Sleep in the ICU

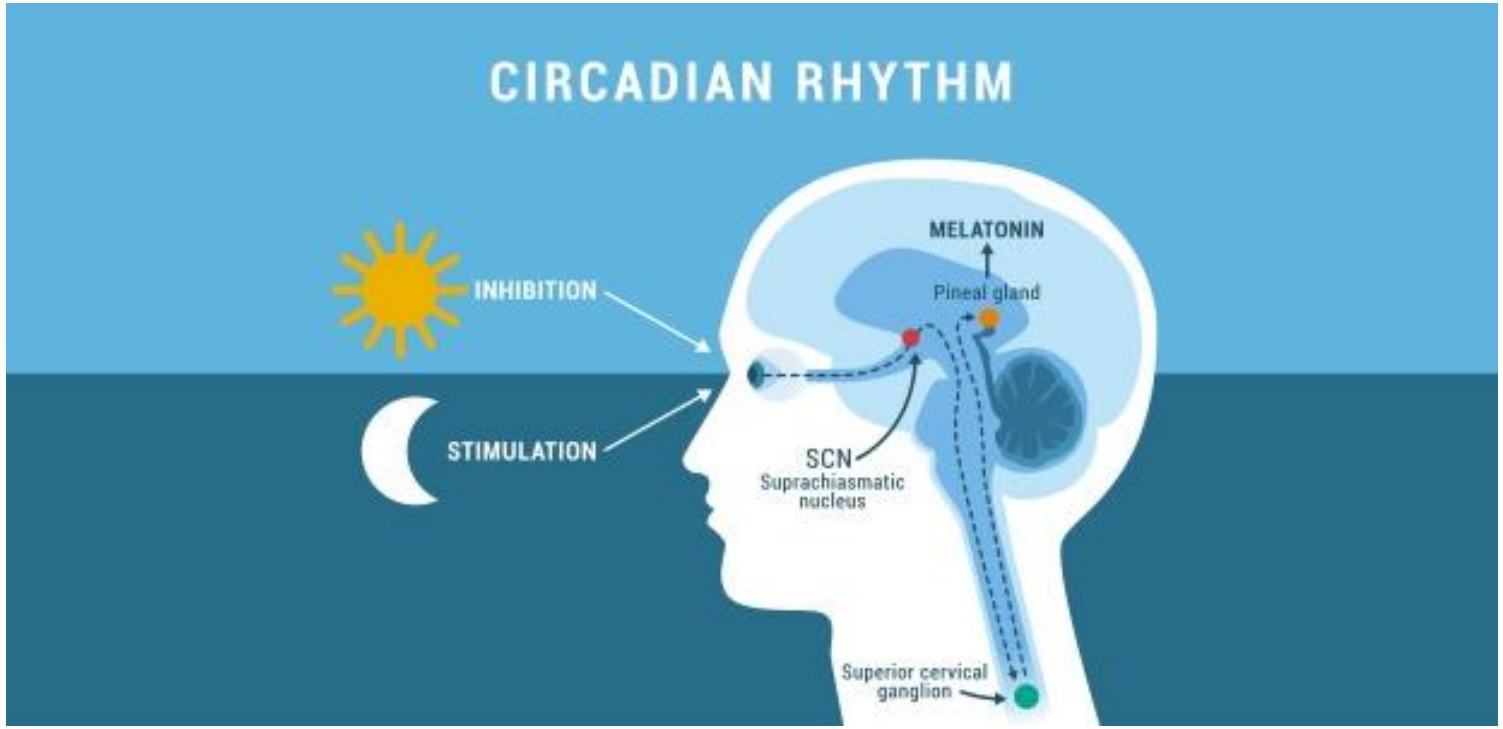
Sunghoon Park

Professor, Department of Pulmonary, Allergy and Critical Care Medicine

Director of ICUs

Hallym University Scared Heart Hospital

Normal sleep and wakefulness



https://www.news24.com/news24/partnercontent/are-you-an-early-bird-or-a-night-owl-20201029

Suprachiasmatic nucleus (**SCN**) is the master pacemaker of circadian system.
This is responsible for multiple biologic process including hormone regulation.

Sleep in critically ill patients

Characteristic	Result
Sleep latency	Prolonged
Sleep fragmentation	Increased
Arousals from sleep	Increased
Total sleep time	Unchanged
Timing of sleep	Throughout the 24-h cycle (rather than consolidated at night)
Sleep stage	
1 NREM	Increased
2 NREM	Increased
3 NREM	Decreased or absent
REM	Decreased or absent
	Atypical sleep increased (EEG patterns that do not conform to scoring rules), can be up to 85% of total sleep recorded

Atypical sleep: 85%

Pisani and D'Ambroiso. CHEST 2020; 157(4):977-984

Box 1. Contributors to sleep disruption in the intensive care unit

Ventilator mode and other settings (eg, respiratory rate, tidal volume)
Patient-ventilator dyssynchrony
Discomfort, pain, or anxiety caused by endotracheal tube, ventilator or acute illness
Air leakage during NIV
Sedation and other medication (eg, analgesics, vasopressors, corticosteroids)
Patient care activities (eg, vital signs, suctioning, positioning)
Severity of critical illness (eg, sepsis, multiorgan dysfunction)
Noise (eg, conversations, alarms)
Light

