

# Achieving Restful Ventilation: The Impact of Patient-Ventilator Interaction on Sleep



## **Disclosure Statement**

**I have received a research grant from Covidien for a clinical research assistant.**

## Case Scenario: Sleepless in ICU

- 56 year old male
- 40 pack year smoker, obese, hypertension
- Critical illness now resolved
- Prolonged wean from mechanical ventilation
- Tracheostomy
- Looks comfortable on PSV 12 cmH<sub>2</sub>O, PEEP 5
- Develops distress within 1-2 hr of trach-mask trials
- Nurses say he “hardly gets any sleep”

## Audience Poll

1. How do you ventilate this patient at night to ensure he is well-rested the next day?

- Increase Pressure Support level?
- Assist – Control mode?
- Continue attempts to wean PSV overnight?

*Do ventilator settings impact sleep quality?*

# Outline

- Is sleep quality in ICU important?
- What happens to breathing pattern during sleep
  - Normal, healthy person
  - Ventilated patient
- Patient-ventilator interaction and sleep
  - Central Apnea
  - Asynchrony (eg. Ineffective efforts)
- How should we set the ventilator to promote better sleep quality?

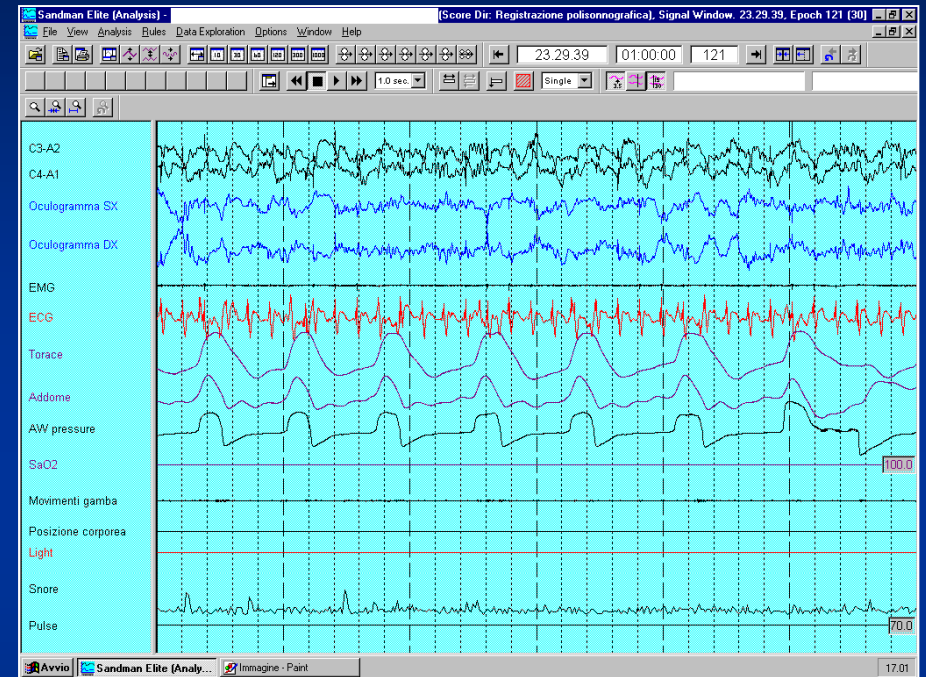
# Sleep Quality in the ICU

- **Highly fragmented**
  - 20-80 arousals and awakenings per hour sleep
- **Abnormal sleep architecture**
  - severely reduced slow wave sleep
  - Reduced to absent REM sleep
- **Disruption of circadian rhythm**
  - 50% of sleep occurs during the day

# Impact of Poor Sleep Quality in ICU

- **61% of ICU patients reported sleep deprivation**
  - *Simini, B. THE LANCET 1999; 354 : 571-2*
- **Being unable to sleep ranked among the highest stressors by patients**
  - *Biancofiore, G. Liver Transplantation, 2005;11(8): 967-972*
  - *Novaes, M. Intensive Care Med , 1999; 25: 1421-6*
- **Associated with Late NIV failure**
  - *Campo, F. Crit Care Med, 2010; 38 (Epub ahead of print)*
- **May contribute to delirium**
  - *Campo, F. Crit Care Med, 2010; 38 (Epub ahead of print)*
  - *Helton MC et al. Heart Lung 1980; 9:464-468*

