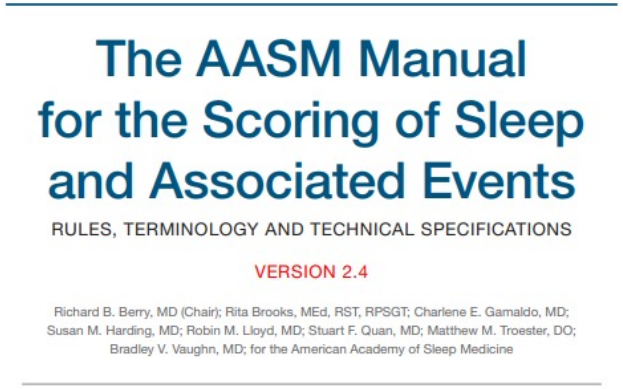
台大醫院 NTUH 睡眠中心

Polysomnography (PSG)



臺大醫院睡眠中心
劉惠美技師/李佩玲主任
2022/8/13

American Academy of Sleep Medicine, Darien, IL

Parameters to be Reported for PSG

- General parameter
- Sleep scoring data
- Arousal event
- Cardiac event
- Movement event
- Respiratory event
- Summary statement

- Recommend
  - Routine scoring of in-laboratory PSG or HSAT
- Acceptable
  - Alternative for recommend
- Optimal

Signal

睡眠檢查頻道

- 睡眠分期

1. 腦波(F4-M1, C4-M1, O2-M1, F3-M2, C3-M2, O1-M2)
2. 眼動圖(ROC;E2-M1, LOC;E1-M2)
3. 下顎肌電圖(ChinZ-Chin1, ChinZ-Chin2)

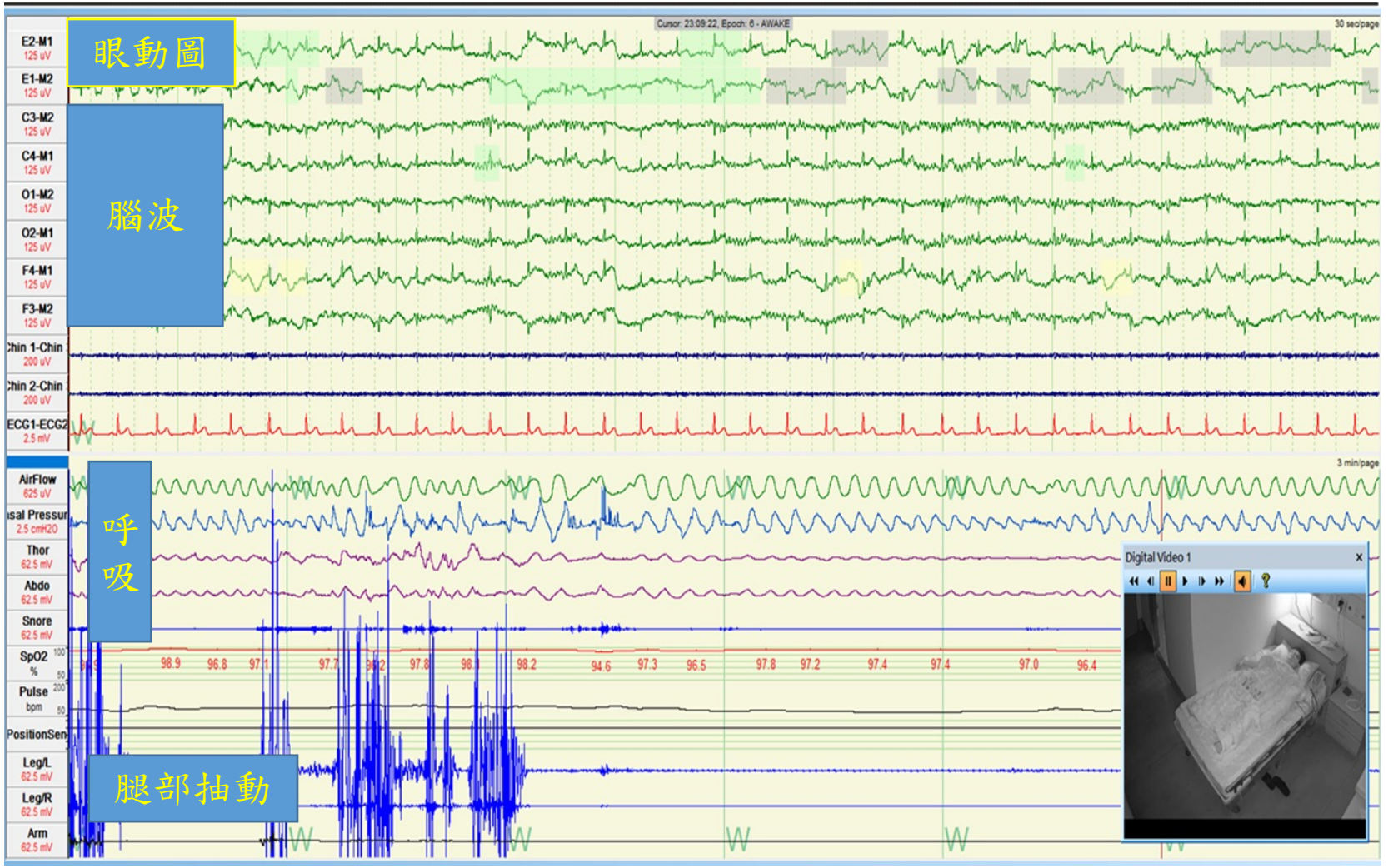
- 呼吸

1. 溫度呼吸氣流(thermist)
2. 鼻腔壓力呼吸氣流 (nasal pressure)
3. 胸腹呼吸電感體積描計 (Thor ,abdo)
4. 鼾聲snore
5. 血氧氣飽和度SPO2

Signal

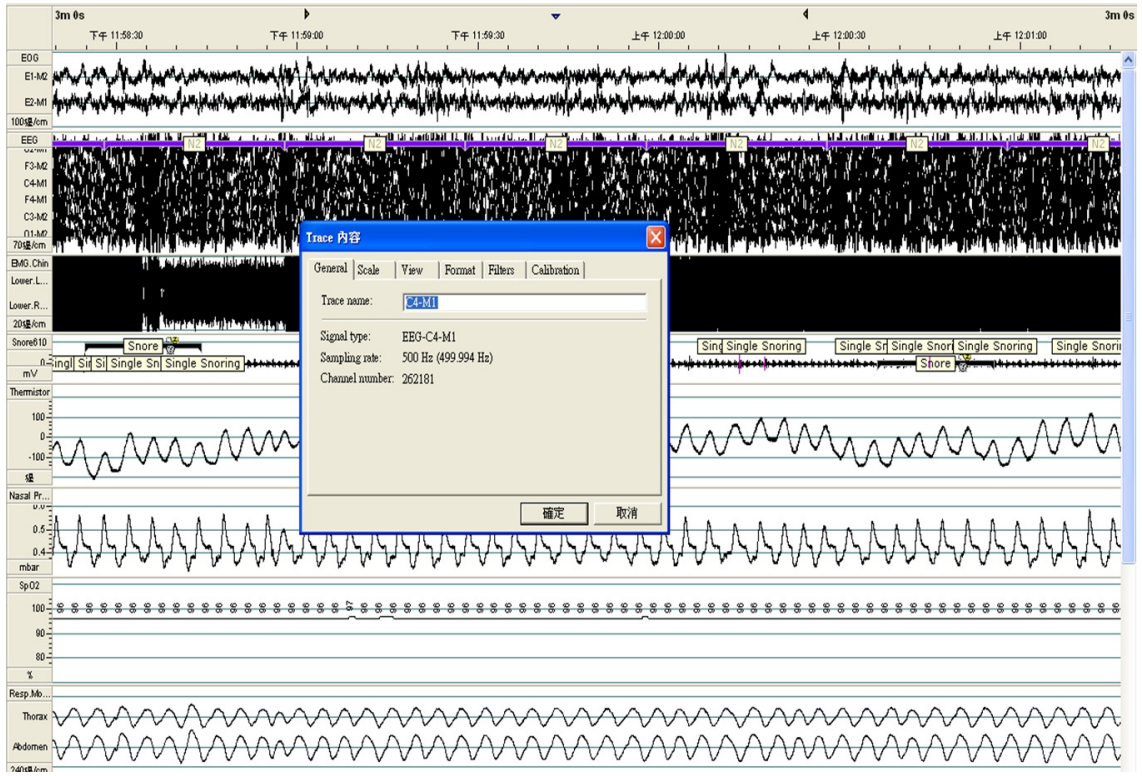
- 其他

1. 睡眠體position
2. 心電圖ECG
3. 前脛骨肌電圖
   R't leg & L't leg
4. 錄影



Technical and Digital Specifications
Recommend sampling rate

	Desirable	Minimal
EEG[N3,N4]	500 Hz	200 Hz
EOG[N5]	500 Hz	200 Hz
EMG[N6]	500 Hz	200 Hz
ECG[N7]	500 Hz	200 Hz
Airflow	100 Hz	25 Hz
Oximetry, Transcutaneous PCO_2[N8]	25 Hz	10 Hz
Nasal Pressure, End-Tidal PCO_2, PAP Device Flow[N9]	100 Hz	25 Hz
Esophageal Pressure	100 Hz	25 Hz
Body Position[N10]	1 Hz	1 Hz
Snoring Sounds[N11]	500 Hz	200 Hz
Rib Cage and Abdominal Movements[N12]	100 Hz	25 Hz



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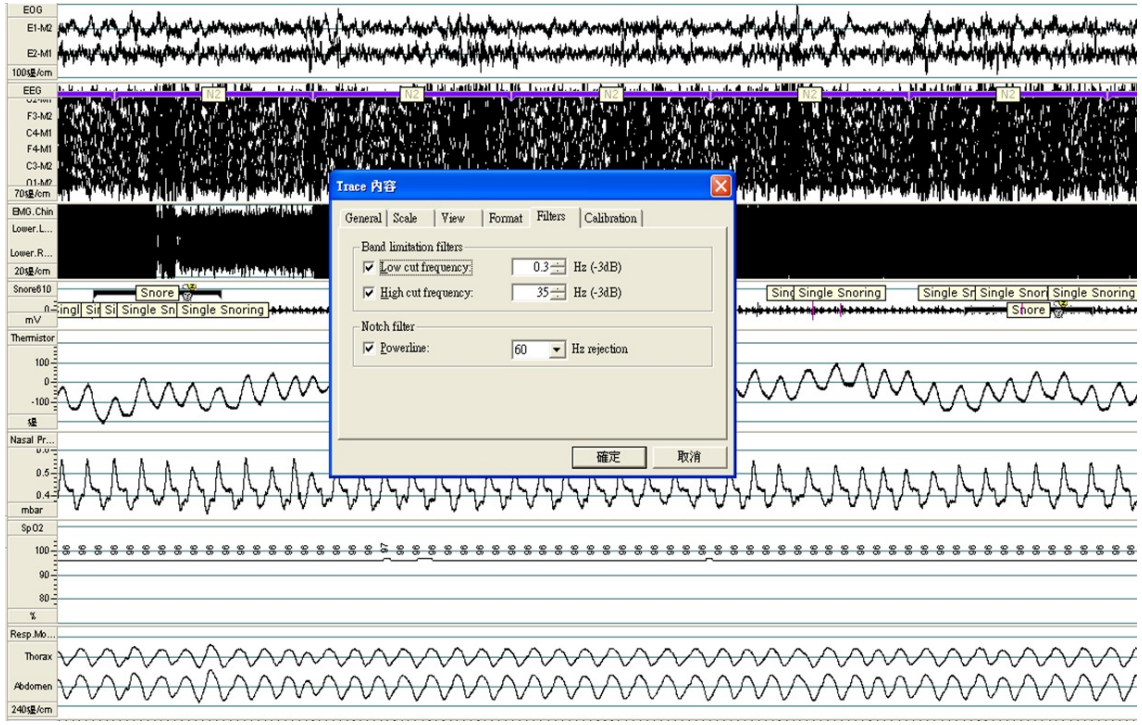
Technical and Digital Specifications
Recommend Filter setting