Ozsancak et al. Crit Care Clin. 2008;24:517–531

Environmental barriers

- Noise
- Light
- Patient care activities

Noise

- Alarms from ventilators, IV pump, CRRT, and nebulizers.
- The WHO recommendations for hospitals: 30 dB (average) and 40 dB (peak)
- Studies in ICUs: 43~66 dB (average) and 80~90 dB (peak)
- Sound peaks > 80 dB are associated with arousals from sleep.
- However, noise is just one of many sleep-disturbing factors.
  - It accounted for only 10~11.5% of arousals, 17% of awakenings, and 8~14% of fragmentation (results by PSG).
- A systematic review was not able to quantify the contribution of noise to sleep disruption

Pisani and D'Ambroiso. CHEST 2020; 157(4):977-984
Burglund et al. World Health Organization 1999.
Freedman et al. Am J Respir Crit Care Med. 2001;163:451-457

Light

- 100 to 500 lux in office but ~ 1,000 lux in ICUs
- Second only to noise for impacting sleep in the ICU
- Light can affect the circadian rhythm of melatonin, leading to sleep disruption.
  - Low morning light levels and delayed peak light (until the late afternoon) may contribute the circadian phase delay.
- Studies showed that daytime bright light interventions improved sleep in elderly patients in non-ICU patients.
- In a small pilot study, enhanced light exposure (9 am ~ noon) improved circadian rhythms of critically ill patients.

Pisani and D'Ambroiso. CHEST 2020; 157(4):977-984
Weinhouse and Schwab. Sleep. 2006;29:707-716.
Gehlbach et al. Am J Respir Crit Care Med. 2018'198:275-278

Patient care activities

- Vital signs, phlebotomy, wound care, imaging, etc.
- 40-60 care interruptions each night.
- But 14% of nocturnal interventions are not time critical.
- Vital signs and phlebotomy can be more disruptive to sleep than noise.
- Consolidation of care activities would reduce the number of interruptions, which may depend on ICU staffing.
- However, only 10% of arousals and awakenings were attributable to patient care activities.

Gabor et al. Am J Repir Crit Care Med, 2003;167:708-715
Tamburri et al. Am J Crit Care 2004;13:102-112
Olson et al. Am J Crit Care 2001;10:74-78

Treatment-related factors

- Mechanical ventilation
- Medications

Sleep in Critically Ill Patients Requiring Mechanical Ventilation*

Andrew B. Cooper, MD; Kristine S. Thornley, BSc, RPSGT; G. Bryan Young, MD; Arthur S. Slutsky, MD, FCCP; Thomas E. Stewart, MD; and Patrick J. Hanly, MD

Table 3—*Disrupted Sleep Group: Sleep Architecture

Study Period	TST, h	SE, %	Stage 1, %	Stage 2, %	SWS, %	REM, %
Night	3.0 ± 1.9	38 ± 24	40 ± 28	40 ± 23	10 ± 17	10 ± 14
Day	4.0 ± 2.9	25 ± 18	43 ± 26	33 ± 18	15 ± 14	9 ± 6

*Mean ± SD unless otherwise noted. All sleep stage values are expressed as percentages of TST.

Cooper et al. Chest. 2000; 117:809–818

Effect of Ventilator Mode on Sleep Quality in Critically Ill Patients

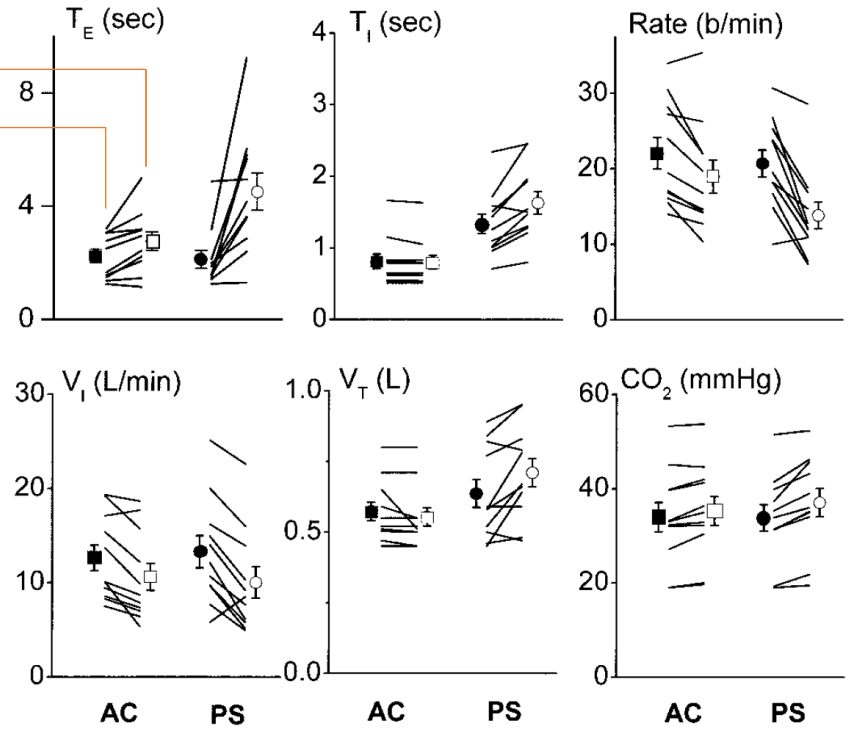
Sairam Parthasarathy and Martin J. Tobin