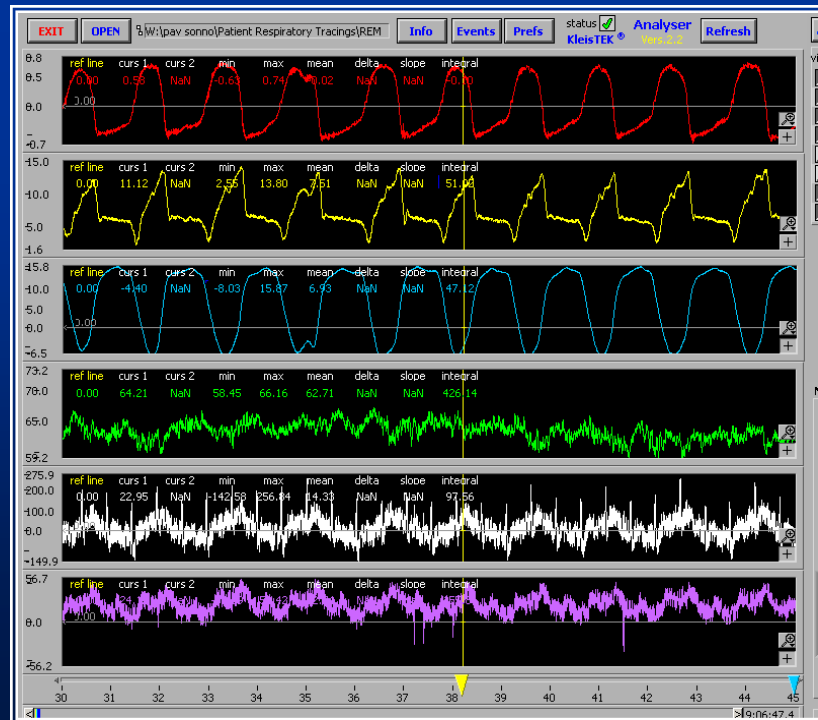
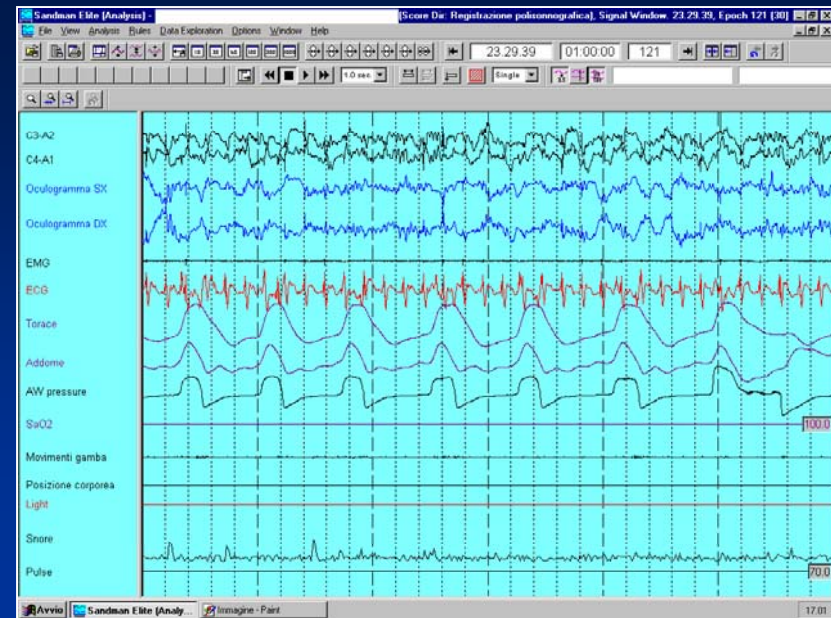
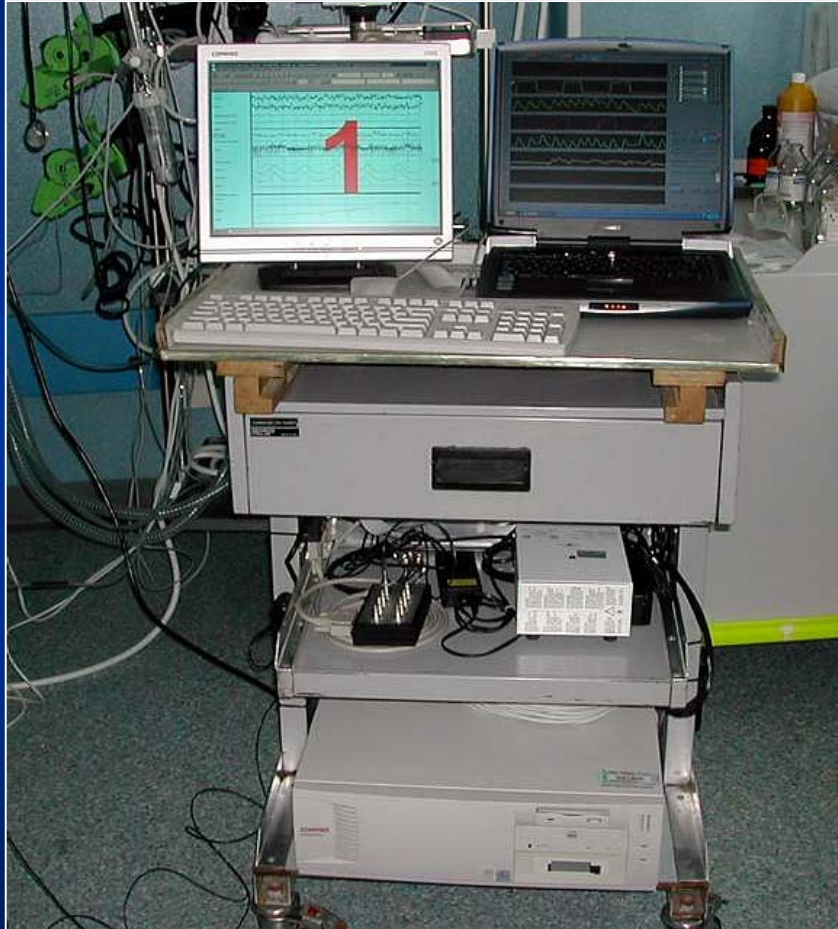
# Polysomnography



**Polysomnography is the gold standard for sleep measurement**



# ICU Sleep Research



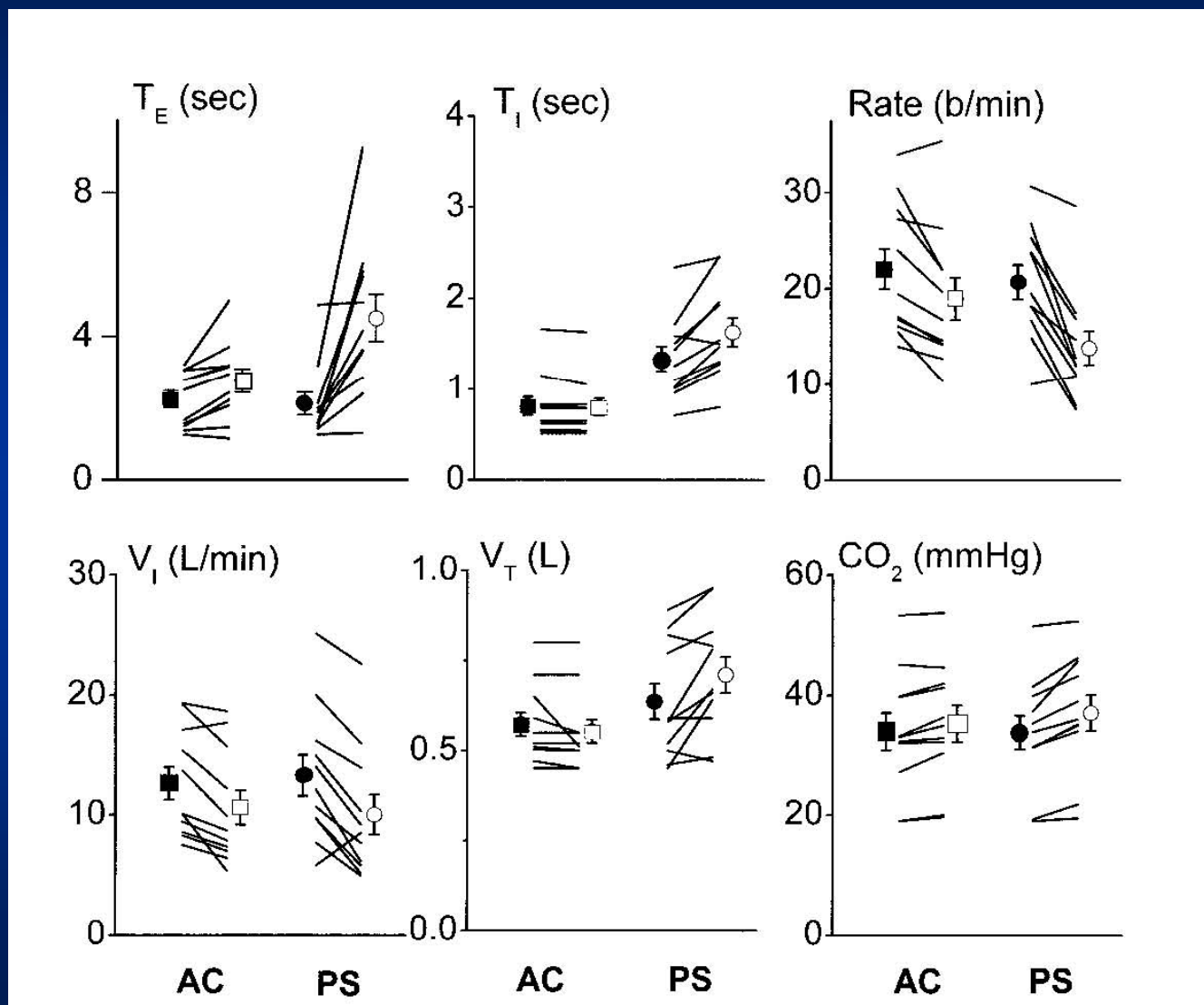
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# Normal Breathing Pattern During Sleep

