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Sleep Study 101: Beyond the AHI

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Disclosures

- I have no conflicts of interest to disclose

Objectives

- Recognize types of sleep testing to evaluate for sleep disordered breathing
- Interpret nuances in AHI, including body position, REM vs NREM, centrals vs obstructive, and hypoxic burden
- Analyze the hypnogram on a sleep study report
- Recognize comorbid sleep disorders on a sleep study report

Definitions

- Obstructive Sleep Apnea (OSA)
  - Obstructed airway despite effort
- Central Sleep Apnea (CSA)
  - Cessation of breathing without effort
- Sleep disordered breathing (SDB)
  - Can be OSA or CSA
- Complex sleep apnea
  - Combination of OSA and CSA

Apnea-Hypopnea Index

- AHI: # apneas +hypopneas/Total Sleep Time
- Apnea: >90% reduction in airflow
- Hypopnea: >30% reduction in airflow with desat (3% or arousal; *4% for Medicare)

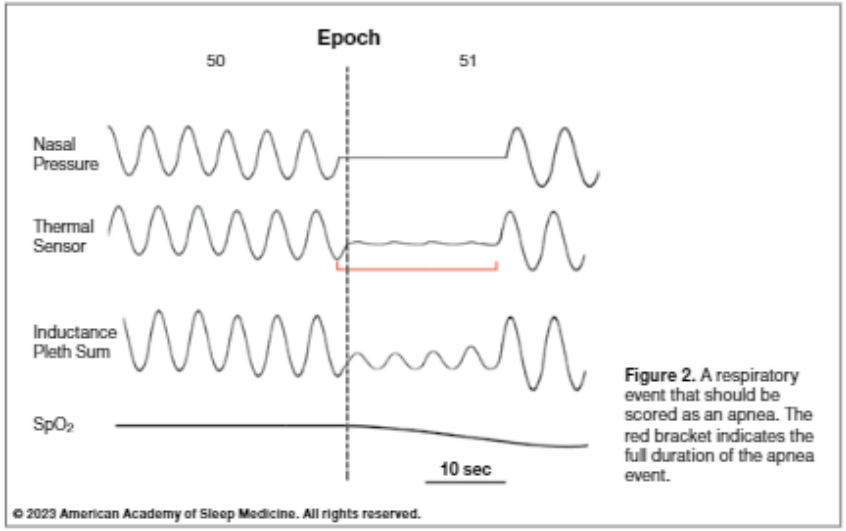


Figure 2. A respiratory event that should be scored as an apnea. The red bracket indicates the full duration of the apnea event.

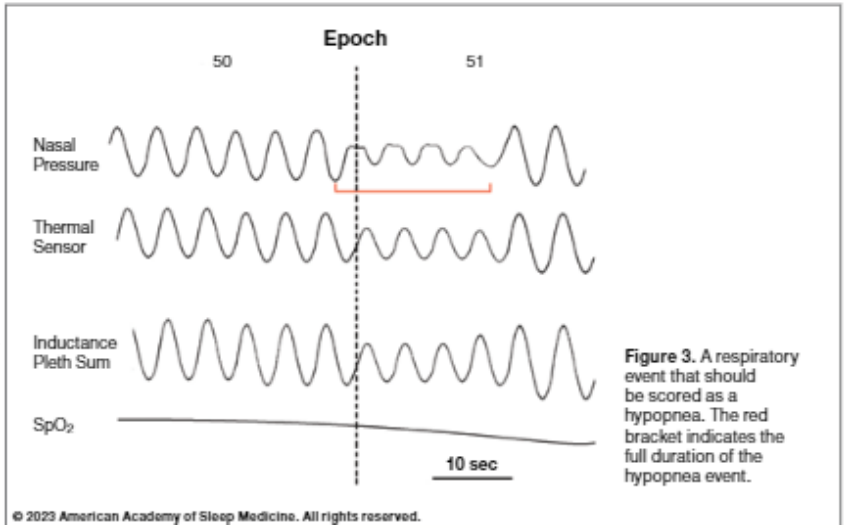


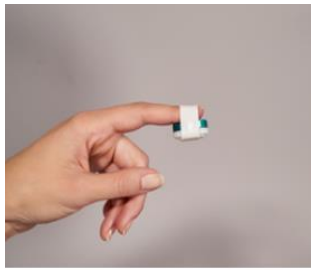
Figure 3. A respiratory event that should be scored as a hypopnea. The red bracket indicates the full duration of the hypopnea event.