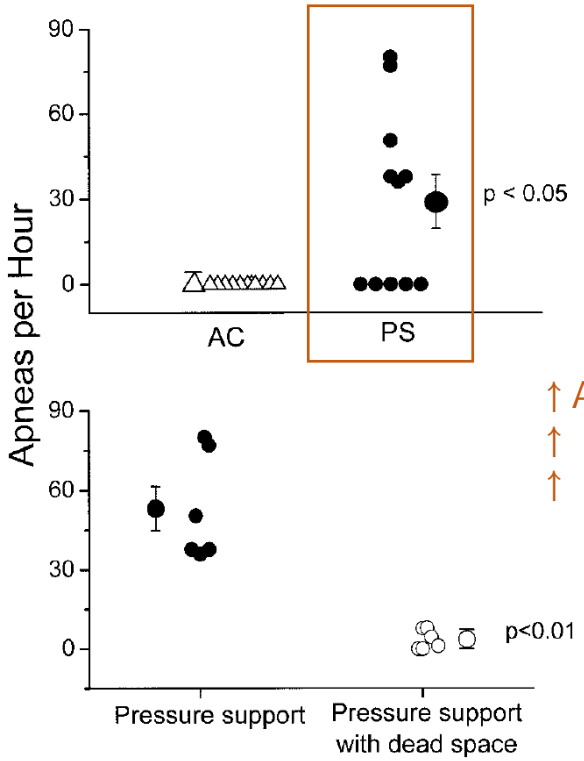
Division of Pulmonary and Critical Care Medicine, Edward Hines, Jr. Veterans Administrative Hospital, Hines, Illinois; and Loyola University of Chicago Stritch School of Medicine, Maywood, Illinois

11 critically ill pts

sleep

wakefulness





↑ Apnea in PSV
↑ HF in central apnea pts
↑ Sleep fragmentation in PSV

Parthasaranthy et al. Am J Respir Crit Care Med 2002;166:1423–1429

Intensive Care Med (2007) 33:1148–1154
DOI 10.1007/s00134-007-0659-2

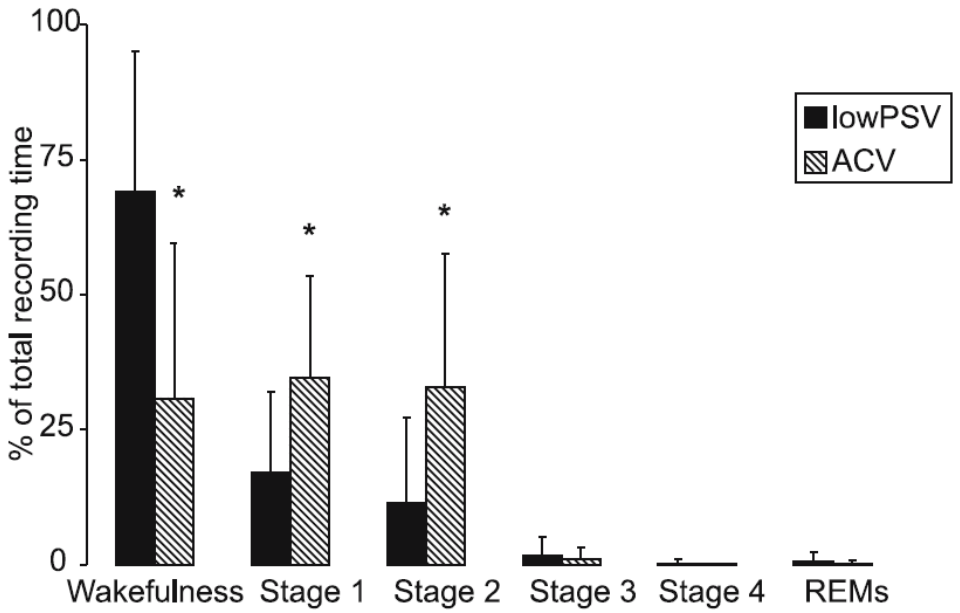
ORIGINAL

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

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

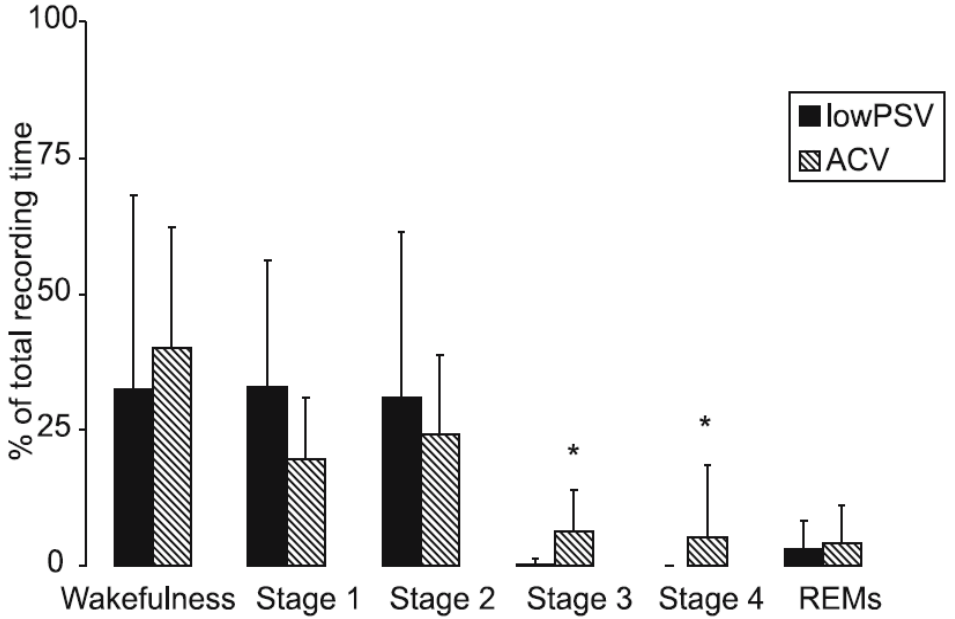
20 patients before extubation (ARF on CRF)