- Downregulation of respiratory muscles
- Decreased VE due to decreased Vt
- CO<sub>2</sub> rises: 2-4 mmHg higher during sleep
- REM sleep: paralysis of major muscle groups with exception of diaphragm and upper airway muscles
- RR highly variable

# From Wakefulness to Sleep on PSV and ACV

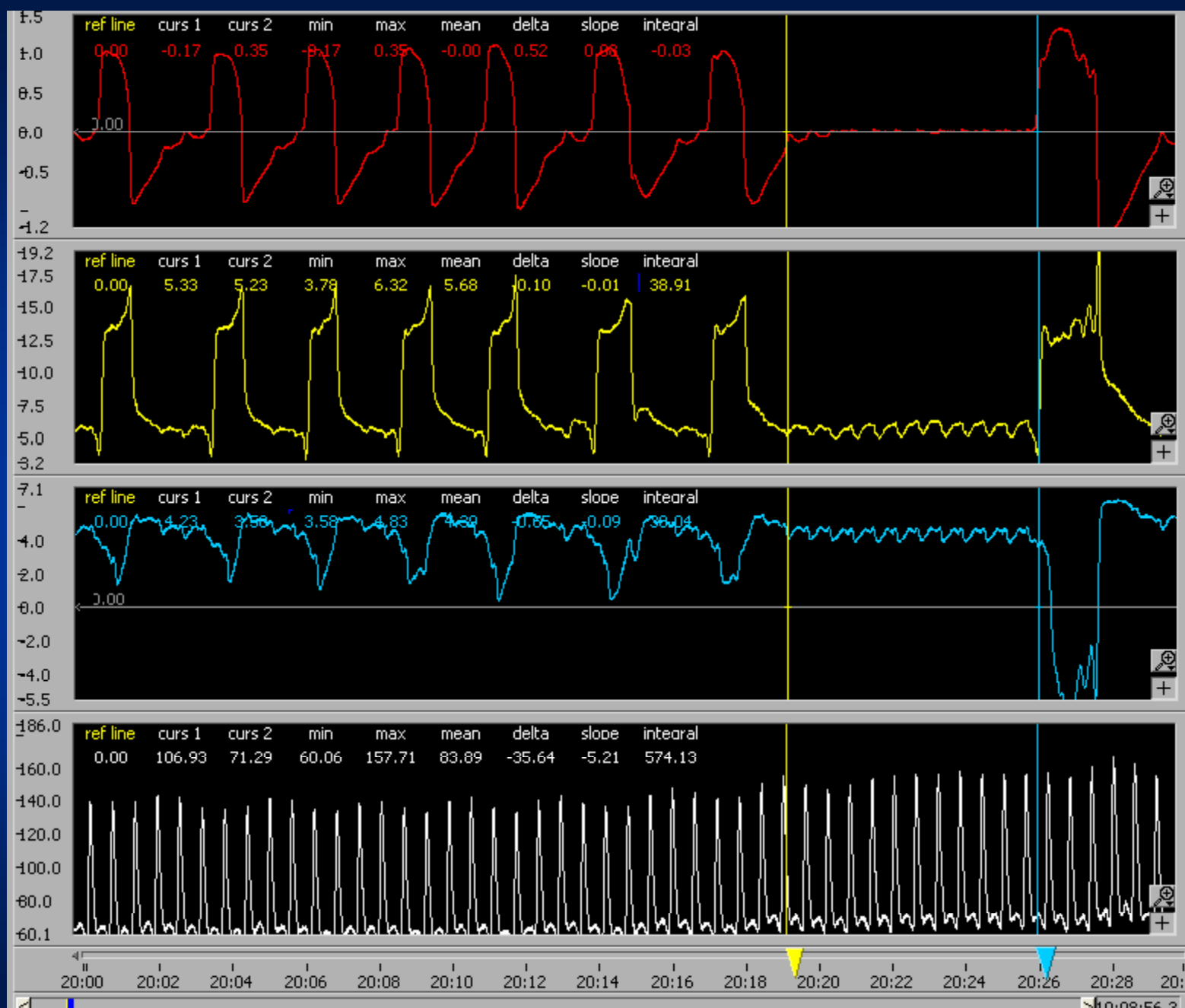


Parthasarathy S. & Tobin MJ.

Am J Respir Crit Care Med 2002; 166:1423-1429

## Central Apnea ← Over-ventilation

- Patient's respiratory drive decreases in response to decreased minute ventilation requirements, but minute ventilation provided by ventilator does not decrease proportionally
  - CO<sub>2</sub> falls below the apneic threshold
  - Patient stops making respiratory efforts
  - CO<sub>2</sub> rises above apneic threshold
  - Respiratory efforts resume
- “physiologic apnea” –pH may be normal to alkalotic
  - \*not to be confused with drug-induced apnea – if untreated, pH < 7.35



# Central Apnea

- More common during sleep
- More common in patients with CHF
- More common with higher levels of ventilatory support (without set back-up rate)