	Low-Frequency Filter	High-Frequency Filter
EEG [N4,N13]	0.3 Hz	35 Hz
EOG [N13]	0.3 Hz	35 Hz
EMG [N6]	10 Hz	100 Hz
ECG [N14]	0.3 Hz	70 Hz
Oronasal Thermal Flow, Thoracoabdominal Belt Signals	0.1 Hz	15 Hz
Nasal Pressure	Direct current (DC) or ≤0.03 Hz	100 Hz
PAP Device Flow	DC	DC
Snoring	10 Hz	100 Hz



Hook on, calibration and trouble shooting illustration video

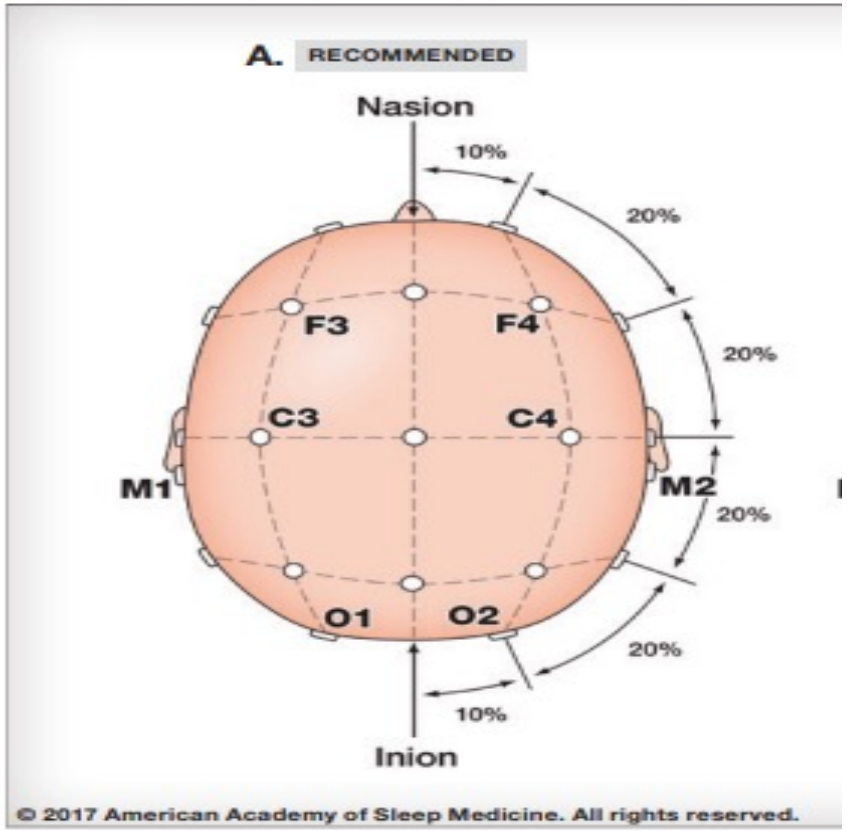
2021年12月錄製了PSG Reception Hook up and calibration 教學影片，提供想來睡眠中心見習或是實習的學生及醫師，可在網站上點閱影片，了解PSG的操作流程：

http://sleep.mc.ntu.edu.tw/media/165

Hook on

- PSG腦波有六個電極位置
  - 前額區:F3,F4
  - 中央區:C3,C4
  - 枕骨區:O1,O2
- 測量方法: 國際10-20系統的標準配位法

AASM.VERSION 2.4



Calibration

(一)阻抗測試:

- 全部電極阻抗須小於五千歐姆
- 肌電圖電極阻抗可容許小於1萬歐姆

(二)生物校正:

- 1.安靜張開和閉上眼睛個紀錄30秒鐘
- 2. 請勿移動頭部眼睛向左看,眼睛向右看
- 3. 請勿移動頭部眼睛向下看,眼睛向上看
- 4. 清楚地慢慢眨眼三次
- 5. 明確磨牙三次
- 6. 連續正常呼吸
- 7. 自然呼氣後閉氣10秒鐘
- 8. 模擬打鼾聲音
- 9. 改變睡眠體位
- 10.彎曲左足在伸展回來3次
- 11.彎曲右足在伸展回來3次
- 12.安靜閉眼30秒鐘

Trouble shooting and solution

訊號問題	處理方法
1. EOG:E2 電極脫落	• 檢查電極或感應線有沒有脫落 • 檢查電極或感應線接頭有沒有鬆脫 • 更換電極或感應線重新黏貼
2. EEG:C3 電極脫落	
3. EEG:M1 電極脫落	
4. Chin-R 電極脫落	
5. Themistor 脫落	
6. Cannula 脫落	
7. Thorax 異常	
8. Spo2 壓到 spo2異常	
9. Leg EMG 電極脫落	

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PSG Report

Sleep stage

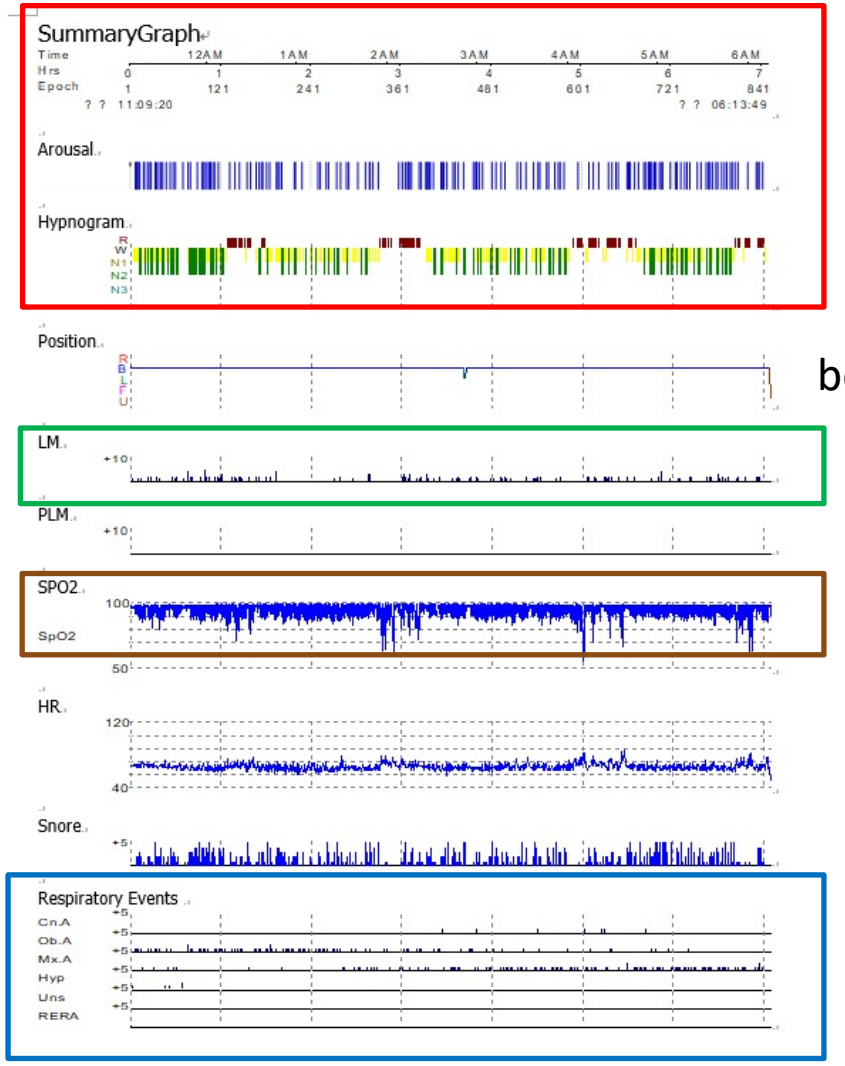
Respiratory

SpO2

limb movement

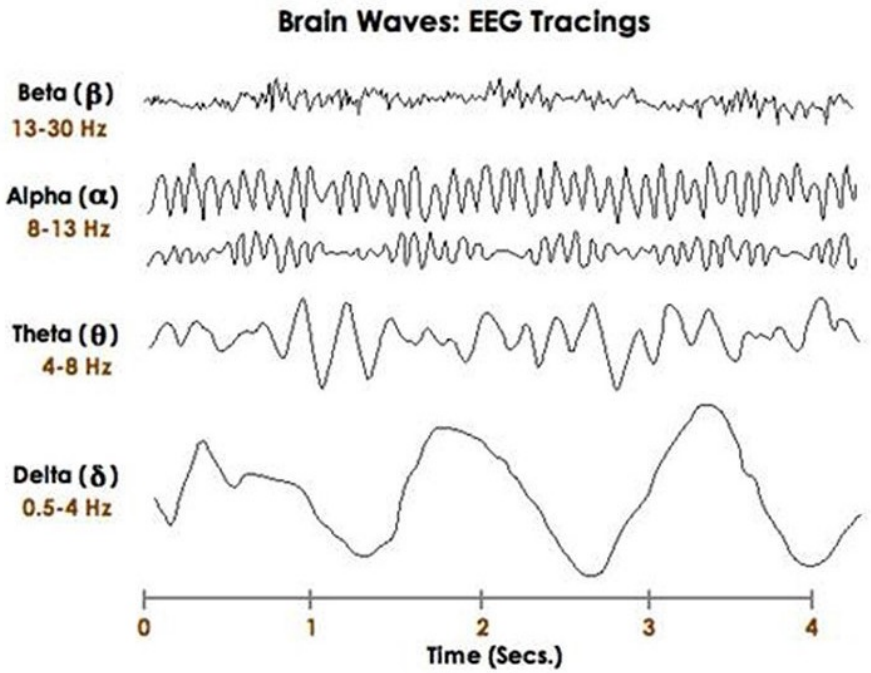
Sleep Summary

Total Time Analyzed:	424.5 minutes	
Sleep Period:	417.5 minutes	
Wake Time During Sleep Period:	126.5 minutes	
Total Sleep Time:	294.5 minutes	
Sleep Onset:	3.5 minutes	
Sleep Efficiency:	69.4%	
Number of Awakenings:	124	
Movement Time :	0.0 minute	
Sleep Latency to N1:	0.0 minutes	
Sleep Latency to N2:	1.5 minutes	
Sleep Latency to N3:	- minutes	
REM Latency from Sleep Onset:	61.5 minutes	
Apnea + Hypopnea (A+H):	226	46.0 / h
Obstructive Apnea:	105	21.4 / h
Central Apnea:	5	1.0 / h
Mixed Apnea:	112	22.8 / h
Hypopnea:	4	0.8 / h
Oxygen Desaturation Events (OD):	298	60.7 / h
Snore counts:	809	164.8 / h
Limb Movements:	186	
PLM Sequences:	0	



