

Cincinnati Children's UNIVERSITY OF CINCINNATI

The Basics of Sleep

Stacey L. Ishman, MD
 Surgical Director, Upper Airway Center
 Cincinnati Children's Hospital Medical Center
 University of Cincinnati, Cincinnati OH, USA

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objectives

1. Define sleep stages and recognize the typical proportions of each for children and adults
2. Differentiate sleep staging as determined by electroencephalogram (EEG) signal
3. Recognize the utility and side effects associated with continuous positive airway pressure (CPAP)

2

Cincinnati Children's UNIVERSITY OF CINCINNATI

Sleep Staging

NREM (non-rapid eye movement sleep)

- Stage 1 – 5-10% - transition wakefulness to sleep
 - Increased in conditions with increased sleep fragmentation such as sleep apnea and narcolepsy
- Stage 2 – 50% - consolidated stage of sleep with fewer spontaneous arousals
- Stage 3 – 20-25% - deep sleep – restorative sleep
 - Decreased in sleep apnea

American Thoracic Society, Am J Resp Crit Care Med. (1996) 153:866-78.

Cincinnati Children's UNIVERSITY OF CINCINNATI

Sleep Staging

REM (rapid eye movement) sleep

- 20-25% Brain in active state
- Increasing duration of REM periods as the sleep period goes on

American Thoracic Society, Am J Resp Crit Care Med. (1996) 153:866-78.

Cincinnati Children's UNIVERSITY OF CINCINNATI

Sleep Staging

REM Characterized by:

- Eye movement has a rapid oscillating pattern
- Vivid Dreams
- Skeletal muscles are virtually paralyzed
- Loss of temperature regulation, hypoventilation
- Decreased arousal thresholds

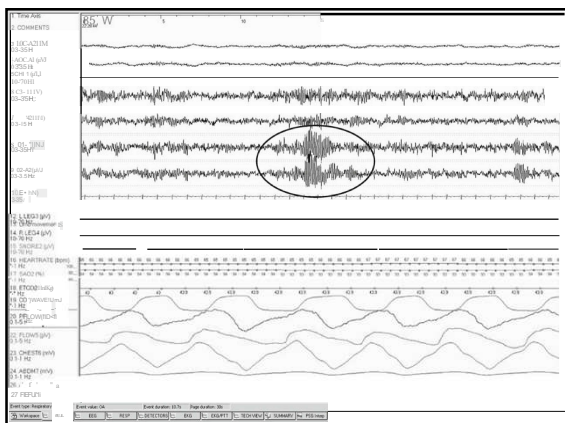
American Thoracic Society, Am J Resp Crit Care Med. (1996) 153:866-78.

Cincinnati Children's UNIVERSITY OF CINCINNATI

Sleep Staging

Wake Characterized by:

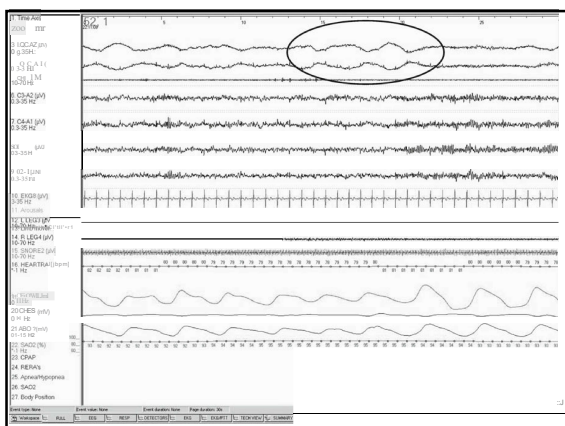
- Increased chin EMG tone
- Fast moving and blinking eyes
- Alpha or dominant posterior rhythm EEG activity



Cincinnati Children's UNIVERSITY OF Cincinnati Sleep Staging

N1 Characterized by:

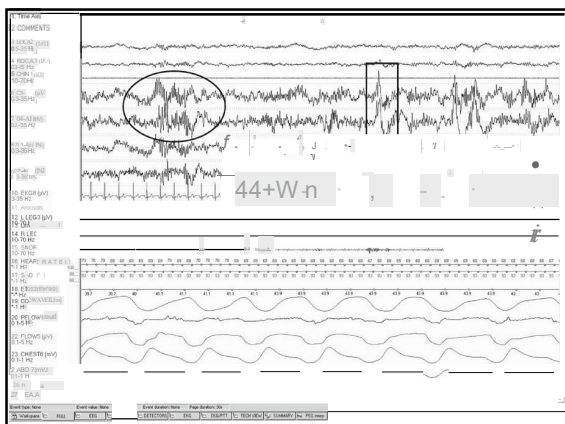
- First stage of sleep
- Represents the transition of wakefulness to sleep
- Low-amplitude and mixed frequency EEG
- Slow rolling eye movements