**Do central apneaus disrupt sleep?**



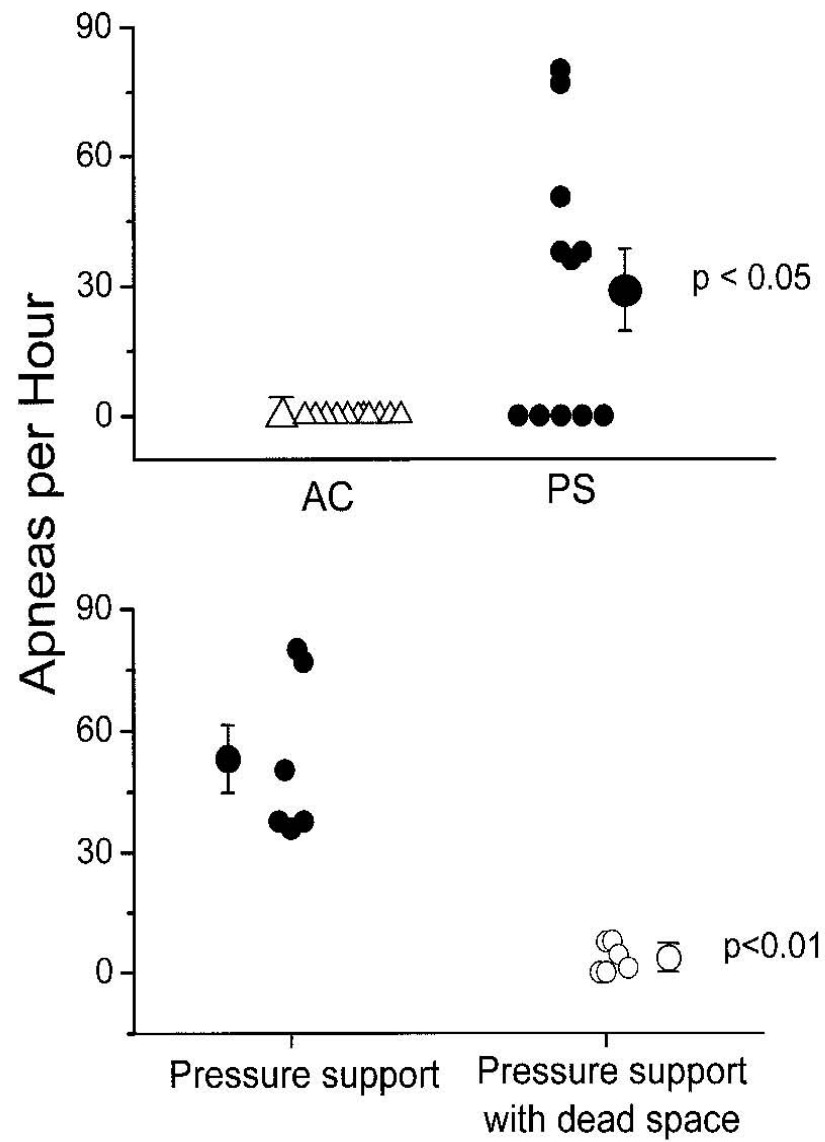
# **Effect of Ventilator Mode on Sleep Quality in Critically Ill Patients**

Sairam Parthasarathy and Martin J. Tobin

Am J Respir Crit Care Med Vol 166, pp 1423–1429, 2002

- **11 ICU patients**
- **Polysomnography**
- **Spent 2 hours each on ACV (Vt 8 ml/kg), PSV (targeting 8 ml/kg)**
- **Arousals and awakenings from sleep**

# Central Apneas



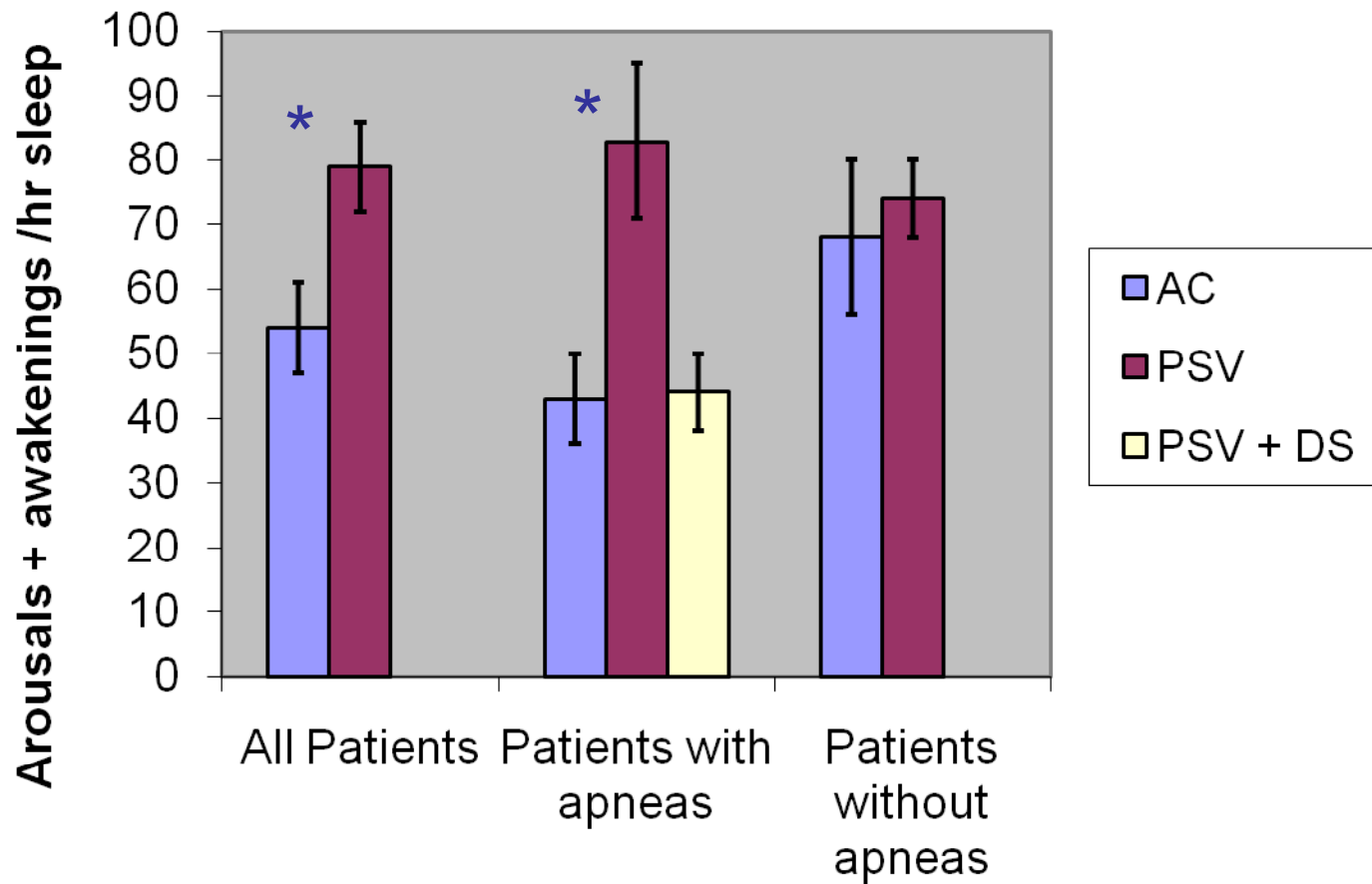
# Central Apneas Increase Sleep Fragmentation