10 pm – 2 am



↓ wakefulness in ACV

2 am – 6 am



↑ Stage 3 & 4 in ACV

↑ subjective sleep quality in ACV

Toublanc et al. Intensive Care Med 2007;33:1148–1154

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

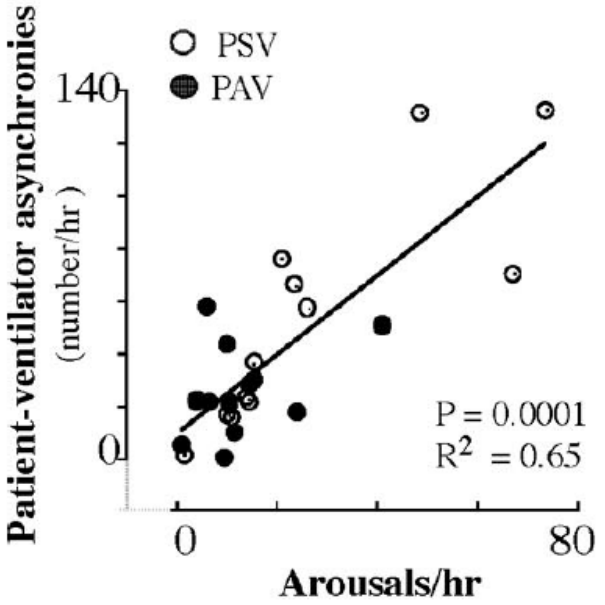
A crossover study with 13 pts

Table 4. Respiratory variables during proportional assist ventilation (PAV) and pressure support ventilation (PSV)

Respiratory Variable	PAV	PSV
V_T, L[a]	0.59 ± 0.13	0.63 ± 0.13[b]
Ti/Ttot, %[a]	41 ± 5	40 ± 3
RR, breaths/min[a]	24.5 ± 6.1	24.2 ± 5.3
V_E, L/min[a]	13.5 ± 2.3	14.4 ± 2.7[b]
$PetCO_2$, mm Hg[a]	39.4 ± 6.8	37.3 ± 5.3[b]
pH[c]	7.43 ± 0.03	7.44 ± 0.03
Morning Pa_{O_2}, mm Hg[c]	112 ± 15	109 ± 22
Morning Pa_{CO_2}, mm Hg[c]	43 ± 4	41 ± 4[b]
Pao, cm H_2O	11.7 ± 3.5	13.3 ± 3.2[b]
PTP/min, cm H_2O·sec/min	197 ± 78	174 ± 56