Severity of Sleep Disordered Breathing

Classification	AHI
Normal or “Primary Snoring”	<5/hr
Mild	5-14.9/hr
Moderate	15-29.9/hr
Severe	>30/hr

Sleep Studies for SDB - lots of choices!

- Home Sleep Tests
  - Nasal pressure, chest and abdominal effort, oximetry
  - PAT (peripheral arterial tonometry) **
  - 80-90% sensitivity for detecting OSA in high-risk patients (AHI>5/hr)



- Polysomnography (PSG): gold standard for diagnosis
  - Baseline
  - Split
  - Titration

Kapur V.K. JCSM 2017;13;479-504

Things to Focus On

- Clinical History
- Weight and BMI – compare with present
- Sleep Architecture
- Breakdown of AHI
  - Obstructive vs Central
  - Supine vs non-supine
  - Hypoxia
- Other non-respiratory findings
- Hypnogram

Criteria for Hypoglossal Nerve Stimulation Therapy

- 18 years of age or older
  - 13 years or older in patients with Down Syndrome
- Body mass index (BMI) is less than **32** or **40 kg/m2**
- PSG or HST (often needed within past 2 years)
- Apnea hypopnea index (AHI) is **15 to 100** events per hour, <25% central or mixed apneas
- CPAP failure or CPAP intolerance or the CPAP has been returned despite CPAP interface and/or setting optimizations or unwilling to use CPAP
- Absence of complete **concentric** collapse on (DISE) procedure
- No other anatomical findings that would compromise performance of device (e.g., tonsil size 3 or 4 per tonsillar hypertrophy grading scale)

Clinical History

- 70 yo male with PMH OSA and intolerance to CPAP and Bi-PAP, MAD presents for evaluation.
  - PMH Depression, T2DM, Parkinsonism, cleft lip/palate, 30 lbs weight loss since initial study
  - PSH cleft lip repair, septoplasty/turb reduction
  - Baseline PSG ordered (without MAD)
  - Clinical history on PSG: wearing mandibular advancement device (MAD) aka oral appliance during study

Sleep Architecture

- In-lab PSGs
- Total Sleep Time
- Sleep efficiency
- REM sleep
- Arousal Index
  - Respiratory
  - Idiopathic

Sleep Continuity and Sleep Architecture

Lights Out: 22:37	Lights On: 05:04	Stage N1 of TST: 13.5 %	Arousals:
Time in bed: 387 minutes	*TST: 322.5 minutes	Stage N2 of TST: 59.7 %	-Index: 20.7
Sleep efficiency: 83.3 %	Sleep latency: 0 min.	Stage N3 of TST: 14.9 %	-PLM: 1.9
*WASO: 63 min.	REM latency: 32.5 min	Stage REM of TST: 11.9 %	-Resp: 11.9
REM Supine: 3 min.	REM Non-Sup: 35.5 min.		

PSG Respiratory Table

- Obstructive vs Central AHI
  - Beware that mixed apneas typically get lumped into obstructive apneas.
- Supine vs non-supine AHI (w/hypnogram)
- AHI4%: Medicare
- SpO2 mean

Respiratory Summary: Baseline AHI: 34.2 per hour

Obstructive AHI (per hour):	31.6	Supine AHI (per hour):	58.6
Central AI (per hour):	1.7	Non supine AHI (per hour):	21.9
REM AHI (per hour):	43.6	NREM AHI (per hour):	33.
REM Supine AHI (per hour):	40	REM Non-Supine AHI (per hour):	43.9
SpO2 mean:	92 %	SpO_2 nadir:	85 %
EtCO2 %>=50mmHg	0	Time SpO_2<=88% (mins):	3
AHI 3%:	34.2	AHI 4%:	23.1

Non-Respiratory findings

- May be of interest if patient not doing well on current treatment modality or you are primary physician reviewing results