	AC	PSV
Arousals + Awakenings (# / hr sleep)	54 ± 7*	79 ± 7
Central Apneas (# of patients)	0 /11*	6 /11
Apnea-related arousals + awakenings (# / hr)	0*	23 ± 7

\*significantly different from PSV p <0.05

**Parthasarathy and Tobin**  
**Am J Respir Crit Care Med 2002; 166:1423-1429**

# Parthasarathy and Tobin study

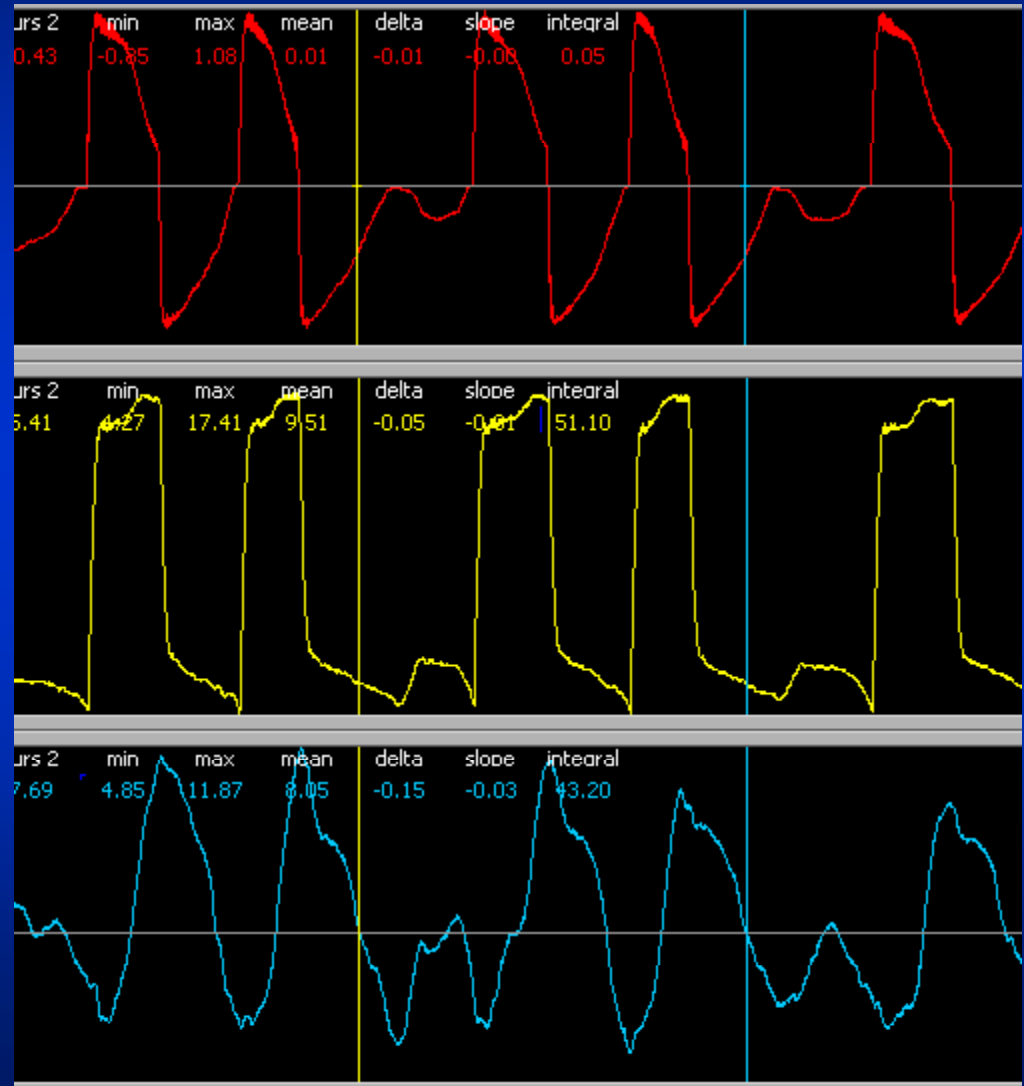


## Patient-Ventilator Asynchrony

	Patient Breath	Ventilator Breath
Ineffective Efforts	1	0
Autotriggering	0	1
Double Triggering	1	2
Delayed Cycling	2	1

# Asynchrony: Ineffective Triggering

- Patient effort < PEEPi + set trigger sensitivity
- More common during sleep
  - Fanfulla, *F. Resp Med* 2007;101: 1702
- More common with higher PSV levels
  - Giannouli, *E. AJRCCM* 1999
  - Thille, *A. Intensive Care Med* 2006



**Does patient-ventilator asynchrony  
disrupt sleep?**

## Patient-ventilator interaction and sleep in mechanically ventilated patients: Pressure support versus proportional assist ventilation\*

Karen Bosma, MD, FRCPC; Gabriela Ferreyra, MSc, RRT; Cristina Ambrogio, MD; Daniela Pasero, MD; Lucia Mirabella, MD; Alberto Braghiroli, MD; Lorenzo Appendini, MD; Luciana Mascia, MD, PhD; V. Marco Ranieri, MD

*Crit Care Med 2007;35:1048-54*

- **13 stable ICU patients weaning from MV**
- **2 modes: PSV and PAV (Evita 4, Dräger)**
- **Level of support set to offload work of breathing by 50% relative to spontaneous breathing**
- **2 consecutive nights on PAV and PSV (random order) recording sleep and breathing pattern**