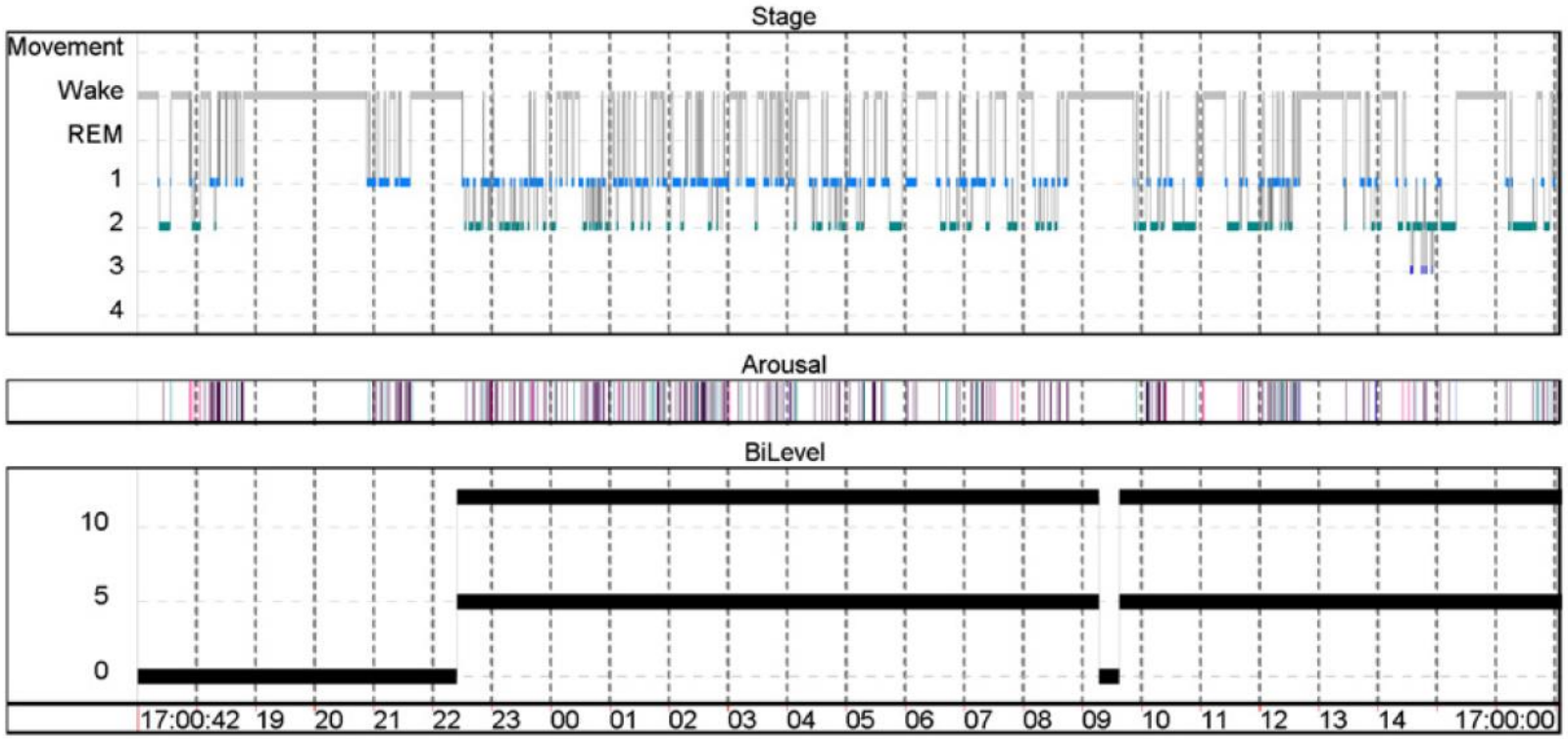
Table 6. Patient-ventilator asynchrony

Type of Asynchrony	PAV	PSV
Auto-triggering	5.4 ± 8.2	25.8 ± 42.3[a]
Ineffective triggering	11.6 ± 10.8	19.6 ± 31.8
Double triggering	5.8 ± 7.3	7.3 ± 6.8
Delayed cycling	0.6 ± 1.0	3.1 ± 4.6[a]
Total asynchronies	23.7 ± 15.4	52.9 ± 59.2[a]



Bosma et al. Crti Care Med. 2007; 35:1048–1054

Sleep disruption during NIV



Mainly Stage 1 & 2
Paucity of slow wave or REM
Arousals, 23/h

Unpublished data from Ozsancak and colleagues.

Ozsancak et al. Crit Care Clin. 2008;24:517–531

Hence,…

Box 2. Strategies to optimize sleep quality during mechanical ventilation

Rest with assist control mode overnight
Avoid overventilation with spontaneous breathing modes (pressure support or PAV)
Use modes that optimize synchrony (PAV)

Ozsancak et al. Crit Care Clin. 2008;24:517–531

Medications

- Benzodiazepines (BZD)
  - ↑ N1 & N2 sleep and ↓ N3 sleep even in low doses
- Propofol
  - ↑ N3 sleep and ↓ REM (↓ sleep quality)
- Dexmedetomidine
  - ↑ N2 sleep and ↓ N1 , a state physiologically similar to natural sleep.
  - The light sedation can lead to more fragmentation in a noisy ICU.
  - Recommended for overnight sedation but not for inducing sleep.
- Opiates
  - At high doses, it contributes to sleep disruption.
  - Symptom of OSA may be worsen
- Beta-blockers, anti-asthmatics, and anti-parkinsonian agents.

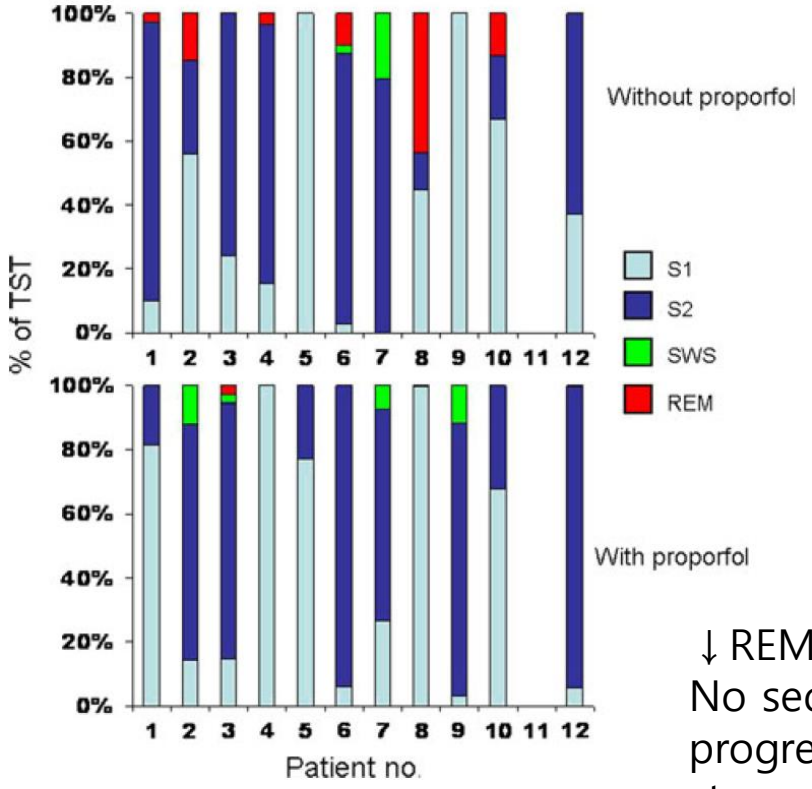
Pisani and D'Ambroiso. CHEST 2020; 157(4):977-984

Propofol can further worsen sleep quality.