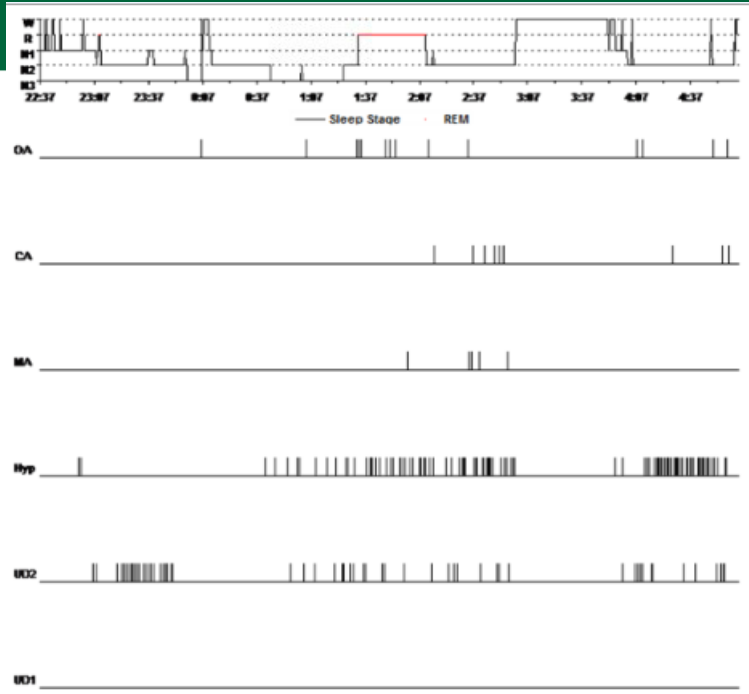
ECG Analysis: The ECG demonstrated normal sinus rhythm with average heart rate (HR) awake of 0 bpm, NREM of 68.2 bpm, and REM of 67.7 bpm.

EEG Analysis: With the limited montage, no abnormalities were noted.

Periodic Limb Movements: Periodic Limb Movements were observed. There were a total of 172 periodic limb movements during sleep (PLMS), of which 10 were PLMS with arousal. The resulting PLMS index was 32. per hour and PLMS index with arousal was 1.9 per hour.

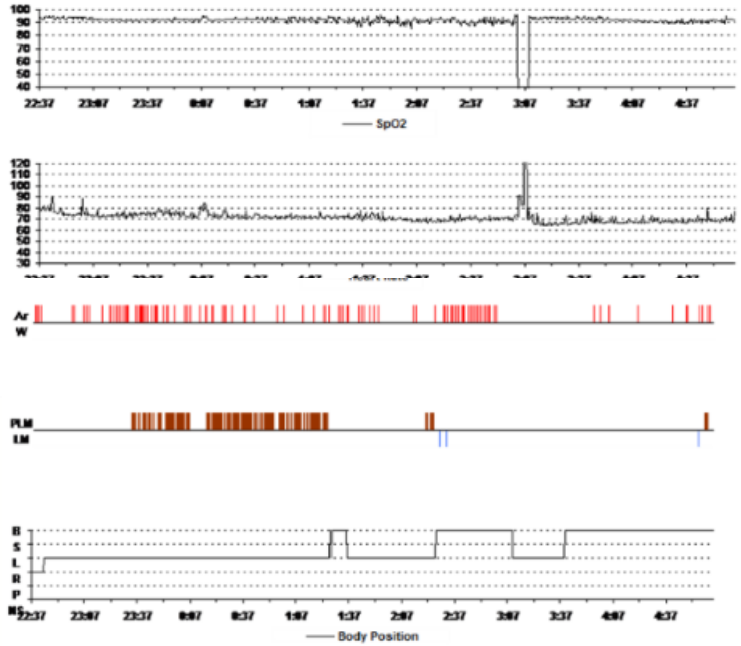
Other observations: No other findings including sleep talking or abnormal sleep behavior observed (dream enactment, sleepwalking, bruxism, etc).