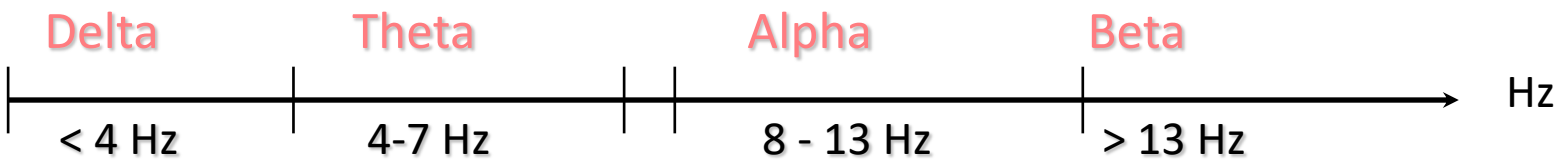
body position

Sleep stage: EEG spectrum



Sample	Label
	Alpha activity
	Theta activity
	Vertex sharp waves
	Sleep spindle

	K complex
	Slow waves
	REM
	SEM



Sleep stage feature 睡眠周期特徵

期別 / 狀態	腦電圖	眼動圖	肌電圖
放鬆清醒期	閉眼：律動阿爾法波 (8-13 cps) 頭後區最顯著 注意力集中時減弱 張眼：相對低振幅、混合頻率	自主性控制 眨眼或快速眼球轉動 欲睡時緩慢眼球轉動	肌肉持續性活動相對較高 自主性身體移動
非快速動眼第一期	相對低振幅、混合頻率 係他波 (4-7 cps) 和較大振幅頭頂銳波（< 0.5 秒） 同速高振幅係他波	緩慢眼球轉動	肌肉持續性活動可能較清醒期稍微降低
非快速動眼第二期	基本波：相對低振幅、混合頻率 紡錘波：漸增、漸減 11-16 cps（12-14 cps 為主），而且 ≧ 0.5 秒 K 複合波：尖銳負波和隨後的緩慢正波（≧ 0.5 秒）自發性或反應聲音	接近第一期之偶發性緩慢眼球轉動	肌肉持續性活動相對較低
非快速動眼第三期	≧ 20% 高 幅(>75 μV) 慢波 (≦ 2 cps)	無，反映腦電波	肌肉持續性活動相對較低
快速動眼期	相對低振幅、混合頻率 鋸齒波 係他波 緩慢阿爾法波	間歇性快速眼球轉動	肌肉持續性活動受到抑制 間歇性肌纖維抽動

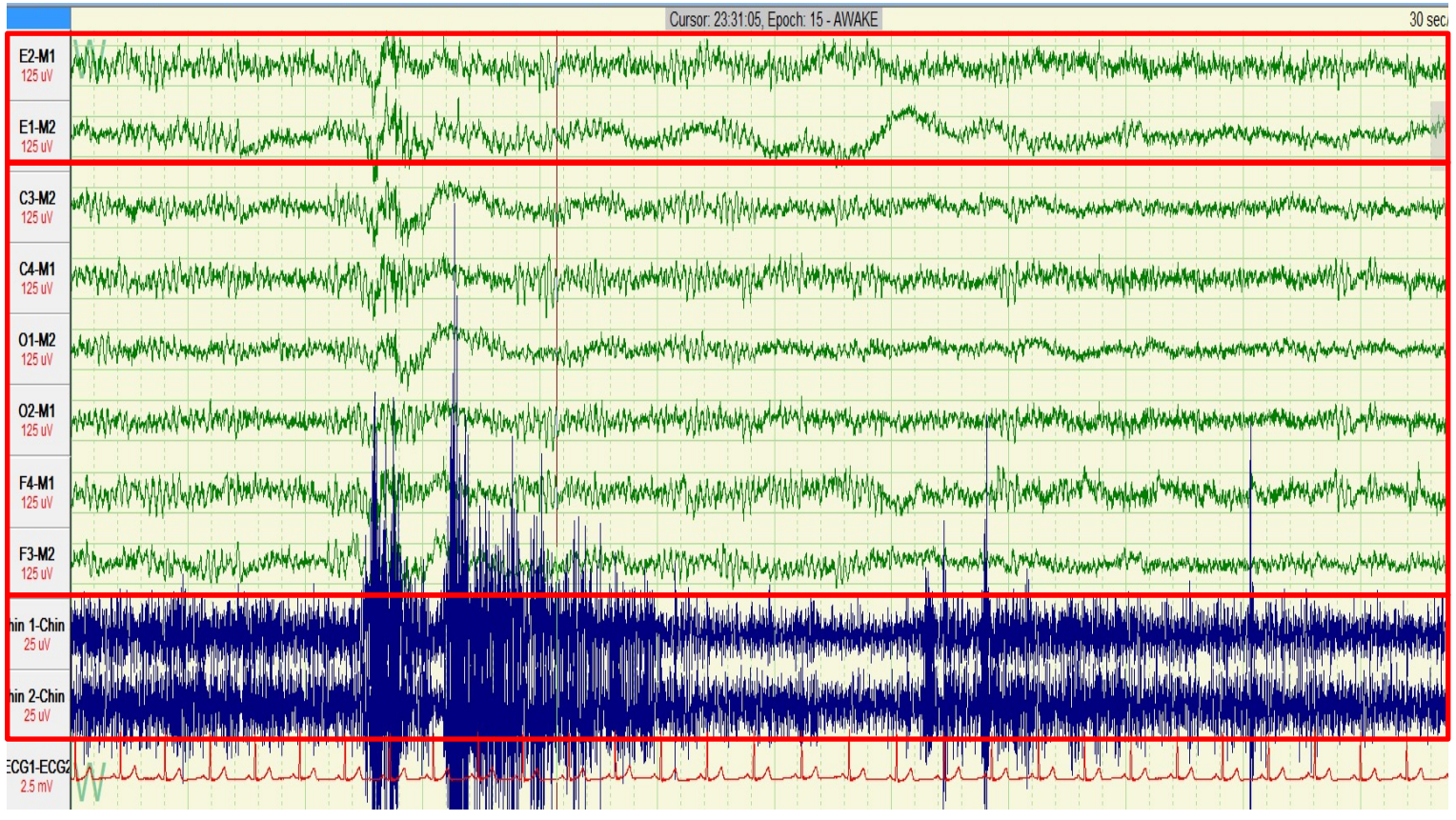
Stage Wake

- 腦波(EEG): low voltage, mixed frequency, alpha activity when eye close, prominent in occipital region
- 眼動(EOG): eye movement
- 肌電(EMG): elevated chin EMG

眼動

腦波

肌電



Stage N1

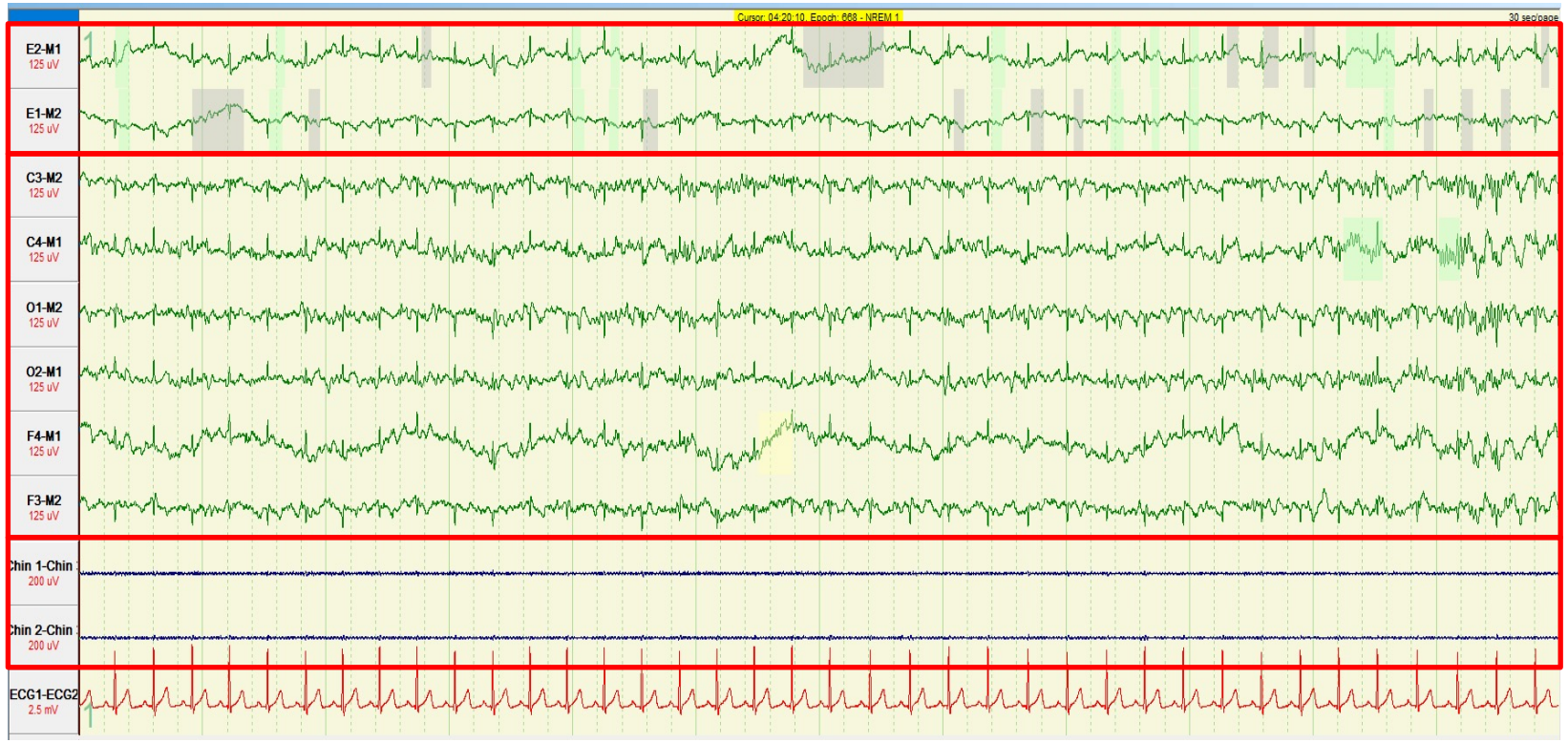
- 腦波(EEG): relative low voltage, mixed frequency, theta wave (4-7 Hz) prominent, loss of alpha wave, absence of K wave or spindle. Vertex sharp wave (central region) prominent in the late N1
- 眼動(EOG): slow eye movement (SEM)
- 肌電(EMG):下巴張力比清醒時低

緩慢眼球轉動，振幅較低肌電圖

眼動

腦波

肌電



Stage N2

- 腦波(EEG): K complex (frontal), spindle (central region), with mixed-frequency background
  - K complex:突出於腦波背景波的尖頂負銳波與隨後緩慢正波的組合波，總持續時間≥0.5秒，通常在頭部前額區的振幅最大
  - Sleep spindle:具有持續時間的11-16 Hz（最常見的是12-14 Hz）的波形，需≥0.5秒,以頭部中央區的振福最大

眼動

腦波

肌電

Stage N3

- 腦波(EEG):高幅慢波≧20%(F4與F3中出現,頻率0.5-2HZ、振幅>75 μV)
- 眼動(EOG): 通常不會看到眼球運動
- 肌電(EMG):張力的幅度可變，通常低於 N2 睡眠階段，有時甚至與 REM stage 一樣