Cincinnati Children's UNIVERSITY OF Cincinnati Sleep Staging

N2 Characterized by:

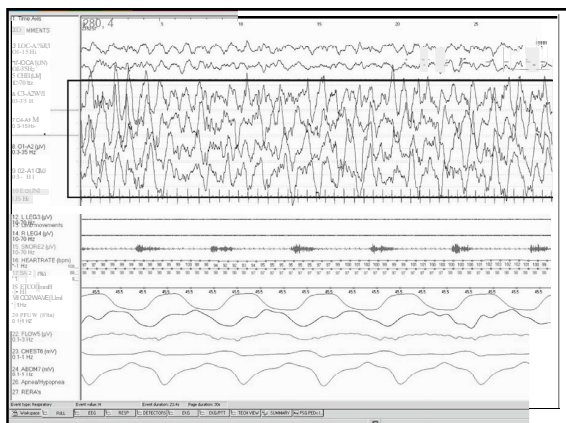
- Second stage of sleep
- Characterized by K complexes and sleep spindles
- Approximately half the total sleep time
- K complexes = bipolar sharp waves that last for at least 0.5 s
- Sleep spindles = distinct episodic high-frequency (11–16 Hz) waveforms



Cincinnati Children's UNIVERSITY OF Cincinnati Sleep Staging

N3 Characterized by:

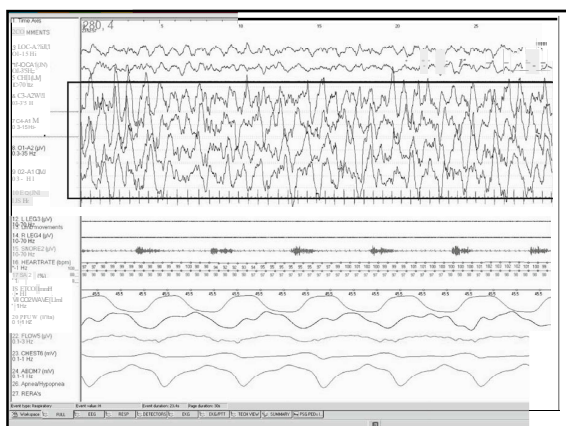
- Third stage of sleep
- Slow wave sleep
- Low frequency (0.5–2 Hz) and high-amplitude (>75 mV) waveforms for > 20% of the epoch
- Combines sleep stages 3 and 4 previously described by Rechtschaffen and Kales



Cincinnati Children's UNIVERSITY OF Cincinnati **Sleep Staging**

N3 Characterized by:

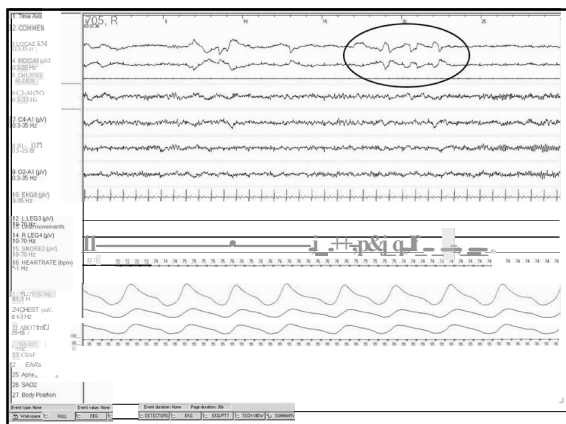
- Third stage of sleep
- Slow wave sleep
- Low frequency (0.5–2 Hz) and high-amplitude (>75 m V) waveforms for greater than 20% of the epoch
- Combines sleep stages 3 and 4 previously described by Rechtschaffen and Kales



Cincinnati Children's UNIVERSITY OF Cincinnati **Sleep Staging**

REM Characterized by:

- Low voltage and mixed-frequency EEG pattern
- Rapid eye movements on EOG leads
- Low chin EMG tone
- Percent of rem sleep decreases with advancing age



Cincinnati Children's UNIVERSITY OF Cincinnati **CPAP**

REM Characterized by:

- Low voltage and mixed-frequency EEG pattern
- Rapid eye movements on EOG leads
- Low chin EMG tone
- Percent of rem sleep decreases with advancing age

Cincinnati Children's UNIVERSITY OF CINCINNATI

- **Nasal CPAP**
 - Many studies show its utility in adults & kids

0.0 cm H₂O 5.0 cm H₂O 10.0 cm H₂O 15.0 cm H₂O

Retropalatal
Retroglossal

Katzenmeyer K. www.cultmba.de/Info/June2002.

