhythm sleep-wake disorder (CRSWD)

(1) Chronic or recurrent pattern of sleep-wake rhythm disruption primarily caused by an alteration in the endogenous circadian timing system or misalignment between the endogenous circadian rhythm and the sleep-wake schedule desired or required,

(2) a sleepwake disturbance (ie, insomnia or excessive sleepiness, and

(3) associated distress or impairment

- For all CRSWDs, with the exception of jet lag disorder, duration criterion of at least 3 months needed

Evaluation of suspected CRSWD

- Use of sleep logs and, whenever possible, actigraphy for 7 to 14 days to evaluate suspected circadian rhythm sleep-wake disorders

Polysomnography

- Not necessary to diagnose CRSWD

- May be performed to rule out other comorbid sleep conditions

- PSG conducted may demonstrate delay of sleep onset or early morning awakening in patients with delayed or advanced sleep-wake phase disorders, respectively

- **MSLT:** Not used to diagnose CRSWD

- If obtained, mean sleep latency may be reduced in CRSWD in the setting of sleep loss and excessive daytime sleepiness

*Morgenthaler T. et al. Sleep 2007;**30(4):519–29***

Take home message

- Sleep disorder are common in clinical settings
- Many sleep disorder can be diagnosed based on history
- Polysomnography is a multiparametric testing based of physiological response during sleep
- It is used as gold standard test to diagnose OSA
- Besides OSA, PSG has its role in diagnosis of other sleep disorder
- MSLT is standard investigation for assessing daytime sleepiness objectively
- MSLT is diagnostic in Narcolepsy and IH
- MWT can be used to assess safety at work place and alertness following therapeutic interventions