眼動

腦波

肌電

>75 μV

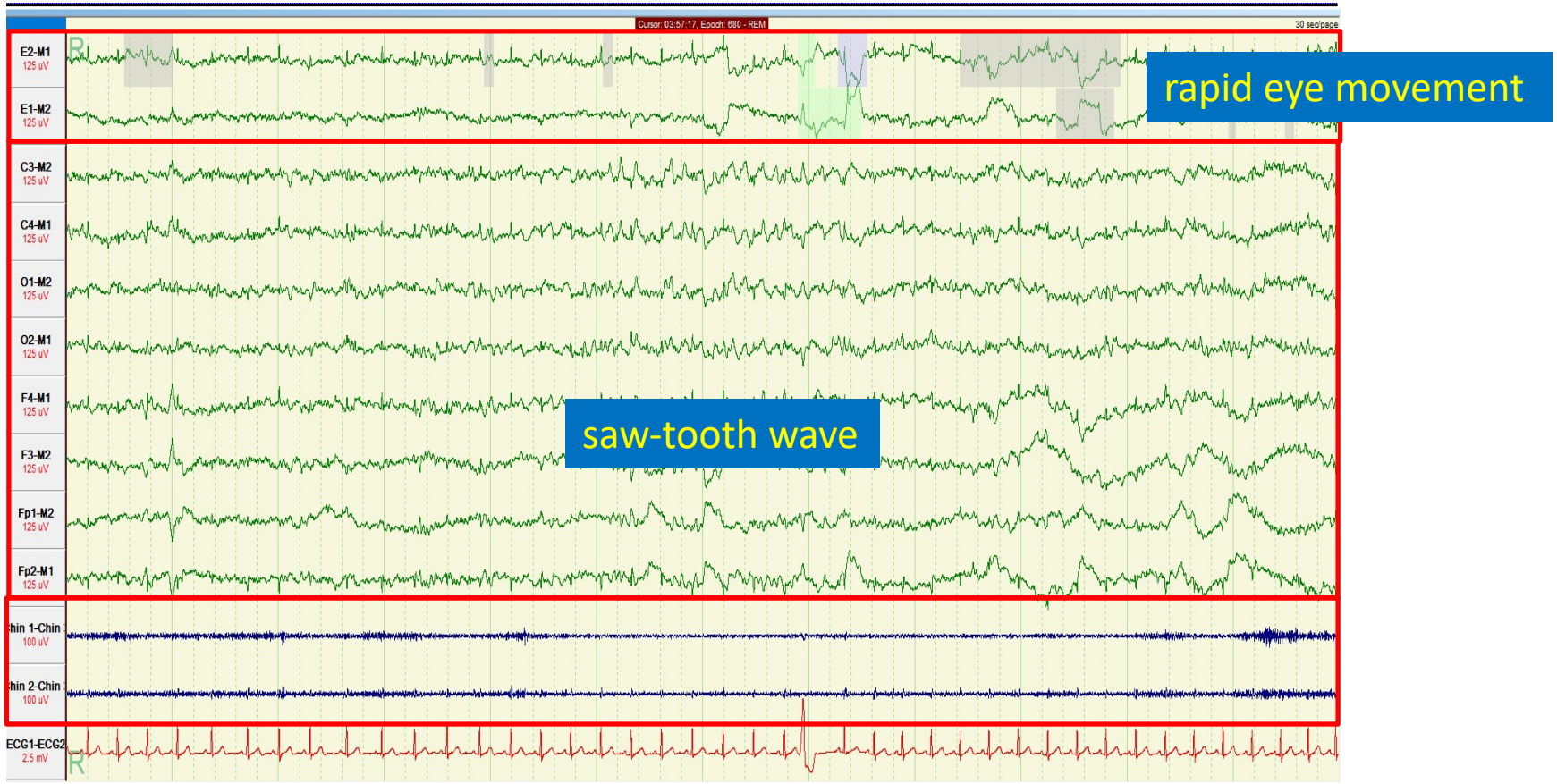
Stage REM

- 腦波(EEG): relative low-voltage, mixed frequency background, alpha burst, saw-tooth wave (central region)
- 眼動(EOG): intermittent rapid eye movement
- 肌電(EMG): low voltage

眼動

腦波

肌電



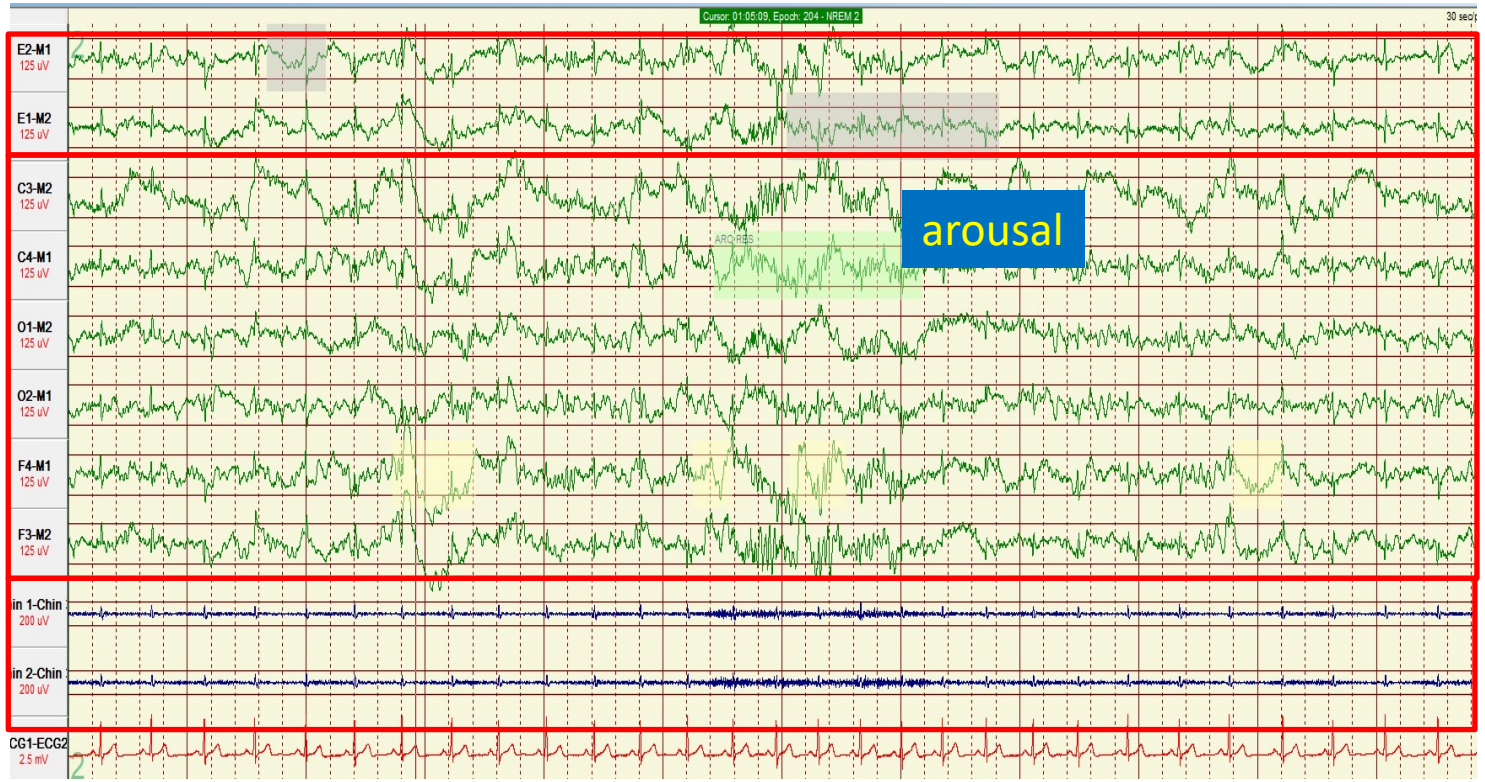
Arousal腦波覺醒

- 睡眠中發生特定的腦波變化，以反應身體的內外刺激
- 中央區或頭後區至少3秒鐘腦波頻率的突然改變(包括alpha、beta和/或超過16 Hz的頻率(非紡錘波))

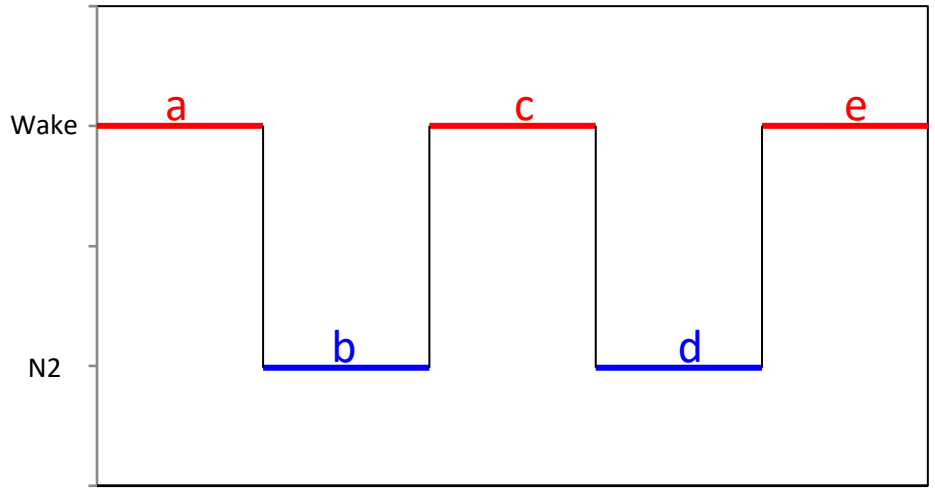
眼動

腦波

肌電



Compumedics and Embla sleep parameter



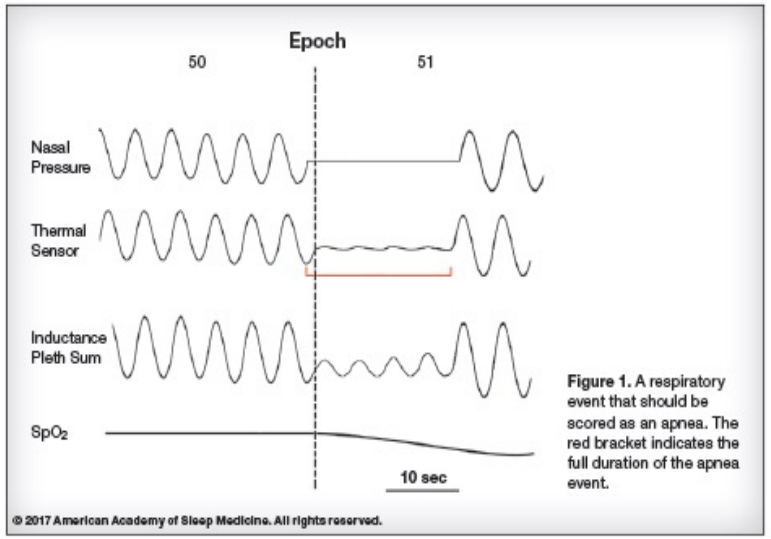
- Total time recording = Total time analysis = Time in bed = a+b+c+d+e
- Sleep latency = a
- Total sleep time = b+d
- WASO = wake time during sleep = c+e
- Total time awake during sleep period = c
- Sleep period = b+c+d (compumedics), b+c+d+e (embla)
- Sleep efficiency = Total sleep time / Time in bed = (b+d) / (a+b+c+d+e)

台大醫院 NTUH 睡眠中心

Respiratory rule for Adult
呼吸判讀 (V2.4)