Cincinnati Children's UNIVERSITY OF CINCINNATI

- **Nasal CPAP**
 - 1st approved 5/06 (>=7 years or >40lbs)
 - Now >= 2 years
 - Appropriate masks are not always available for children younger than this, especially a problem in infants
 - 40-90% acceptance adults
 - Better if daytime symptoms improved

Cincinnati Children's UNIVERSITY OF CINCINNATI

- **Nasal CPAP**
 - Facial side effects of PAP
 - 6m-18yo – median age 10 – median duration 15 months (1 to 85 months)
 - Skin injury in 48% (erythema, skin necrosis)
 - Global facial flattening in 68%
 - Maxillary retrusion in 37%

Fauroux et al. Intensive Care Med (2005) 31:965-9.

Cincinnati Children's UNIVERSITY OF CINCINNATI

- **Nasal CPAP**
 - Range 4-20 cm H₂O
 - Heated humidification
 - Compliance reader (wireless?)
 - Ramp

Fauroux et al. Intensive Care Med (2005) 31:965-9.

Cincinnati Children's UNIVERSITY OF CINCINNATI

- **AutoPAP**
 - Range 4-20 (14 usually the highest) cm H₂O
 - Decrease until flow obstruction seen
 - Final pressure = pressure used >=90% of the time

Fauroux et al. Intensive Care Med (2005) 31:965-9.

Cincinnati Children's UNIVERSITY OF CINCINNATI

**Sleep Studies:
The Significance of All Those Other Numbers**

Stacey L. Ishman, MD
Surgical Director, Upper Airway Center
Cincinnati Children's Hospital Medical Center
University of Cincinnati, Cincinnati OH, USA

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objectives


1. Understand the events included in a sleep report
2. Interpret the data regarding OSA on a PSG for adults and children
3. Determine the importance of the other parameters reported on the PSG including sleep efficiency, periodic limb movements

25

Cincinnati Children's UNIVERSITY OF CINCINNATI

Polysomnogram

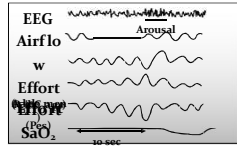
- EEG
- EKG
- Submental EMG
- Anterior tibialis EMG
- EOG
- Nasal/oral airflow
- Pulse oximetry
- Respiratory effort
- Sleeping position
- Esophageal manometry



Cincinnati Children's UNIVERSITY OF CINCINNATI

Polysomnogram

- Definition of an obstructive apnea
Obstructive apnea = Cessation of airflow with respiratory effort
 For at least 10 seconds OR
 For 2 breath cycles in older children OR
 For 6 seconds or 1.5 to 2 breaths in infants

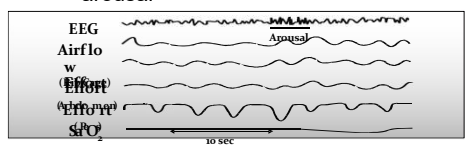


American Thoracic Society, Am J Resp Crit Care Med. (1996) 153:866-78.

Cincinnati Children's UNIVERSITY OF CINCINNATI

Polysomnogram

- Definition of a Hypopnea
Hypopnea = Hypoventilation secondary to partial obstruction
 • Decrease in airflow by 30-50% despite effort with desaturation at least (3 or) 4% or an arousal









American Thoracic Society, Am J Resp Crit Care Med. (1996) 153:866-78.

Cincinnati Children's UNIVERSITY OF CINCINNATI

Polysomnogram

- Definition of a central and mixed apnea.
- **Central apnea** = Cessation of airflow without respiratory effort
- **Mixed apnea** = Characteristics of both

Obstructive	Mixed	Central
		
		

American Thoracic Society, Am J Resp Crit Care Med. (1996) 153:866-78.