A crossover RCT with 12 MV pts (Ramsay score 3)

Table 2 Sleep architecture without and with propofol

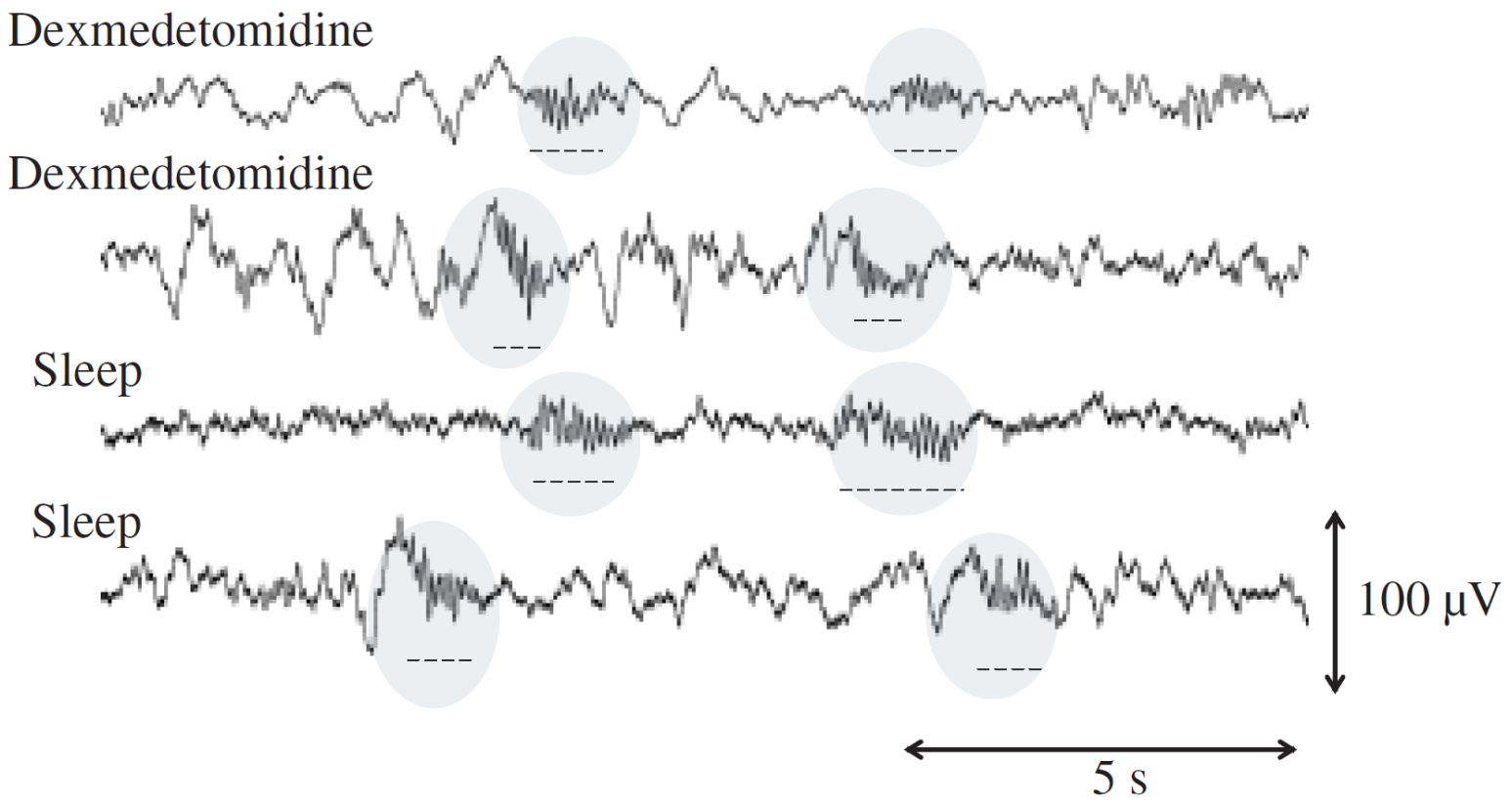
	Without propofol	With propofol	*p* value
TST (min)	214 (40–285)	260 (113–417)	0.37
Sleep efficiency (% TST)	62.6 (13.1–85.9)	76.3 (28.4–96.9)	0.37
Stage 1 (% TST)	30.7 (4.6–66.7)	20.8 (5.6–80.6)	1.00
Stage 2 (% TST)	46.1 (3.0–80.4)	48.9 (4.8–84.0)	0.66
SWS (% TST)	0 (0–0)	0 (0–5.8)	0.75
REM (% TST)	1.4 (0–13.0)	0 (0–0)	0.04
TSFI (events/h)	8.1 (2.9–16.2)	4.8 (1.3–14.6)	0.33
Stage shifts	21 (7–48)	22 (11–28)	0.69
Intersleep awake (% TST)	11.4 (3.1–42.9)	6.8 (1.2–43.5)	0.79