Obstructive apnea	The presence of continued inspiratory effort associated with ≥90% decrease in airflow for duration of ≥ 10 sec If a portion meet criteria for a hypopnea meets criteria for apnea, the entire event should be scored as an apnea
Central apnea	Absent inspiratory effort associated with ≥90% decrease in airflow for duration ≥ 10 sec
Mixed apnea	Central apnea followed by obstructive apnea
Hypopnea	The presence of continued inspiratory effort associated with ≥30% decrease in airflow ≥10 sec associated with reduced SaO_2 in ≥3% or arousal.
Respiratory Effort-Related Arousal (RERA)	A sequence of breaths lasting ≥10 sec, leading to arousal from sleep and not meet criteria for an apnea or hypopnea
Hypoventilation	1. PaCO2 > 55 mm Hg for ≥ 10 minutes. 2. PaCO2 increase ≥ 10 mm Hg during sleep to a value > 50 mm Hg for ≥ 10 minutes
Cheyne-Stokes Breathing	1. ≥ 3 consecutive cycles of cyclical cresendo and decreasndo change in breathing amplitude with a cycle length of ≥ 40 sec and 2. AHI ≥ 5 record ≥ 2 hours monitor

Apnea

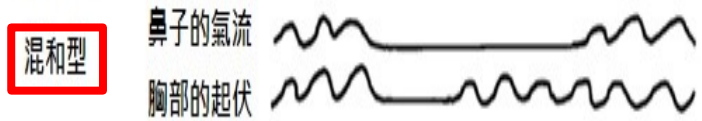


睡眠呼吸中止判讀法則

- 溫度感應氣流振幅較基準振幅減少≥90%
- 事件時間持續超過10秒

睡眠呼吸中止類型:

- 阻塞型:持續或增加的吸氣動作
- 混和型:吸氣動作先缺乏而後恢復
- 中樞型:缺乏呼吸動作



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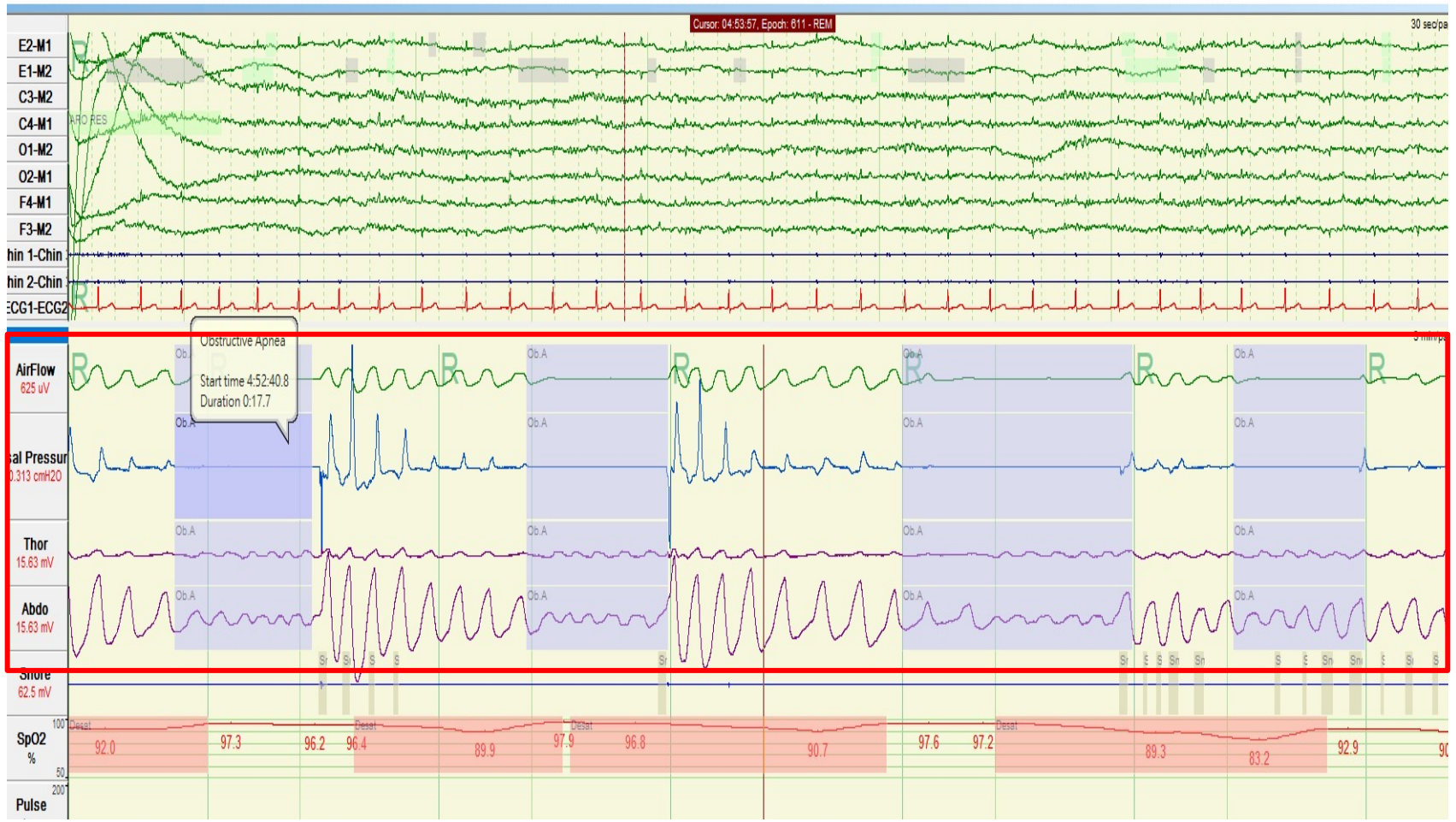
Obstructive apnea

溫度呼吸氣流

鼻腔壓力呼吸氣流

胸腹呼吸



Central apnea

溫度呼吸氣流

鼻腔壓力呼吸氣流

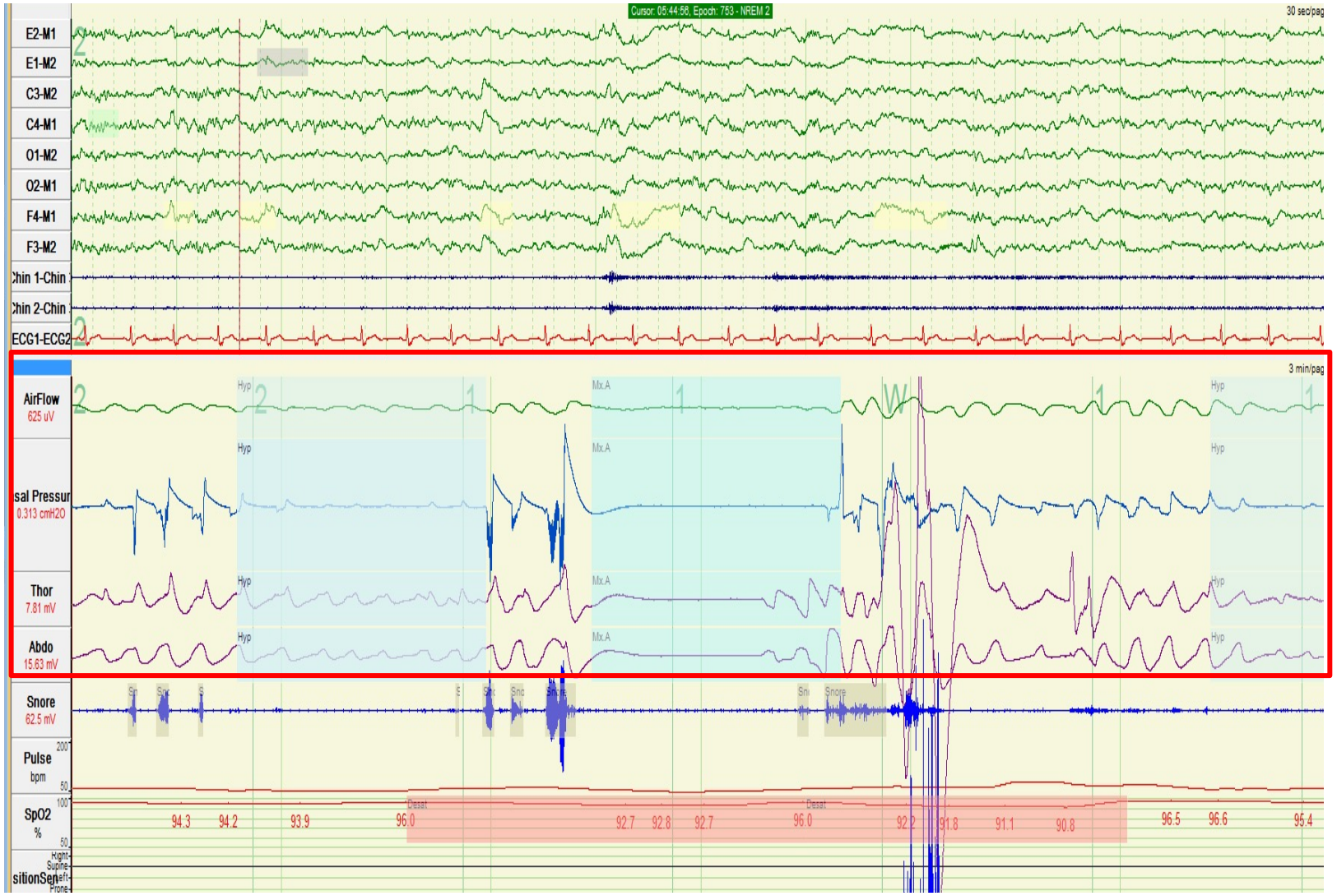
胸腹呼吸

Mixed apnea

溫度呼吸氣流

鼻腔壓力呼吸氣流

胸腹呼吸



Hypopnea

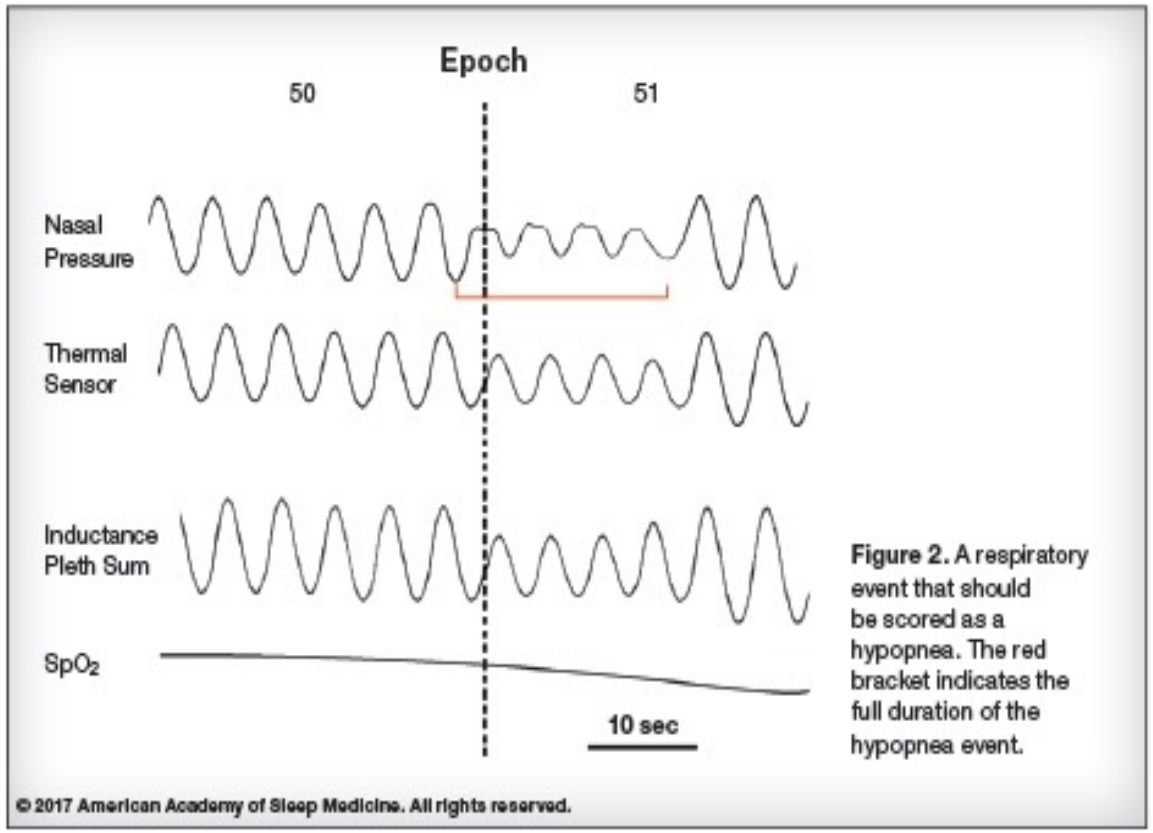


Figure 2. A respiratory event that should be scored as a hypopnea. The red bracket indicates the full duration of the hypopnea event.