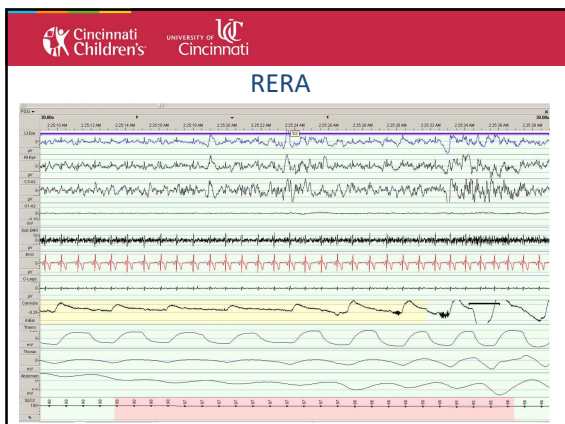
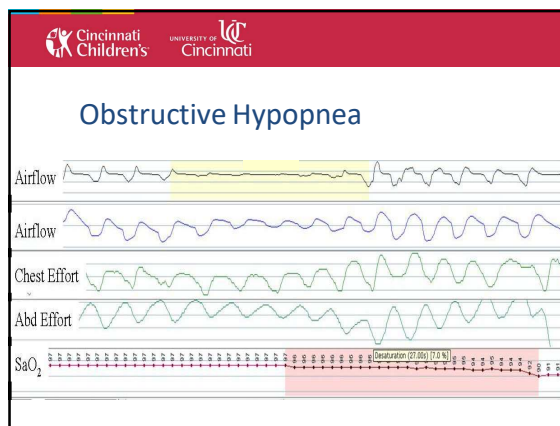
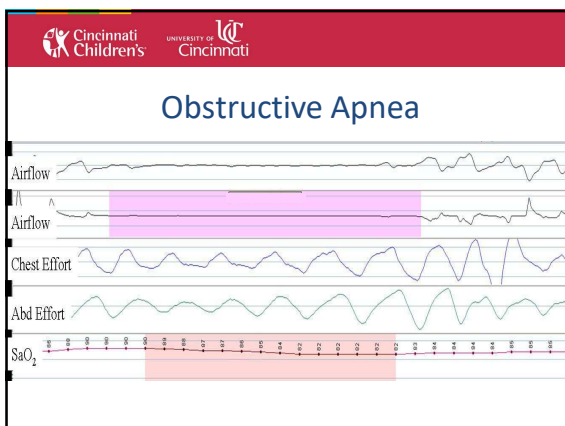
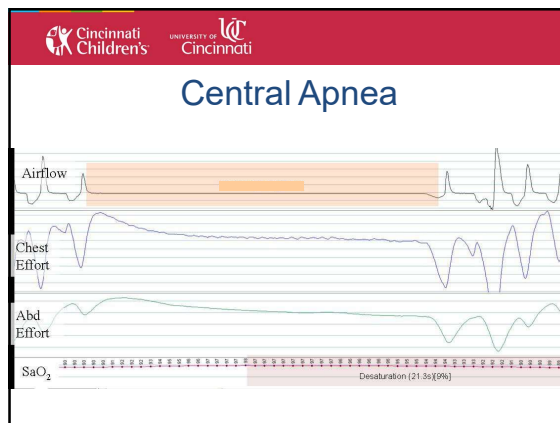
Cincinnati Children's UNIVERSITY OF CINCINNATI

Polysomnogram

- What is a RERA
RERA = Respiratory event related arousal
 • Arousals that aren't associated with a clear-cut apnea or hypopnea but with a slight change in airflow or respiratory effort

Cincinnati Children's UNIVERSITY OF CINCINNATI Polysomnogram

- What is the difference between RDI & AHI?
 - If they report RERAs, then:
 $AHI + RERAs = RDI$
 - If they only report apneas & hypopneas, then: $AHI = RDI$



Cincinnati Children's UNIVERSITY OF CINCINNATI Polysomnogram

- What are causes of underestimation of RDI?
 - Decreased total sleep time
 - Reduced REM sleep
 - Parents reporting atypical night of sleep
- First-night effect
 - Adaption to sleep lab leading to disruption of sleep architecture

Katz ES. Chap 17 in Principles & Practices of Pediatric Sleep Medicine. Sheldon SH (ed). 2005

Cincinnati Children's UNIVERSITY OF CINCINNATI

Normal PSG Values: Pediatric

- Central apneas
 - <1/hour = normal
 - <5/hour not considered significant
- AHI
 - AHI: 0 to 0.8 per hour = normal
- Oxygen saturations – baseline/nadir normals
 - Baseline O2 saturations: 96% to 99.5%
 - O2 Saturation nadir: 89% to 98%

Traeger N et al. Pediatric Pulmonology (2005)40:22-30.

Cincinnati Children's UNIVERSITY OF CINCINNATI

Normal PSG Values: Pediatric

	Traeger et al.	Uljel et al.	Wong et al.	Marcus et al.	Urschitz et al.	Poets et al.	Goh et al.
Central Apnea (N/hr)	0.08 +/- 0.14	0.22	0.1 +/- 0.1				
AHI (N/hr)	0.23 +/- 0.31		0.0 +/- 0.1	0.2 +/- 0.6			
O2 Baseline (%)	97+/-1	97+/-1			98+/-1	99.5	
O2 Nadir (%)	92+/-3	95+/-2	95+/-3	96+/-2	93+/-3		95+/-1

Traeger N et al. Pediatric Pulmonology (2005)40:22-30.