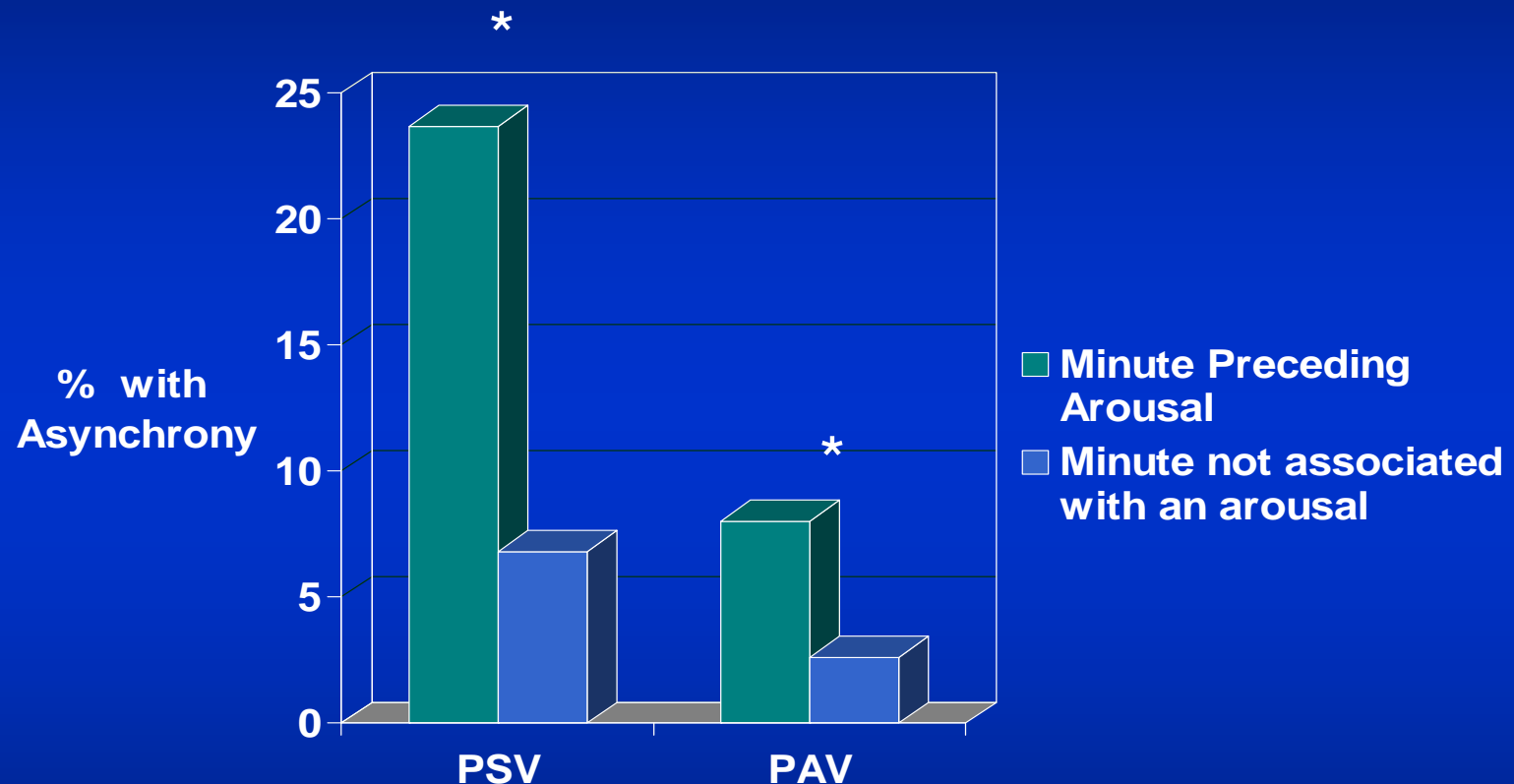


# Asynchrony Causes Sleep Disruption

	PAV	PSV	Pvalue
Apneas (n patients)	0	2	
Total Asynchronies (n/h)	23.7 ± 15.4	52.9 ± 59.2*	0.02
Arousals/h	12.8 ± 10.3	25.6 ± 23.2	0.02
Arousals + awakenings/h	18.0 ± 10.4	33.9 ± 28.9	0.055

Bosma, K. Crit Care Med. 2007; 35(4):1048-54

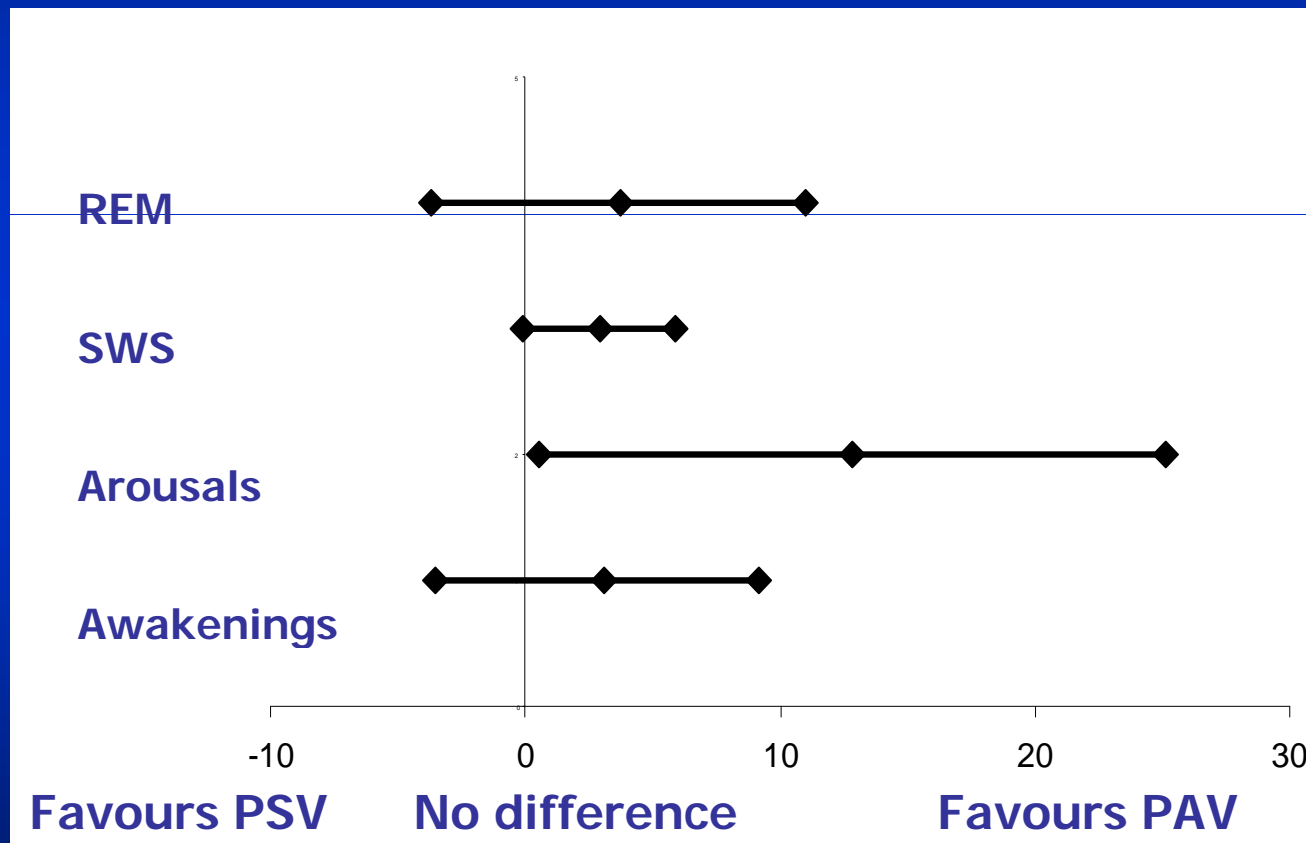
# Incidence of Asynchrony prior to arousal vs. period of uninterrupted sleep