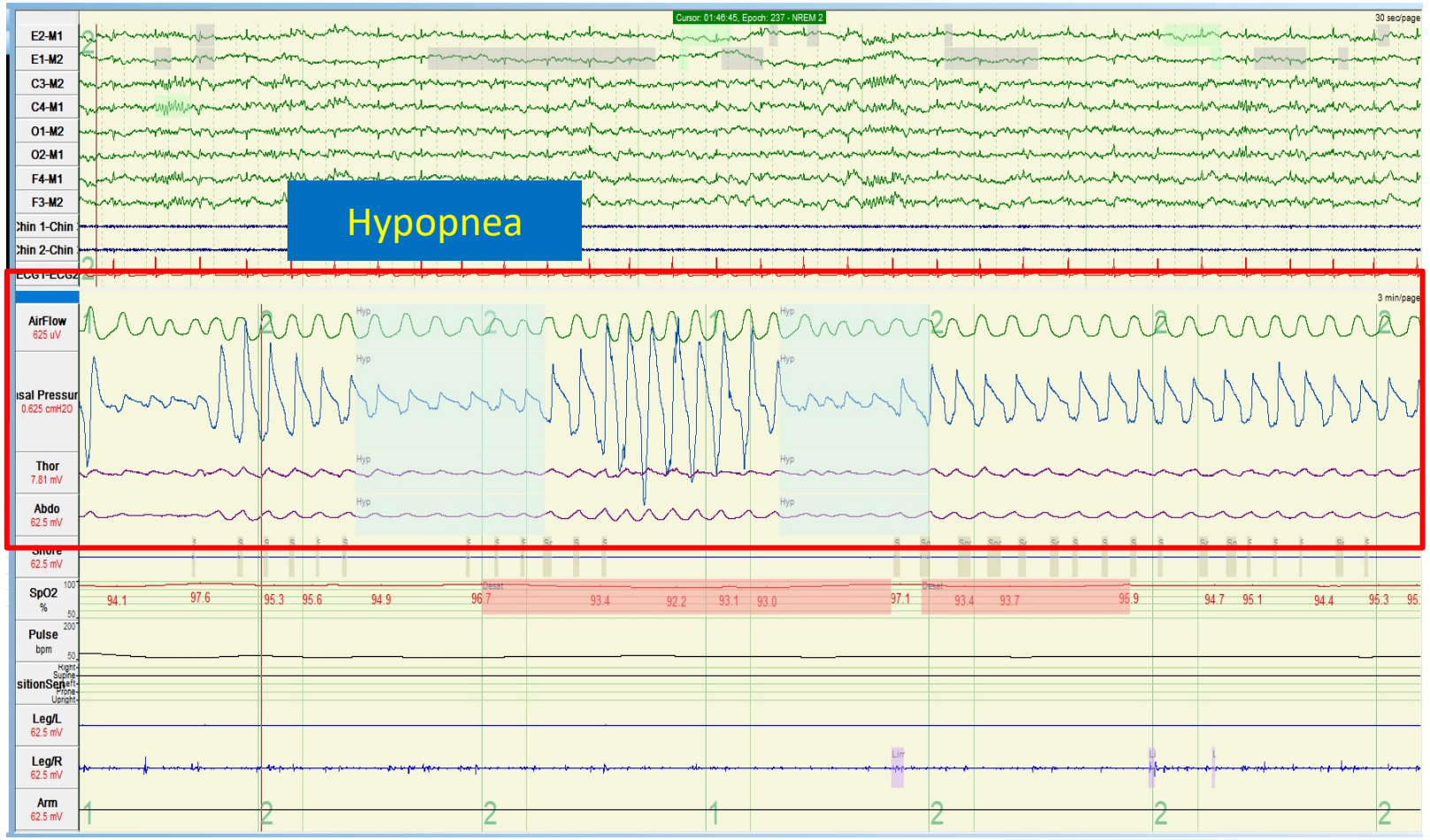
- 鼻腔壓力之氣流振幅較基準振幅減少≥30%)
- 事件時間持續超過10秒
- 血氧飽和度降低≥3%或事件發生後伴隨一個覺醒

Hypopnea

溫度呼吸氣流

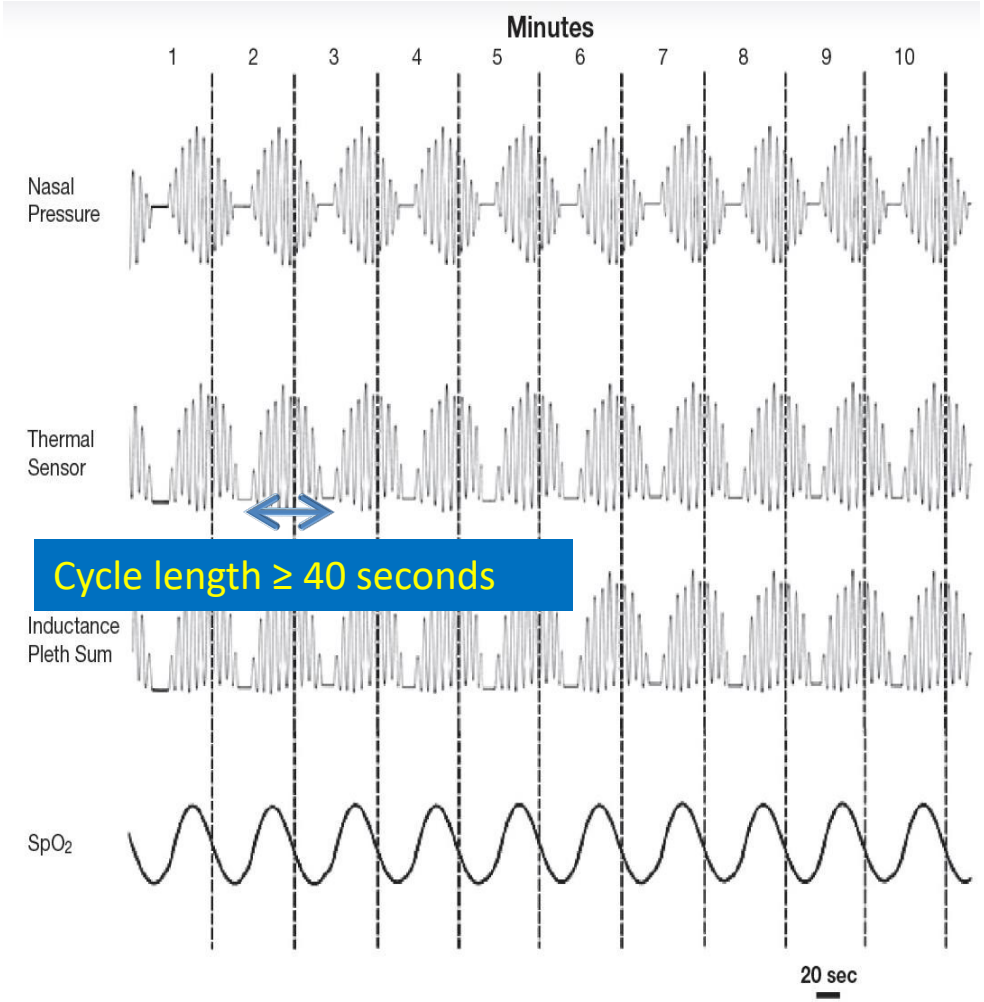
鼻腔壓力呼吸氣流

胸腹呼吸



Cheyne-Stokes Breathing

- 至少有3個連續的central apnea or central hyponpeas+呼吸幅度漸強漸弱的變化+1個cycle至少40秒(通常45~90秒)
- Central apnea or central hypopnea≥5/hr+監視記錄至少2小時