Cincinnati Children's UNIVERSITY OF CINCINNATI

Pediatric PSG Parameters

- Standard Research Definitions:
 - Mild 1- <5 events/hour
 - Moderate 5 - <10 events/hour
 - Severe 10 or more events/hour
- Some debate regarding standard cutoffs

Cincinnati Children's UNIVERSITY OF CINCINNATI

Adult PSG Parameters

- Standard Definitions:
 - Mild 5-<15 events/hour
 - Moderate 15 - <30 events/hour
 - Severe 30 or more events/hour

Cincinnati Children's UNIVERSITY OF CINCINNATI

Subjective PSG Parameters

SLEEP ANALYSIS:

Subjective

Sleep Onset: Good Quality: Fair Compared to Home: Same

Subjective
Input from the patient is important

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective Parameters

Total Sleep Time (TST, min):	429.9
Time in Bed (TIB, min):	453.1
Sleep Efficiency (TST/TIB):	0.95
Initial Sleep Latency (min):	1.7
Initial REM Latency (min):	72.5
Wake After Sleep Onset (min):	21.5

Objective
Total sleep time – at least 4, ideally 6 hours
Sleep efficiency ideally >90% (>85% ok)

Objective PSG Parameters

Total Sleep Time (TST, min):	429.9
Time in Bed (TIB, min):	453.1
Sleep Efficiency (TST/TIB):	0.95
Initial Sleep Latency (min):	1.7
Initial REM Latency (min):	72.5
Wake After Sleep Onset (min):	21.5

Initial sleep latency
 Less than 20 minutes = normal
 <8 minutes (& 5 mins) = sleepy

Objective PSG Parameters

Total Sleep Time (TST, min):	429.9
Time in Bed (TIB, min):	453.1
Sleep Efficiency (TST/TIB):	0.95
Initial Sleep Latency (min):	1.7
Initial REM Latency (min):	72.5
Wake After Sleep Onset (min):	21.5

Wake after sleep onset
 time awake after initially falling asleep
 informative regarding sleep efficiency

Objective PSG Parameters

	Minutes	Normal	%TST
Stage NREM 1 (N1):	12.5	0-5%	2.9%
Stage NREM 2 (N2):	222.0	50%	51.6%
Stage NREM 3 (N3):	89.5	20-25%	20.8%
Stage REM (R):	105.9	25%	24.6%

Especially in children, be sure that there is adequate REM, ideally >20%

Objective PSG Parameters

PERIODIC LEG MOVEMENTS (PLM) IN NON-REM and REM SLEEP

	Total Number (NREM + REM Sleep)	Index (per hour)
PLM	0	0.0
PLM with Arousal:	0	0.0
Percent PLM with Arousal:	-	-

- PLM < 5 is normal kids - <15 adults
- If >5 and symptomatic, consider checking iron and determine if symptomatic for restless leg or periodic limb movements
- If >5 with arousals, consider treating if sleepy or any daytime symptoms

RESPIRATORY ANALYSIS
 Diurnal Breathing (DB) Analysis

	NREM	REM	NREM+REM
Sample Time (min):	324.0	10.9	429.9
AH Events:	17	55	72
AH Rate per Hour:	3.1	31.2	10.0
Apnea Rate per Hour:	0	6.2	1.8
Hypopnea Rate per Hour:	2.8	24.9	8.2
AH Avg. Event Time (s):	6.4	32.7	31.2
Apnea Avg. Event Time (s):	15.6	21.4	20.5
Hypopnea Avg. Event Time (secs):	27.8	35.5	33.5
Apnea/DB Time:	0.07	0.13	0.12
Oxygen Desaturation Analysis			
Avg. Low Sat:	91.7	95.3	95.1
Minimum O ₂ Sat:	91.4	91.1	91.2
RETA vents:	8	83.0	83.0
RETA Rate per Hour:	21.0	32.0	53.0
DB Rate per Hour:	3.9	18.1	7.4
DB Rate per Hour:	5.0	41	47

Objective PSG Parameters

	NREM	REM	NREM+REM
Sample Time (Min):	324.0	105.9	429.9
AH Events:	17	55	72
AH Rate per Hour:	3.1	31.2	10.0
Apnea Rate per Hour:	0.4	6.2	1.8
Hypopnea Rate per Hour:	2.8	24.9	8.2

Reminder to check for adequate REM, (20-25%)
 AH = apnea and hypopnea events = total events
 AH rate/hour = apnea hypopnea index

Look at REM vs Total #s (NREM+REM)

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

	NREM	REM	NREM+REM
AH Avg. Event Time (secs):	26.4	32.7	31.2
Apnea Avg. Event Time (secs):	15.6	21.4	20.5
Hypopnea Avg. Event Time (secs):	27.8	35.5	33.5

AH Avg event time = length of the apnea /hypopnea
= a general idea of severity of disease