↓ REM
No sequential progression of sleep stage

Kondili et al. Intensive Care Med (2012) 38:1640–1646

DMDT: a state resembling physiological S2 sleep

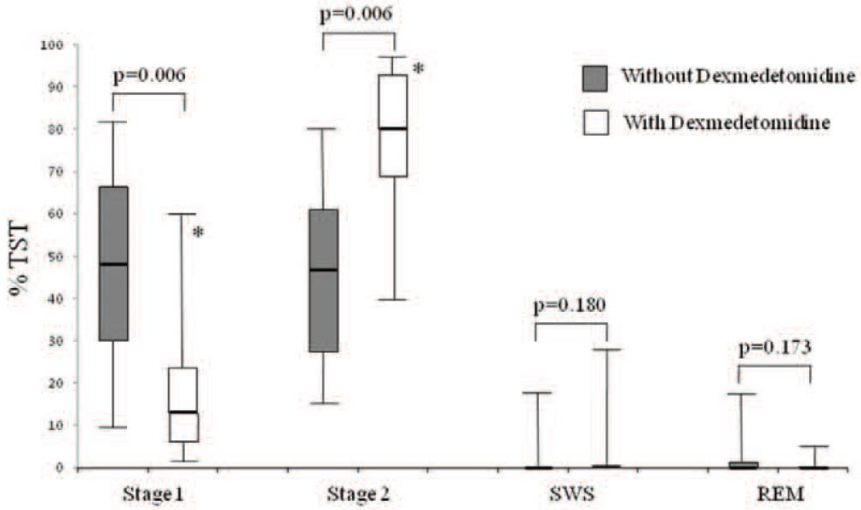


↑ Sleep spindle density and moderate amount of slow wave activity

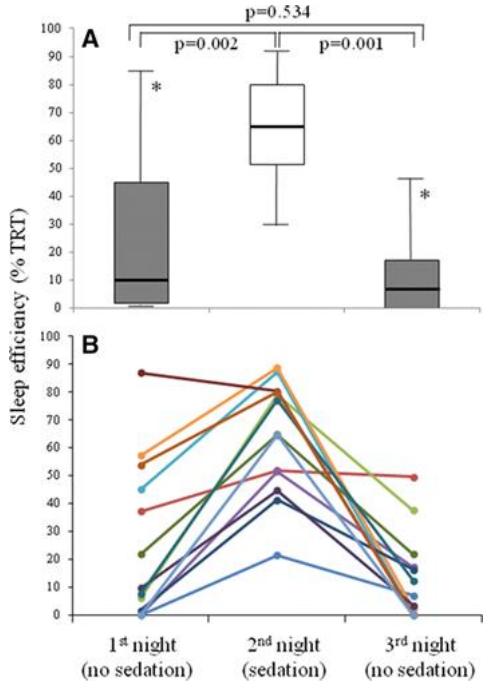
Huupponen E, et al. Acta Anaesthesiol Scand. 2008 Feb;52(2):289-294.

Effects of Dexmedetomidine on Sleep Quality in Critically Ill Patients

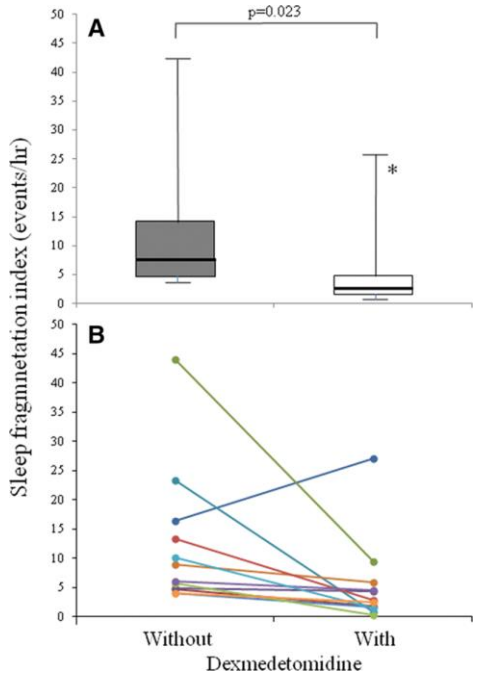
13 stable pts with MV in light sedation



↓ N1 and↑ N2 with DMDT



↑ Sleep efficacy



↓ Sleep fragmentation

Alexopoulou C, et al. *Anesthesiology*. 2014;121:801-807.

Be careful not to withdraw medication abruptly.

- Withdrawal of opioids, BZDs, nicotine, antidepressants can lead to insomnia and sometimes an increase in REM sleep.

- Abrupt cessation of BZDs or opiates, which are REM-suppressing drugs, may increase REM sleep disproportionately leading to cardiac or respiratory instability

Novak and Shapiro. Drug Saf. 1997;16:133-149

Sleep and delirium

- Their relationship is bidirectional, creating a potentially vicious cycle.
  - REM sleep deprivation was associated with an increase in delirium.
  - Number of days of delirium was associated with post-discharge sleep disturbance.
- No large, well-conducted studies and previous studies did not control for risk factors such as noise, light, and medications.
  - However, strong associations between sleep disturbances and occurrence of post-OP delirium in a systematic review.
- Possible mechanisms
  - Abnormalities of functional network connectivity in prefrontal cortical areas
  - Circadian/melatonin dysregulation

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.journals.elsevier.com/journal-of-critical-care

Association between death and loss of stage N2 sleep features among critically Ill patients with delirium

A retrospective study of 93 critically ill patients with delirium

Table 2
Electroencephalographic characteristics by K-complex Status.

Full montage EEG characteristics	Sleep category based on sleep montage EEG		
	All patients N = 93	K-complex n = 15	No K-complex n = 78
Degree of encephalopathy: Count (%)			
None	1 (1%)	0 (0%)	1 (1%)
Mild	6 (6%)	5 (33%)	1 (1%)
Mild to moderate	8 (9%)	2 (13%)	6 (8%)
Moderate	36 (39%)	5 (33%)	31 (40%)
Moderate to severe	32 (34%)	3 (20%)	29 (37%)
Severe	10 (10%)	0 (0%)	10 (13%)
			Fisher's Exact $p = .001$

Table 4
Logistic regression model for death during hospitalization by absence of K-complex.