- Sleep stage
- Respiratory events



Hypnogram

- Oxygen sat
- Heart rate
- Arousals and Limbs
- Body position



Interim History

- Patient noted intolerance to MAD and desired evaluation for HGNS
- DISE demonstrated AP collapse
- Inspire placed 6/28/23
- 9/2023: Patient awakes feeling refreshed, wife notes snoring nearly resolved. Using nightly at 2.0 V; but frequent pauses during the night
- Follow-up testing with WatchPAT HST 10/5/23

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WatchPAT on Inspire

"Baseline"

- AHI3%: 34.2/hr
- AHI4%: 23.1/hr

Sleep Study Report

Sleep Summary

Start Study Time:	11:01:44 PM
End Study Time:	8:26:38 AM
Total Recording Time:	9 hrs, 24 min
Total Sleep Time	**8 hrs, 44 min**
% REM of Sleep Time:	29.2

Respiratory Indices

	Total Events	REM	NREM	All Night
pRDI:	205	37.3	18.2	**23.7**
pAHI 3%:	190	35.3	16.6	**22.0**
ODI 3%:	205	40.5	16.9	**23.7**
pAHIc 3%:	22	3.6	2.1	**2.6**
% CSR:	0.0			
pAHI 4%:	111			**12.9**
ODI 4%:	121			**14.0**

Indices are calculated using technically valid sleep time of 8 hrs, 38 min.

pRDI is calculated using oxi desaturation ≥ 3%

Oxygen Saturation Statistics

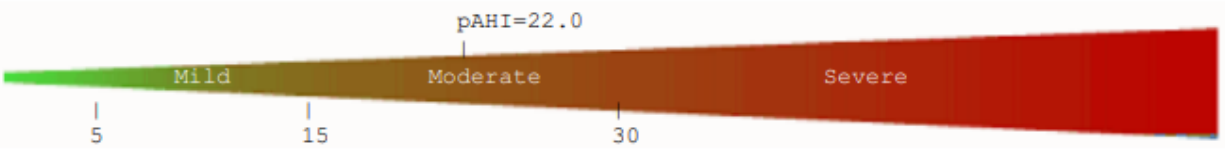
Mean:	95	Minimum:	82	Maximum: 99
Mean of Desaturations Nadirs (%):				92

Oxygen Desatur. %:	**3-9**	**10-20**	**>20**	**Total**
Events Number	192	13	0	205
Total	93.7	6.3	0.0	100.0

Oxygen Saturation:	**<90**	**<=88**	**<85**	**<80**	**<70**
Duration (minutes):	1.5	0.7	0.0	0.0	0.0
Sleep %	0.3	0.1	0.0	0.0	0.0