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

	NREM	REM	NREM+REM
Oxygen Desaturation Analysis			
Avg. Baseline O ₂ Sat.:	94.7	95.3	95.1
Avg. Low O ₂ Sat.:	91.4	91.1	91.2
Minimum O ₂ Sat.:	85.0	83.0	83.0

Avg Baseline O₂ sat = average oxygen saturation
Minimum O₂ Sat = most useful information
factor most likely to correlate with outcome

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

	NREM	REM	NREM+REM
RERA Events:	21.0	32.0	53.0
RERA Rate per Hour:	3.9	18.1	7.4
DB Rate per Hour:	7.0	49.3	17.4

RERA = respiratory event related arousal events
rate/hour = index
RERAS – consistent with previous definition of hypopnea with arousal and oxygen desaturation
DB rate/hour = RDI = respiratory disturbance index

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Type of Disordered Breathing Events	NREM	REM	NREM+REM
% Obstructed DB :	57.9%	88.4%	90.9%
% Mixed DB :	0.0%	0.0%	0.0%
% Central DB :	4.3%	11.6%	9.1%
% Central Hypopneas:	0.0%	0.0%	0.0%

Look at obstructed versus central events
Mixed usually added to obstructive
Central DB > 5/hour is important
 $10/hr \times 9.1\% = 0.9$ central events/hour

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Effect of Body Position on Disordered Breathing	Duration	NREM	REM	NREM+REM
Supine	223.5 min.	13.2	64.9	29.0
Non-Supine	206.4 min.	1.4	20.8	4.9

Supine (on your back) much higher than non-supine
may suggest positional therapy for treatment
REM much greater than non-supine
suggests the importance of all stages of sleep

Cincinnati Children's UNIVERSITY OF CINCINNATI

Positional Therapy



Positional pillows
Zzoma = only FDA-cleared positional medical device
Tennis ball sown in the back of the shirt

Cincinnati Children's UNIVERSITY OF Cincinnati

Positional Therapy



Vibro-tactile device
 Night Shift: worn on the back of the neck
 Night Balance: worn around the torso

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

Scoring Rules:
 Apneas were scored when there was cessation of flow for ≥ 10 seconds; hypopneas were scored as reduction in the nasal cannula pressure or effort channels for ≥ 10 seconds associated with $\geq 4\%$ desaturation. Respiratory effort related arousals (RERAs) were scored as a reduction in the nasal cannula pressure and/or increasing respiratory effort for ≥ 10 seconds leading to an EEG arousal.

If working with a new lab
 Look at the criteria they use
 Do they use 10 sec for children or 2 resp cycles
 Do they score RERAs or just hypopneas
 ie does $AHI = RDI$

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

SLEEP ARCHITECTURE
 The nocturnal sleep study demonstrated normal sleep onset with normal Stage N3 sleep and normal percentage of REM sleep. Total sleep time was normal and the sleep efficiency was reduced.

Discussion of the sleep staging
 adequate REM (20-25%)
 adequate slow wave sleep – Stage $\frac{3}{4}$ (20-25%)

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

RESPIRATORY ANALYSIS
 During non-REM sleep, the breathing pattern demonstrated mild sleep disordered breathing characterized predominantly by obstructive apneas, hypopneas and RERAs. Baseline oxygen saturation was normal and there was a mild fall in O_2 saturation with each disordered breathing event.

During REM sleep, the breathing pattern demonstrated obstructive apneas, hypopneas and RERAs. Baseline oxygen saturation was normal and there was a mild fall in O_2 saturation with each disordered breathing event.

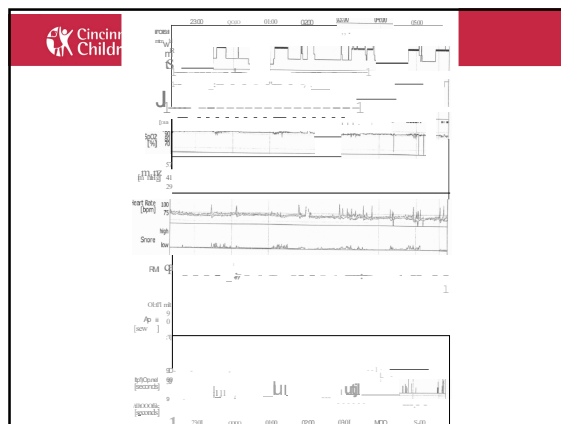
Discussion of the events during REM and NREM
 Types of events
 Baseline oxygen levels
 Desaturations

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

CARDIAC ANALYSIS
 The cardiac rhythm demonstrated normal sinus rhythm throughout the night with no sinus pauses.