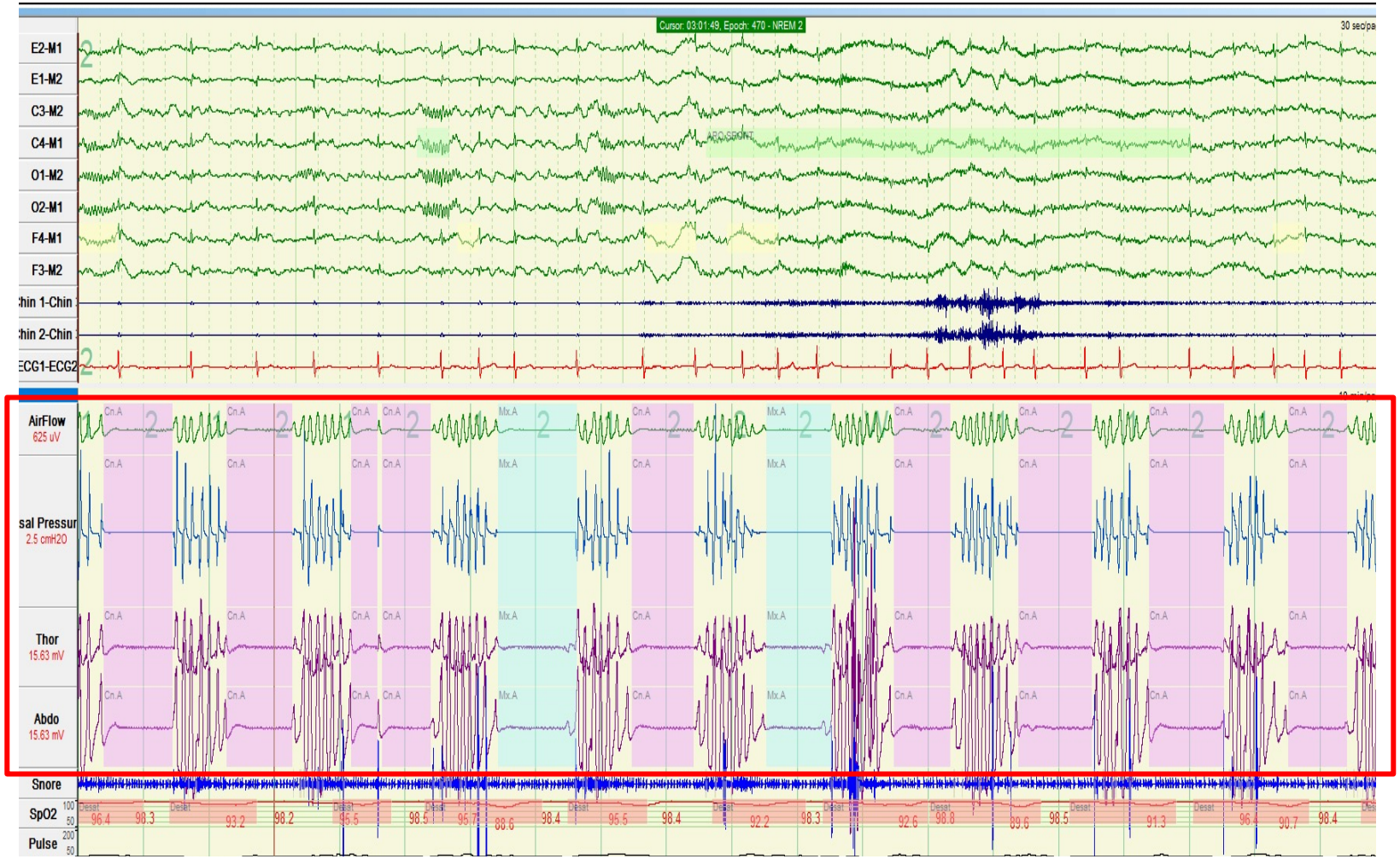


Cheyne-Stokes Breathing

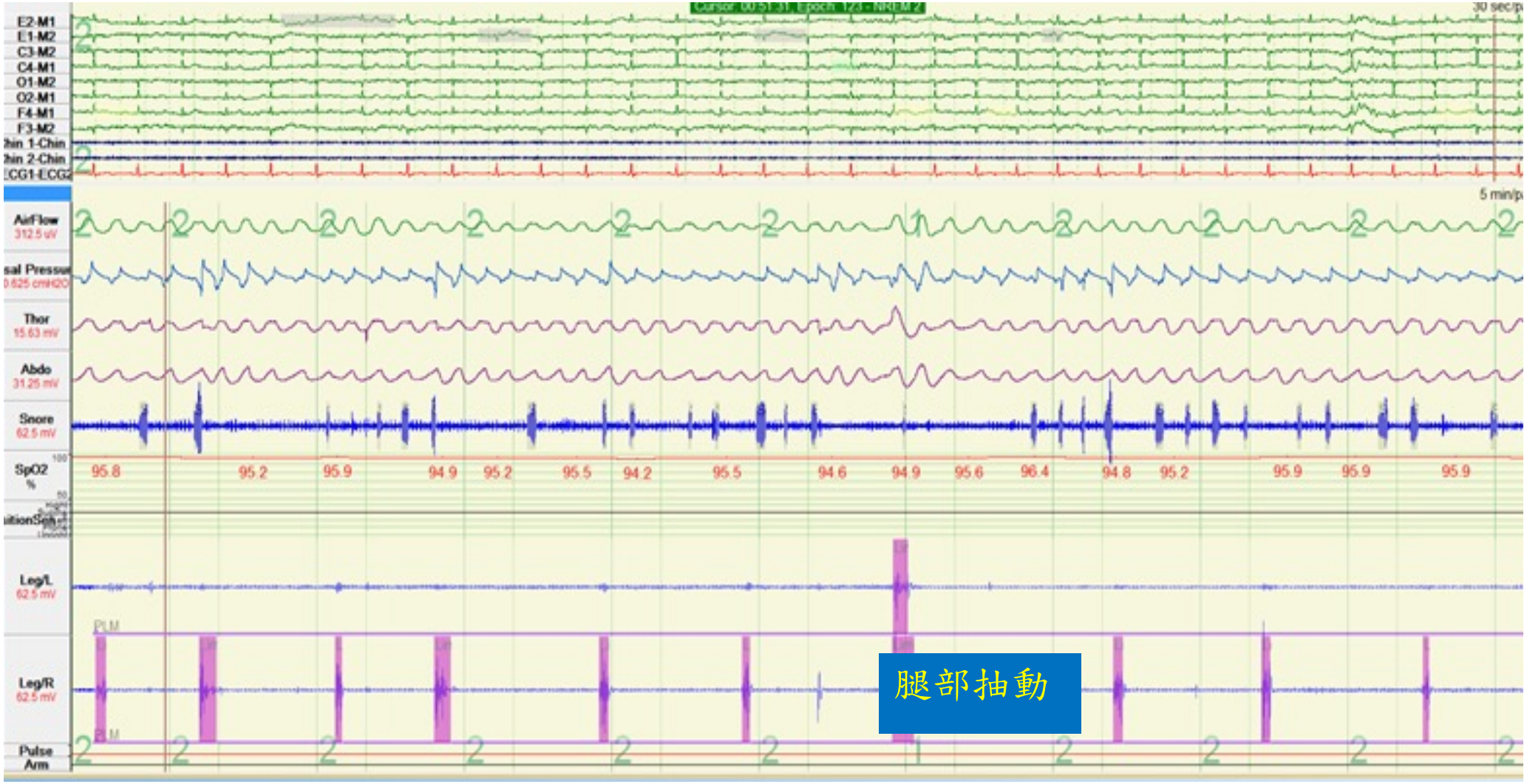
溫度呼吸氣流

鼻腔壓力呼吸氣流

胸腹呼吸



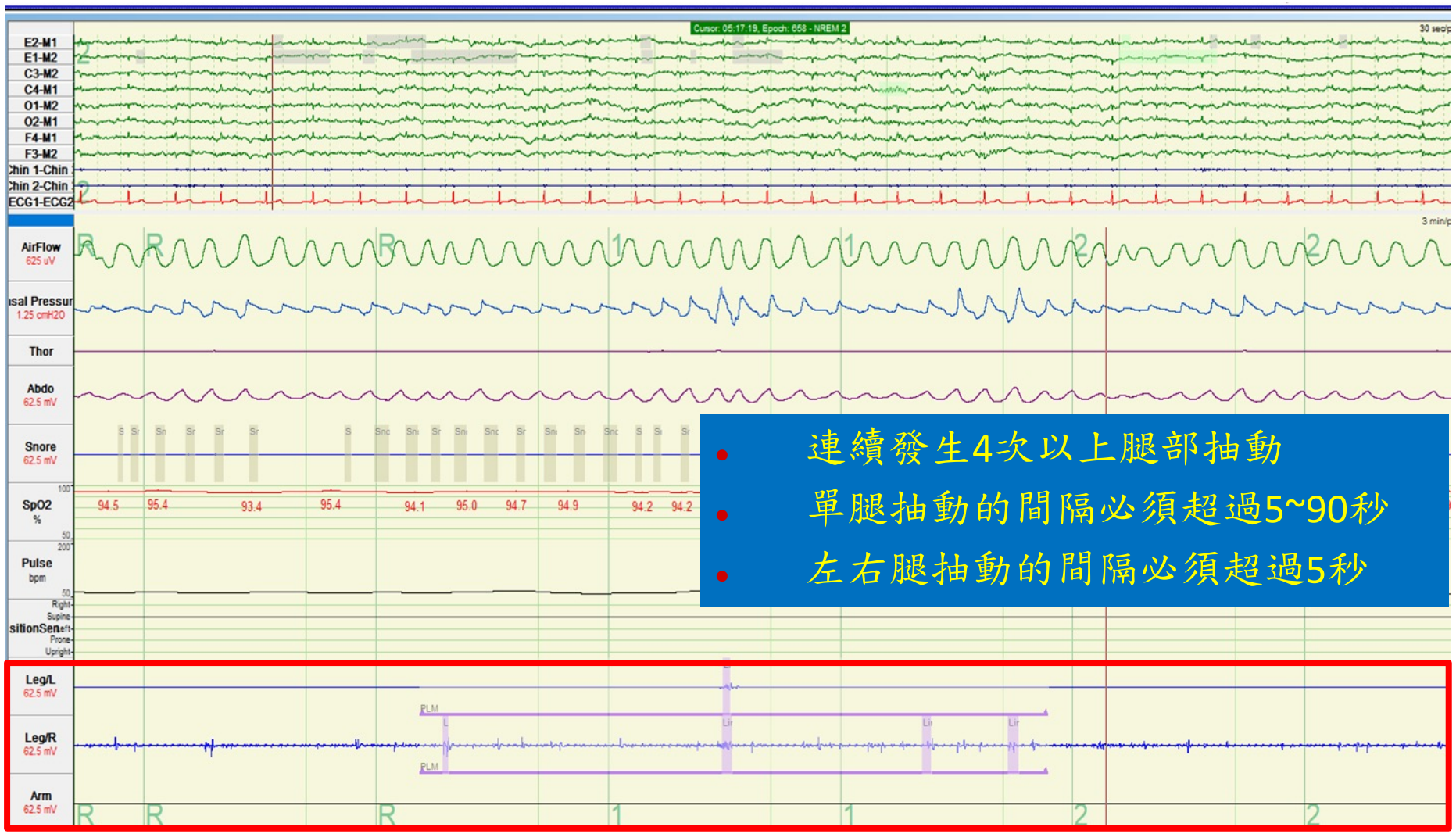
腿部抽動(LM)


E2-M1
E1-M2
C3-M2
C4-M1
O1-M2
O2-M1
F4-M1
F3-M2
Chin 1-Chin
Chin 2-Chin
ECG1-ECG2
AirFlow
Thor
Abdo
Snore
SpO2
95.8
95.2
95.9
94.9
95.2
95.5
94.2
95.5
94.6
94.9
95.6
96.4
94.8
95.2
95.9
95.9
95.9
Leg/L
Leg/R
PLM
Pulse
Arm
腿部抽動

Periodic Limb Movement (PLM)
週期性腿部抽動

- 連續發生4次以上腿部抽動
- 單腿抽動的間隔必須超過5~90秒
- 左右腿抽動的間隔必須超過5秒
- 呼吸中止或淺呼吸前後0.5秒之間的腿部抽動不能列入判讀

週期性腿部抽動


E2-M1
E1-M2
C3-M2
C4-M1
O1-M2
O2-M1
F4-M1
F3-M2
Chin 1-Chin
Chin 2-Chin
ECG1-ECG2
AirFlow
625 uV
Thor
Abdo
62.5 mV
Snore
62.5 mV
SpO2
%
Pulse
bpm
Leg/L
62.5 mV
Leg/R
62.5 mV
Arm
62.5 mV
94.5
95.4
93.4
95.4
94.1
95.0
94.7
94.9
94.2
94.2
連續發生4次以上腿部抽動
單腿抽動的間隔必須超過5~90秒
左右腿抽動的間隔必須超過5秒

Polysomnographic signal input: EDF to Metlab

	A	B	C	D	E	F	G	H	I	J	K	L
1	Grael			Metlab								
2	使用頻道名稱	備用頻道名稱		Nr	Label	Signal Quality Check						
3	E2-M1			1	Fp1	1	27	Pressure	1			
4	E1-M2			2	Fp2	1	28	Nasal Pressure1	1			
5	C3-M2			3	F3	1	29	PositionSen	1	Rirht=0, Supine=1, Left=2,Prone=3,Uprigh		
6	C4-M1			4	F4	1	30	Snore	1			
7	O1-M2			5	C3	1	31	SpO2	1			
8	O2-M1			6	C4	1	32	Pulse	1			
9	F4-M1			7	M1	1	33	Ox Status	1	0=Good, 1=poor, 2=off		
10	F3-M2			8	M2	1	34	Pleth	1			
11	Fp1-M2			9	O1	1	35	CPAP Press	0			
12	Fp2-M1			10	O2	1	36	CPAP Flow	0			
13	Chin1-Chin3			11	E1	1	37	EtCO2	0			
14	Chin2-Chin3			12	ECG1	1	38	EtCO2-W	0			
15	ECG1-ECG2			13	ECG2	1	39	Leak	0			
16	Airflow			14	E2	1	40	TidalVol	0			
17	Nasal Pressure1			15	Chin 1	1	41	Derived HR	1			
18	Thor	Thor-add		16	Chin 2	1	42	ManLights	0	手動輸入調整的position		
19	Abdo	Abdo-add		17	Chin 3	1	43	RespRate	1			
20	Snore			18	Leg/L	1	44	Sum	1			
21	Pulse			19	Leg/R	1						
22	SpO2			20	position	0						
23	PositionSen	Position		21	Arm	1						
24	Leg/L			22	AirFlow	1						
25	Leg/R			23	Thor-add	1						
26	Arm			24	Abdo-add	1		as Grael singal				
27				25	Thor	1		no singal input				
28				26	Abdo	1		derived signal				
29				27	Pressure	1						
30												