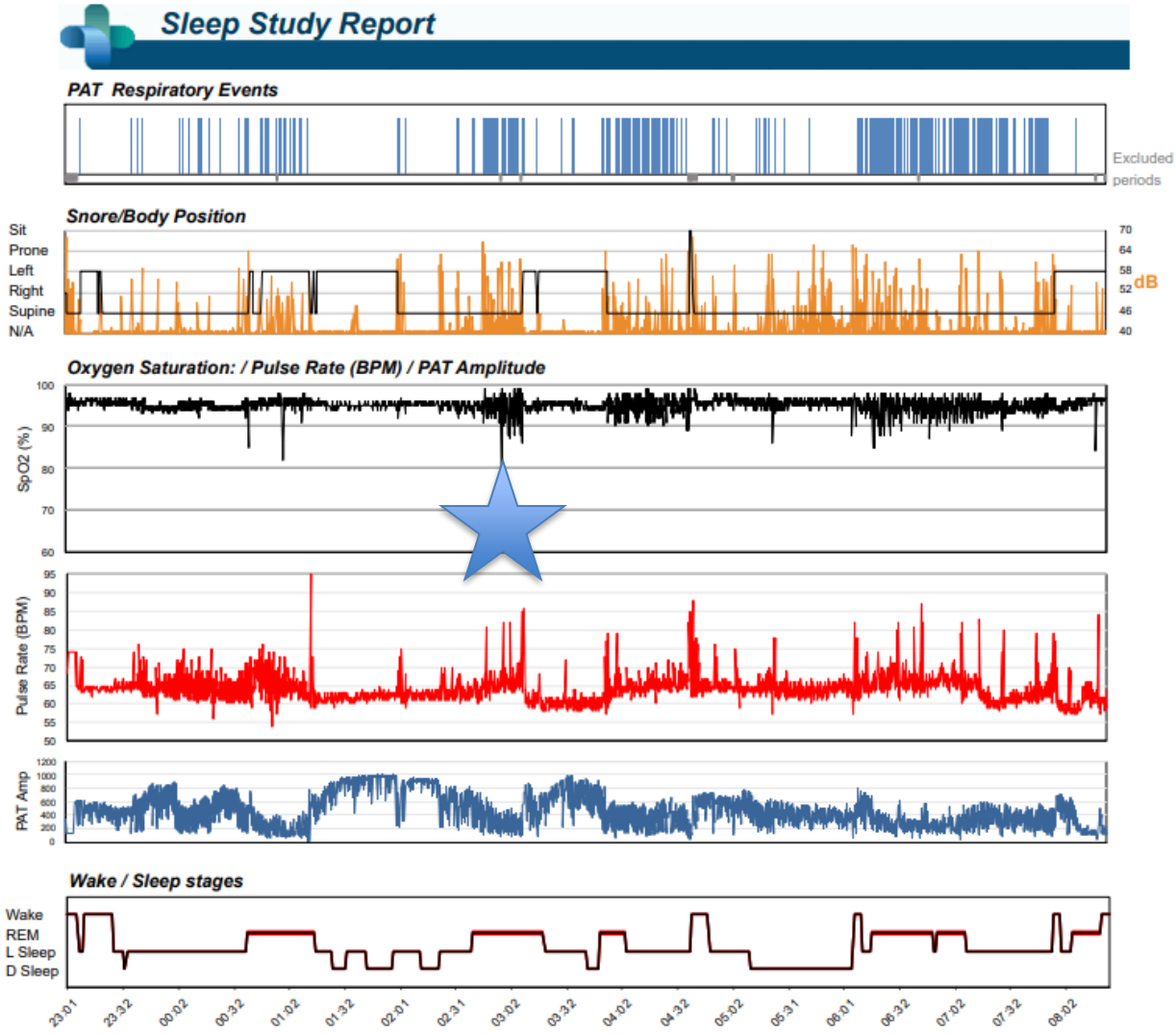
Pulse Rate Statistics during Sleep (BPM)

Mean:	64	Minimum:	55	Maximum:	95



* Reference values are given by physician

WatchPAT Hypnogram

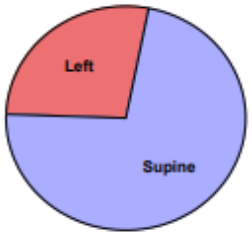


WatchPAT Tables

Sleep Study Report

Body Position Statistics

Position	Supine	Prone	Right	Left	Non-Supine
Sleep (min)	380.5	0.0	0.0	143.9	143.9
Sleep %	72.6	0.0	0.0	27.4	27.4
pRDI	29.8	N/A	N/A	7.6	7.6
pAHI 3%	28.2	N/A	N/A	5.5	5.5
ODI 3%	30.3	N/A	N/A	6.3	6.3



Snoring Statistics

Snoring Level (dB)	>40	>50	>60	>70	>80	>Threshold (45)
Sleep (min)	171.6	13.7	1.9	0.0	0.0	24.9
Sleep %	32.7	2.6	0.4	0.0	0.0	4.7