Analysis of the EKG throughout the night
 Often look for PVCs
 Other arrhythmias



Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

SUMMARY
The nocturnal sleep study was consistent with a diagnosis of moderate sleep apnea, worse on his back. (ICSD # 327.23-0)

Summary

- Degree of SDB (snoring, mild, mod, severe)
- Positioning information
- Sleep stage dependent information

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

Total Recording Time:	430.8 minutes
Sleep Period:	344.0 minutes
Wake After Sleep Onset:	15.0 minutes
Total Sleep Time:	329.0 minutes
Sleep Onset:	86.8 minutes
Sleep Efficiency:	76.4 %

Sleep efficiency – low <85 or 90%
 Sleep onset = 87 minutes = normally 20-30 mins
 Wake after sleep onset = 15 mins – not bad

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

Sleep Latency to N1:	86.8 minutes
Sleep Latency to N2:	87.8 minutes
Sleep Latency to N3 (SWS):	94.8 minutes
Stage R Latency from Sleep Onset:	58.0 minutes

Sleep latency to N1 = sleep onset
 Sleep onset to N3 – usually quick
 Stage R latency from sleep onset = time to REM onset after falling asleep – 90 mins normal

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

Apnea + Hypopnea (A+H):	81	14.8 / h
Obstructive Apnea:	1	0.2 / h
Central Apnea:	4	0.7 / h
Mixed Apnea:	5	0.9 / h
Hypopnea (All):	71	12.9 / h
Obstructive Hypopnea:	-	-
Central Hypopnea:	-	-
Mixed Hypopnea:	-	-

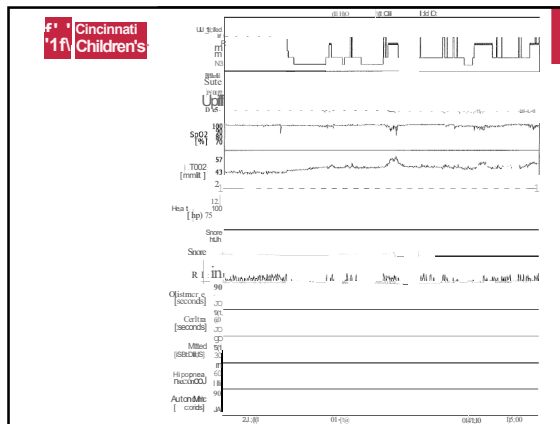
A+H = apnea hypopnea index
 Broken down by type of event (apnea vs hypopnea)
 Broken down by central vs obstructive
 Severe OSA with predominantly obstructive hypopnea

Cincinnati Children's UNIVERSITY OF Cincinnati

Objective PSG Parameters

Oxygen Desaturation Events (OD):	66	12.0 / h
Snore Time:	0.0 minutes	0.0 %
Limb Movement:	-	
PLMI:	-	

Oxygen desaturations/hour = 12/hour
 Usually similar to events/hour if not able to measure discrete apneas and hypopneas
 No snoring
 No limb movements



Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

	N1	N2	N3	R	Wake
Minutes:	1.0 min	184.5 min	90.0 min	53.5 min	101.8 min
% of TST	0.3 %	56.1 %	27.3 %	16.3 %	-
% of Sleep Period	0.3 %	53.6 %	26.2 %	15.6 %	4.4 %

Focus on % of TST = total sleep time
 Normal N1 = stage 1 = 5% or less
 N2 = 50%
 N3 = 20-25%
 Rem = 20-25%

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Respiration	Number	%	A or H/h	Supine	Non-Supine	Mean [seconds]	Longest [seconds]
Apnea	10	12.3	1.8	-	-	11.1	16.1
Obstructive	1	1.2	0.2	-	-	10.3	10.3
Central	4	4.9	0.7	-	-	8.7	10.8
Mixed	5	6.2	0.9	-	-	13.2	16.1
Hypopnea (All):	71	87.7	12.9	-	-	13.2	24.4
Obstructive	-	-	-	-	-	-	-
Central	-	-	-	-	-	-	-
Mixed	-	-	-	-	-	-	-
Total	81	-	14.8	-	-	13.0	24.4

Types of events – add obstructive and mixed
 AHI = 14.8/hour
 Mostly hypopneas (12.9/hr)
 Time of events also included

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Respiration	Number in REM	REM Index	Number in NREM	NREM Index
Apnea	4	4.5	6	1.3
Obstructive	0	0.0	1	0.2
Central	2	2.2	2	0.4
Mixed	2	2.2	3	0.7
Hypopnea (All):	54	60.5	17	3.7
Obstructive	-	-	-	-
Central	-	-	-	-
Mixed	-	-	-	-
Total	58	65.0	23	5.0

Primarily REM disease – common in children
 65/hour vs 5/hour
 Mostly hypopneas = also common in children