台大醫院 NTUH 睡眠中心

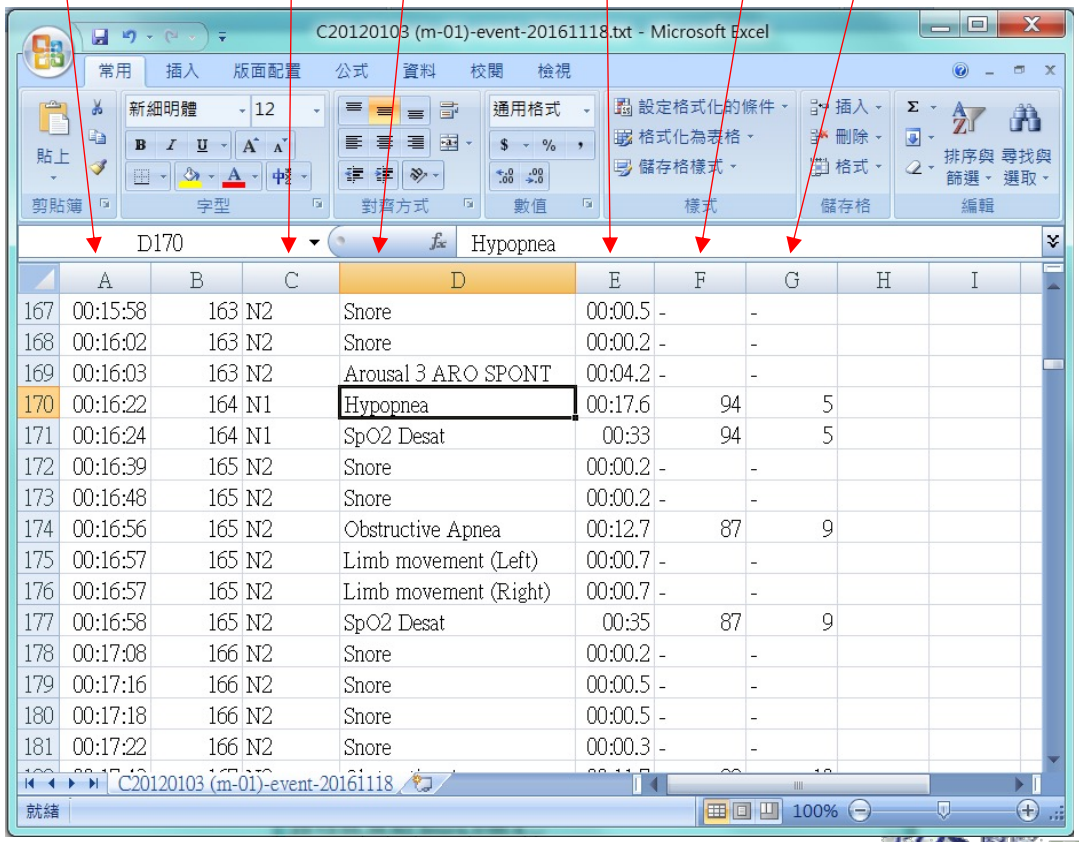
Event: sleep stage, breathing event, SpO_2, ECG

Embletta

SLEEP-S0	POSITION-LEFT	上午 05:26:20.926	Inspiration	1.12	
SLEEP-S0	POSITION-LEFT	上午 05:26:25.265	Flow Limitation	1.54	
SLEEP-S0	POSITION-LEFT	上午 05:26:28.275	Display Change	0.00	
SLEEP-S0	POSITION-LEFT	上午 05:26:28.705	Flow Limitation	1.36	
SLEEP-S0	POSITION-LEFT	上午 05:26:32.065	Inspiration	1.41	
SLEEP-S0	POSITION-LEFT	上午 05:26:35.694	Flow Limitation	1.52	
SLEEP-S0	POSITION-LEFT	上午 05:26:39.634	Inspiration	1.58	
SLEEP-S0	POSITION-LEFT	上午 05:26:43.614	Inspiration	1.67	
SLEEP-S0	POSITION-LEFT	上午 05:26:47.628	Inspiration	1.60	
SLEEP-S0	POSITION-LEFT	上午 05:26:48.000	W	30.00	
SLEEP-S0	POSITION-LEFT	上午 05:26:51.608	Inspiration	1.55	
SLEEP-S0	POSITION-LEFT	上午 05:26:55.523	Inspiration	1.70	
SLEEP-S0	POSITION-LEFT	上午 05:26:59.722	Inspiration	1.59	
SLEEP-S0	POSITION-LEFT	上午 05:27:03.542	Inspiration	1.51	
SLEEP-S0	POSITION-LEFT	上午 05:27:07.176	Inspiration	1.45	
SLEEP-S0	POSITION-LEFT	上午 05:27:10.646	Inspiration	1.40	
SLEEP-S0	POSITION-LEFT	上午 05:27:14.061	Inspiration	1.43	
SLEEP-S0	POSITION-LEFT	上午 05:27:17.575	Inspiration	1.43	
SLEEP-S0	POSITION-LEFT	上午 05:27:18.000	W	30.00	
SLEEP-S0	POSITION-LEFT	上午 05:27:20.312	Display Change	0.00	
SLEEP-S0	POSITION-LEFT	上午 05:27:20.312	Display Change	0.00	
SLEEP-S0	POSITION-LEFT	上午 05:27:20.312	Display Change	0.00	
SLEEP-S0	POSITION-LEFT	上午 05:27:21.230	Inspiration	1.49	
SLEEP-S0	POSITION-LEFT	上午 05:27:25.080	Inspiration	1.49	
SLEEP-S0	POSITION-LEFT	上午 05:27:29.044	Inspiration	1.48	
SLEEP-S0	POSITION-LEFT	上午 05:27:32.929	Inspiration	1.48	
SLEEP-S0	POSITION-LEFT	上午 05:27:36.519	Inspiration	1.47	
SLEEP-S0	POSITION-LEFT	上午 05:27:40.048	Inspiration	1.51	
SLEEP-S0	POSITION-LEFT	上午 05:27:43.778	Inspiration	1.43	
SLEEP-S0	POSITION-LEFT	上午 05:27:47.253	Inspiration	1.53	
SLEEP-S0	POSITION-LEFT	上午 05:27:48.000	W	30.00	
SLEEP-S0	POSITION-LEFT	上午 05:27:51.007	Inspiration	1.58	
SLEEP-S0	POSITION-LEFT	上午 05:27:54.687	Inspiration	1.63	
SLEEP-S0	POSITION-LEFT	上午 05:27:58.461	Inspiration	1.58	
SLEEP-S0	POSITION-LEFT	上午 05:28:02.621	Inspiration	1.49	
SLEEP-S0	POSITION-LEFT	上午 05:28:06.901	Inspiration	1.50	
SLEEP-S0	POSITION-LEFT	上午 05:28:10.458	Left	0.80	
SLEEP-S0	N/A	上午 05:28:10.507	Lights On	0.00	
SLEEP-S0	N/A	上午 05:28:18.000	W	30.00	
SLEEP-S0	N/A	上午 05:28:48.000	W	30.00	

Compumedics

起始時間 Stage Event 持續時間 Lowest O_2 Average desaturation



	A	B	C	D	E	F	G	H	I
167	00:15:58	163	N2	Snore	00:00.5	-	-		
168	00:16:02	163	N2	Snore	00:00.2	-	-		
169	00:16:03	163	N2	Arousal 3 ARO SPONT	00:04.2	-	-		
170	00:16:22	164	N1	Hypopnea	00:17.6	94	5		
171	00:16:24	164	N1	SpO2 Desat	00:33	94	5		
172	00:16:39	165	N2	Snore	00:00.2	-	-		
173	00:16:48	165	N2	Snore	00:00.2	-	-		
174	00:16:56	165	N2	Obstructive Apnea	00:12.7	87	9		
175	00:16:57	165	N2	Limb movement (Left)	00:00.7	-	-		
176	00:16:57	165	N2	Limb movement (Right)	00:00.7	-	-		
177	00:16:58	165	N2	SpO2 Desat	00:35	87	9		
178	00:17:08	166	N2	Snore	00:00.2	-	-		
179	00:17:16	166	N2	Snore	00:00.5	-	-		
180	00:17:18	166	N2	Snore	00:00.5	-	-		
181	00:17:22	166	N2	Snore	00:00.3	-	-		

Inter-scorer reliability using majority score as ground truth: in OSA patients

kappa bad: 0.00–0.20, poor: 0.21–0.40; reasonable: 0.41–0.60, good: 0.61–0.80, excellent: > 0.80

- EEG (kappa)

	Score 1 vs 2	Score 2 vs 3	Score 1 vs 3	Score 1 vs GT	Score 2 vs GT	Score 3 vs GT
Wake	0.95 (+-0.06)	0.97(+-0.08)	0.95(+-0.05)	0.96(+-0.03)	0.98(+-0.06)	0.98(+-0.05)
N1	0.83 (+-0.1)	0.94(+-0.1)	0.84(+-0.08)	0.86(+-0.09)	0.97(+-0.09)	0.98(+-0.04)
N2	0.82 (+-0.12)	0.94(+-0.12)	0.83(+-0.09)	0.85(+-0.10)	0.96(+-0.1)	0.97(+-0.04)
N3	0.93 (+-0.09)	0.97(+-0.09)	0.95(+-0.05)	0.95(+-0.05)	0.98(+-0.02)	0.99(+-0.02)
REM	0.95 (+-0.1)	0.97(+-0.1)	0.96(+-0.02)	0.97(+-0.03)	0.99(+-0.1)	0.99(+-0.02)

- Airflow (kappa)

	Score 1 vs 2	Score 2 vs 3	Score 1 vs 3	Score 1 vs GT	Score 2 vs GT	Score 3 vs GT
Obstructive	0.68(±0.12)	0.75(±0.17)	0.70(±0.16)	0.73(±0.11)	0.65(±0.16)	0.74(±0.12)
hypopnea	0.69(±0.11)	0.81(±0.10)	0.81(0.12)	0.80(±0.12)	0.70(±0.12)	0.79(±0.11)
Central	0.48(±0.21)	0.64(±0.26)	0.69(±0.24)	0.79(±0.20)	0.46(±0.22)	0.60(±0.21)
Mixed	0.49(±0.36)	0.68(±0.20)	0.67(±0.26)	0.69(±0.23)	0.44(±0.26)	0.71(±0.22)
No-event	0.80(±0.10)	0.85(±0.11)	0.83(±0.11)	0.81(±0.11)	0.80(±0.11)	0.84(±0.10)

Chiu HC and Liu PK In preparation

GT: ground truth

謝謝大家的聆聽