**\*p < 0.0001 for both PSV and PAV  
(pooled data, chi square)**

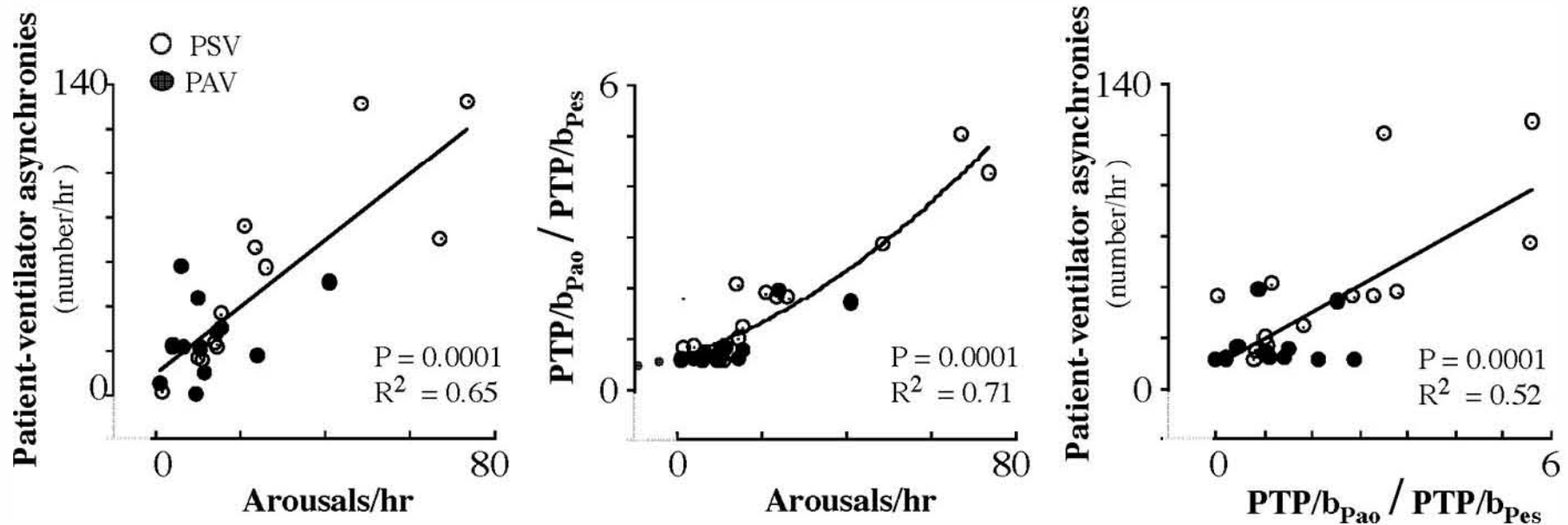
# Overall Sleep Quality

Multivariate ANOVA PAV vs. PSV \*p<0.05



Bosma, K. Crit Care Med. 2007; 35(4):1048-54

# Excessive Ventilator Support Increases Asynchrony and Sleep Fragmentation



Bosma, K. Crit Care Med. 2007; 35(4):1048-54

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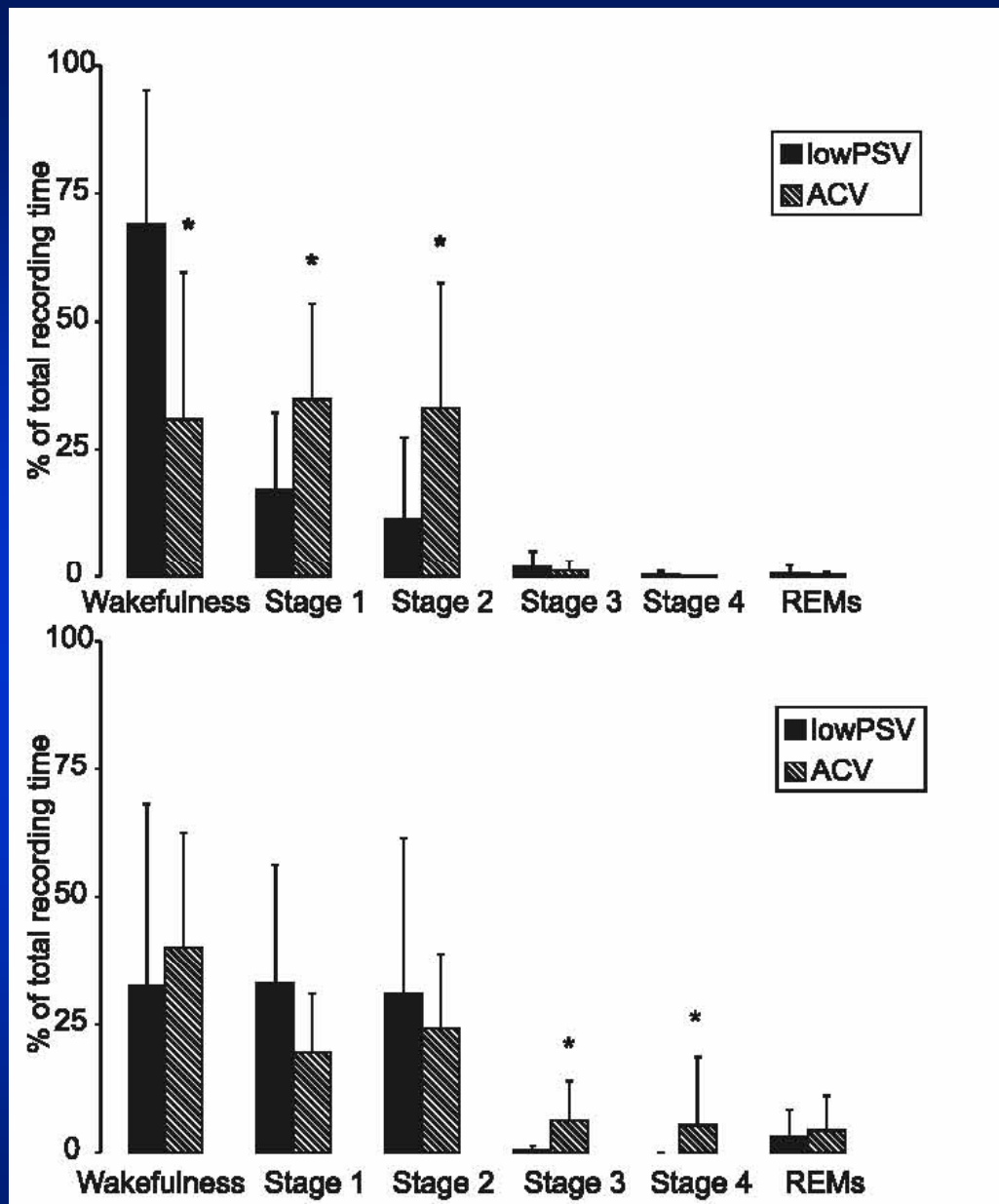
Bénédicte Toublanc  
Dominique Rose  
Jean-Charles Glérant  
Géraldine Francois  
Isabelle Mayeux  
Daniel Rodenstein  
Vincent Jounieaux