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Apnea-Desaturation Relation

Desaturation	Apnea	Obstructive	Central	Mixed	Hypopnea	Total
>90%	6	1	3	2	33	39
81-90%	1	0	1	0	25	26
71-80%	1	0	0	1	0	1
61-70%	0	0	0	0	0	0
51-60%	0	0	0	0	0	0
<50%	0	0	0	0	0	0
Total	8	1	4	3	58	66

of events and associated desaturations
 important to see if desats associated with central or obstructive events
 More useful to look at % less than 90%

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

SpO2 Statistics

Mean Oxygen Saturation:	96.9 %	Saturation < 90%:	3.2 minutes	1.0 %
Lowest Oxygen Saturation:	75.0 %	Saturation < 80%:	0.1 minutes	0.0 %
Average Desaturation:	4.9 %	Saturation < 70%:	-	- %
Average Oxygen Saturation during wake:	97.8 %			
Average Oxygen Saturation during REM:	94.3 %			
Average Oxygen Saturation during NREM:	97.4 %			

Time with saturations below 90% is 1%
 Less than 2% is within normal limits

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Snoring Time:	0.0 minutes
Relative Snoring Time:	0.0 %
Number of Snoring Episodes:	0
Average Snoring Episode Duration:	- minutes
Longest Snoring Episode:	- minutes

No snoring despite significant events

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Position	Number	OD/h	Average OD Fall [%]	Average OD [%]
Total	66	12.0	4.9	90.8
Supine	0	-	-	-
Non-Supine	66	12.0	4.9	90.8

Oxygen desaturation index = # of desaturations/hour – see if they are positional

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

ETCO2 Summary

	Wake	N1	N2	N3	R
Mean	41.5	42.2	46.2	45.1	50.2
High	51.9	43.3	51.9	51.1	60.9
Low	35.6	40.2	38.4	39.7	43.1
Time >50 mmHg	211.0	0.0	134.2	0.2	9687.3
%Time >50 mmHg	0.8	0.0	0.5	0.0	37.5

CO2 information routinely corrected on children
Not commonly in adults
Less than 50 is normal
Separate indication for T&A = 10% over 50mmHg

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

Results:

Saturation Nadir = 75%
Peak end-tidal PCO2 = 61mmHg
RDI = 14.8/hr. (Obstructive Apnea = 0.2/hr.; Hypopnea = 12.9/hr.; Mixed Apnea = 0.9/hr.; Central Apnea = 0.7/hr.)

EtCO2 >50mmHg for 6.2% of total sleep time.
ODI = 12.0/hr.

Low oxygen
High CO2 but <10% over 50mmHg
Severe OSA
Central index within normal limits

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters

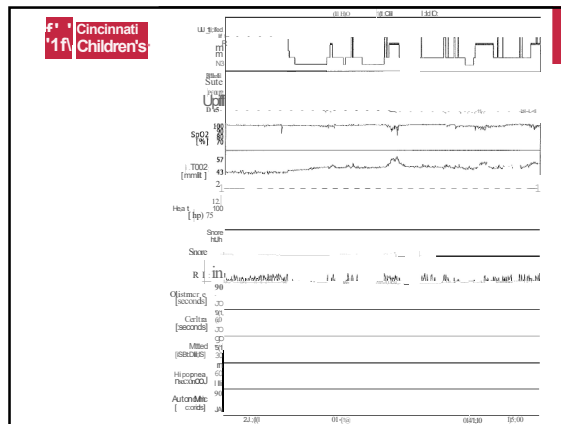
Sleep efficiency was decreased at 76% (TST = 329 minutes). Sleep architecture was abnormal. REM time was decreased at 16% (54 minutes). The number of arousals from sleep was 9.8/hr. Snoring was present at a level of 2 on a subjective scale of 0-4. There were few central apneas.


Low sleep efficiency
Decreased REM time
Normal arousals
Centrals normal

Cincinnati Children's UNIVERSITY OF CINCINNATI

Objective PSG Parameters


These data are consistent with severe OSA. Events may have been underestimated as REM time was decreased.






Summary

- Look at the entire sleep study
 - Especially if it does not show what you expect
- Obstructive vs central is important
- Consider treatment if
 - AHI/RDI: kids > 1; adults >15 or >5 with symptoms
 - CO2 > 50 for > 10% of total sleep time
 - Oxygen saturations below 90% for >2%
 - Symptomatic patients regardless of numbers




Summary

- May question the results if
 - Sleep efficiency low
 - REM time low
 - Subjectively not like a normal night for the patient
 - Doesn't fit with clinical history



#2 in the nation
because we put
KIDS 1st



Proud to be a
Cincinnati Children's
FAMILY
#2 in the nation

Thank You

Stacey.ishman@cchmc.org

Stacey Ishman, MD, MPH
Surgical Director, Upper Airway Center
Cincinnati Children's Hospital Medical Center