Mean: 41 dB

Sleep Stages Chart

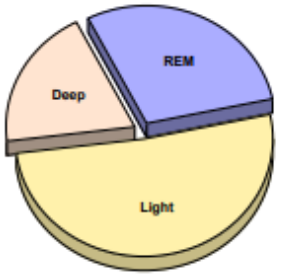
Sleep/Wake States

Wake	7.17%
Sleep	92.83%
Total:	100.00%

Sleep Latency (min):	6
REM Latency (min):	91
Number of Wakes:	6

Sleep Stages

REM	29.25%
Light	51.30%
Deep	19.45%
Total:	100.00%



Follow-Up

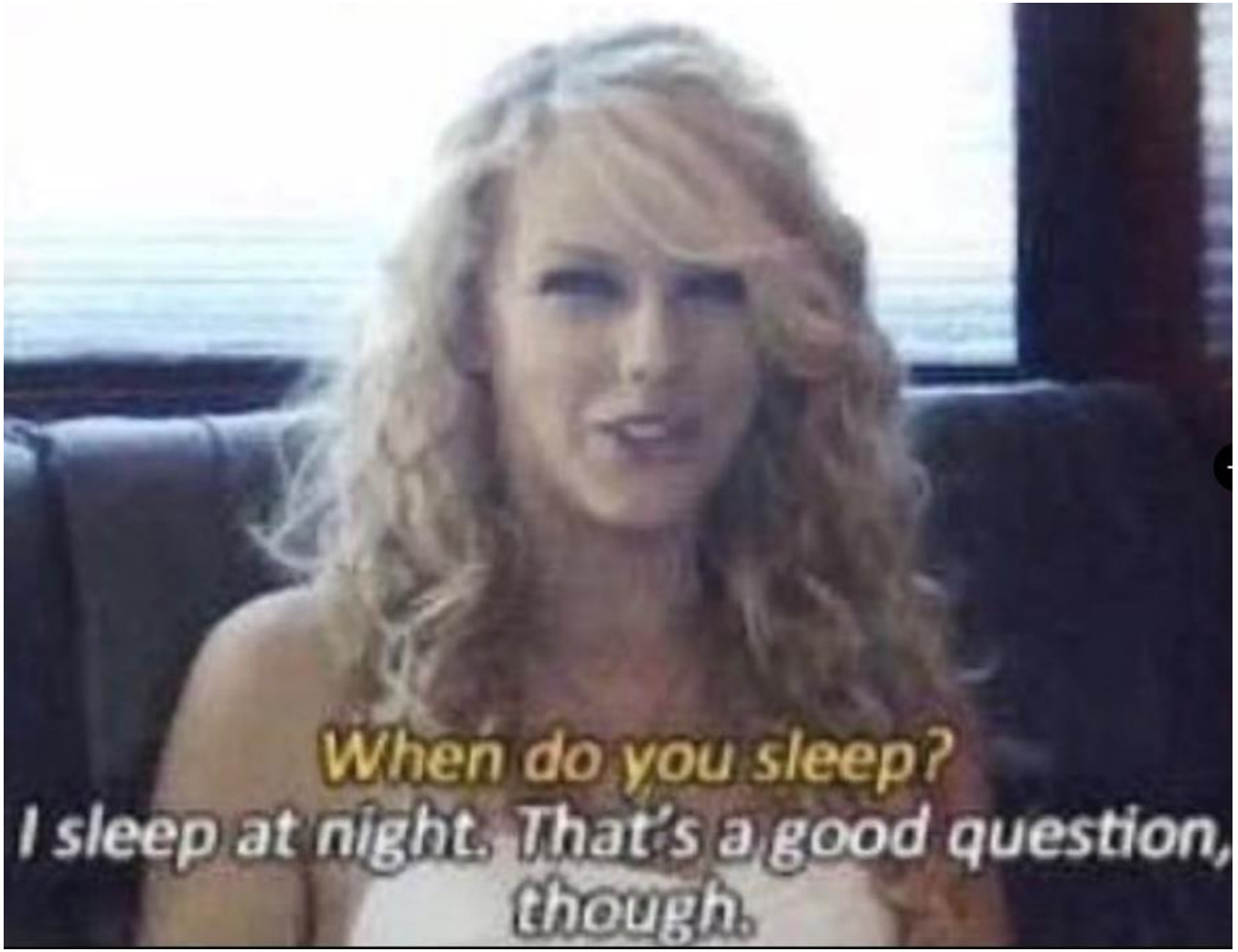
- Advised to up titrate HGNS weekly as tolerated and consider positional therapy (avoiding supine sleep)

- If frequent nocturnal awakenings become issue, consider periodic limb movements (seen on initial study) vs HGNS vs SDB

Key Points

- Hypnogram = BIG PICTURE
- Positionality is essential (supine vs non-supine)
- Review for central and mixed events (overall AHI review is not enough)
- Know your patient's history

Questions?


When do you sleep?
I sleep at night. That's a good question, though.