## **Assist-control ventilation vs. low levels of pressure support ventilation on sleep quality in intubated ICU patients**

- 20 patients with acute on chronic respiratory failure
- Studied night before planned extubation
- Controlled mechanical ventilation vs. low PSV
  - ACV started at 10 ml/kg and rate 12 breaths/min
    - Increased settings until spontaneous efforts abolished
  - PSV set at 6 cmH<sub>2</sub>O
    - Lowest level to compensate for resistance of tube and circuit
- AVC then low PSV vs. Low PSV then ACV

## Results

- No central apneas were observed in either night
- Considering the whole night, 10 pm to 6 am, irrespective of the order of ventilator settings:
- No difference in arousals+awakenings/hr
  - (ACV  $7.5 \pm 5.0$  vs.  $6.5 \pm 4.9$  PSV,  $p=NS$ )
- No significant difference in sleep stages



Toublanc, B. Intensive Care Med. 2007; 33: 1148-54



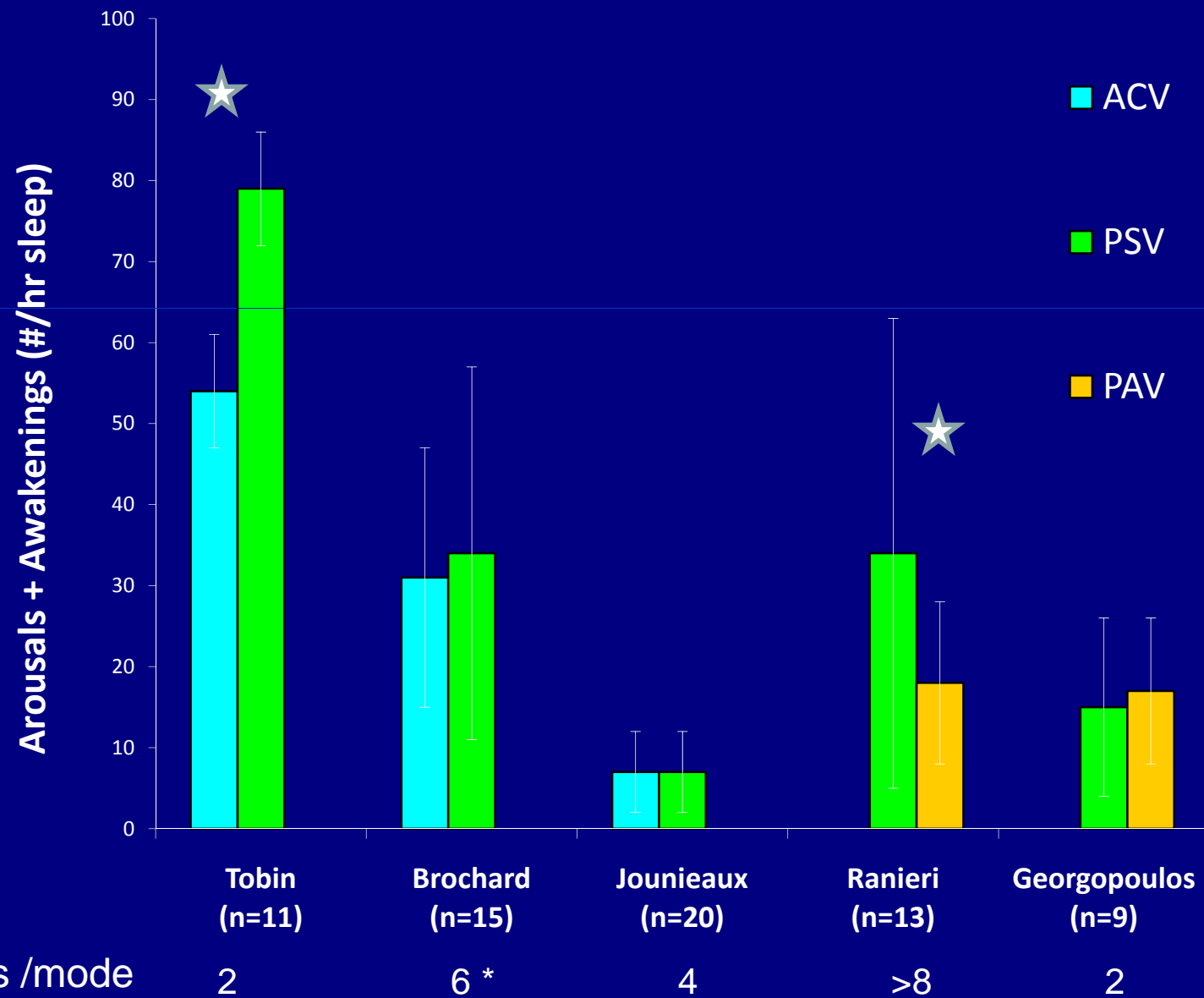
# Caveats to Interpreting these Studies

- What outcome is reported?
- Many facets to sleep:
  - Quantity
  - Quality (time spent in deep sleep or REM sleep)
  - Fragmentation (# arousals + awakenings / hr)
- What matters most to the critically ill patient??
- There is no global index for sleep quality
- And, we don't know that improving sleep improves outcome...

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# What ventilator mode should we use?



# Clinical Implications

- Any mode/settings that provide inadequate support or excessive support will likely result in poor sleep
- In any mode, adjusting settings to optimize patient-ventilator synchrony will likely improve sleep

## Conclusions

- PAV (set properly) makes central apneas rare, ensures good patient-ventilator synchrony, may make life easier for the RT, and appears to improve sleep
  - *Let the patient drive the ventilator*
- Controlled mechanical ventilation eliminates central apneas, obviates the need for synchronization, and also appears to improve sleep
  - *Let the ventilator drive the patient*

## Conclusions

- No direct comparison of PAV and ACV... yet
- What is better for weaning:

**Complete rest of respiratory muscles  
(disuse atrophy?)**

**vs.**

**Maintaining spontaneous breathing  
(muscle fatigue)??**

# Future Research

- Dr R. Kacmarek, Boston, Mass
  - PAV vs PSV for weaning and sleep quality
  - [www.clinicaltrials.gov](http://www.clinicaltrials.gov)
- Dr. K. Bosma, London, ON
  - PAV vs PSV vs ACV for sleep quality
  - PAV vs PSV for weaning
- Dr. M. Ranieri, Torino, Italy
  - PAV vs ACV vs NAVA for sleep quality

**Thank you!**



**Any Questions?**