Independent variables	Odds ratio	Confidence intervals	p-value
No K-Complex	18.8	1.1–337.4	0.046
Moderate Encephalopathy	1.5	0.3–8.1	0.640
Severe Encephalopathy	2.0	0.4–10.7	0.431
Age (per 10 years)	1.5	1.0–2.2	0.039
APACHE II	1.0	0.9–1.0	0.383
Sepsis Present	1.9	0.6–5.4	0.245
Days from Admission to EEG Start	1.1	1.0–1.2	0.116

Knauert et al. J Crit Care. 2018;48:124-129

Sleep disturbances in the critically ill patients: role of delirium and sedative agents

29 post-OP patients
Severe REM reduction: < 6% of TST

TABLE IV.—*Delirium data.*

	ALL (N.=29)	Severe REM reduction (N.=15)	REM reduction (N.=14)	P
Delirium days before PSG, N.	1 (0-11)	3 (2-11)	0 (0-1)	0.009*
Delirium days after PSG, N.	6 (0-62)	25 (6-62)	0 (0-45)	0.006*
Overall Delirium days, N.	9 (0-64)	28 (7-64)	0 (0-51)	0.002*

Data are presented as median (range). *Mann-Whitney test. ICU: intensive care unit; PSG: polysomnography.

TABLE V.—*Multivariate analysis* with sleep ("Severe REM reduction" vs. "REM reduction") as the a priori dependent factor.*

	Mean, SE	Odds ratio (95% CI)	P value
Delirium	119	34.5 (3.9-330.2)	0.0001*
Lorazepam	7	1.9 (1.8-1.2)	0.01*

*Forward logistic regression, Hosmer & Lemeshow test; SE: standard error; CI: confidence interval.

Trompeo et al. Minerva Anestesil. 2011;77:604-12

Interventions

- Non-pharmacologic interventions
- Pharmacologic interventions
- Sleep promotion bundles

Non-pharmacologic intervention

- Control of sound and light (“quiet time at night”)
- Rescheduling of routine patient care (“clustering of care activities”)
- Eye mask and ear plug
- Sleep education
- Treatment of anxiety and promotion of relaxation
- When applicable, adjustment of MV settings
- Massage, VR, warm blanket, music, aromatherapy, acupressure, etc.

“However, complete understanding of preexisting sleep disorder is particularly important”

Cochrane Library
Trusted evidence.
Informed decisions.
Better health.

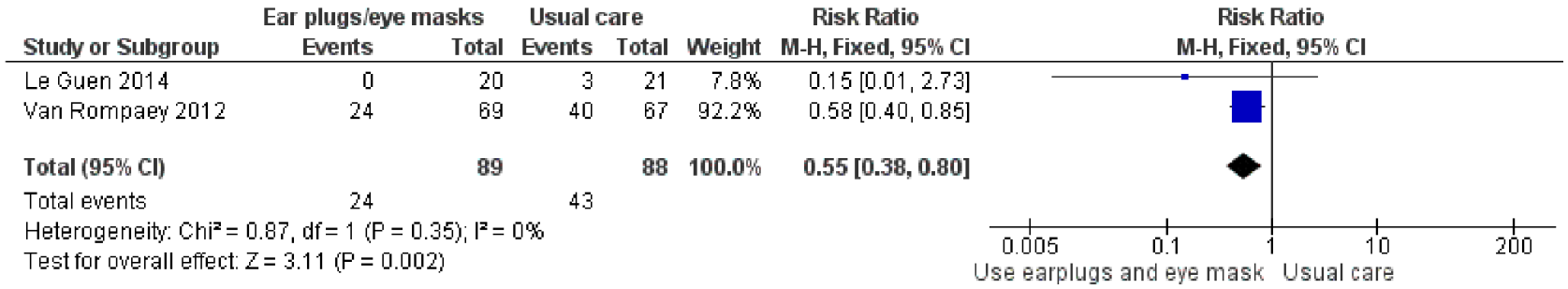
Cochrane Database of Systematic Reviews

[Intervention Review]

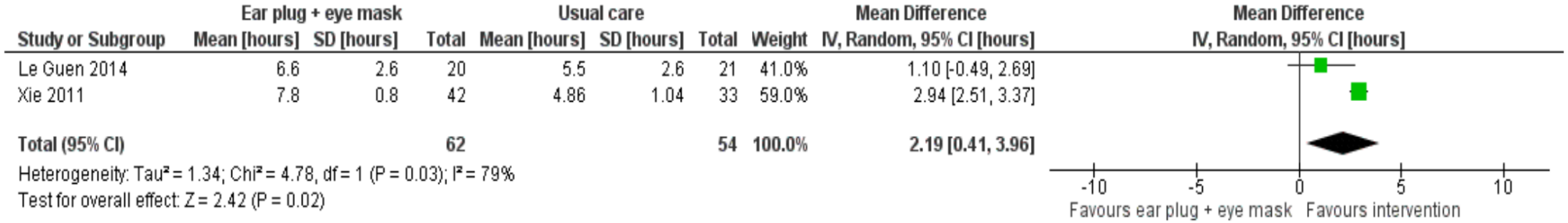
Non-pharmacological interventions for sleep promotion in the intensive care unit

Ear plug/eye mask

Incidence of delirium and confusion

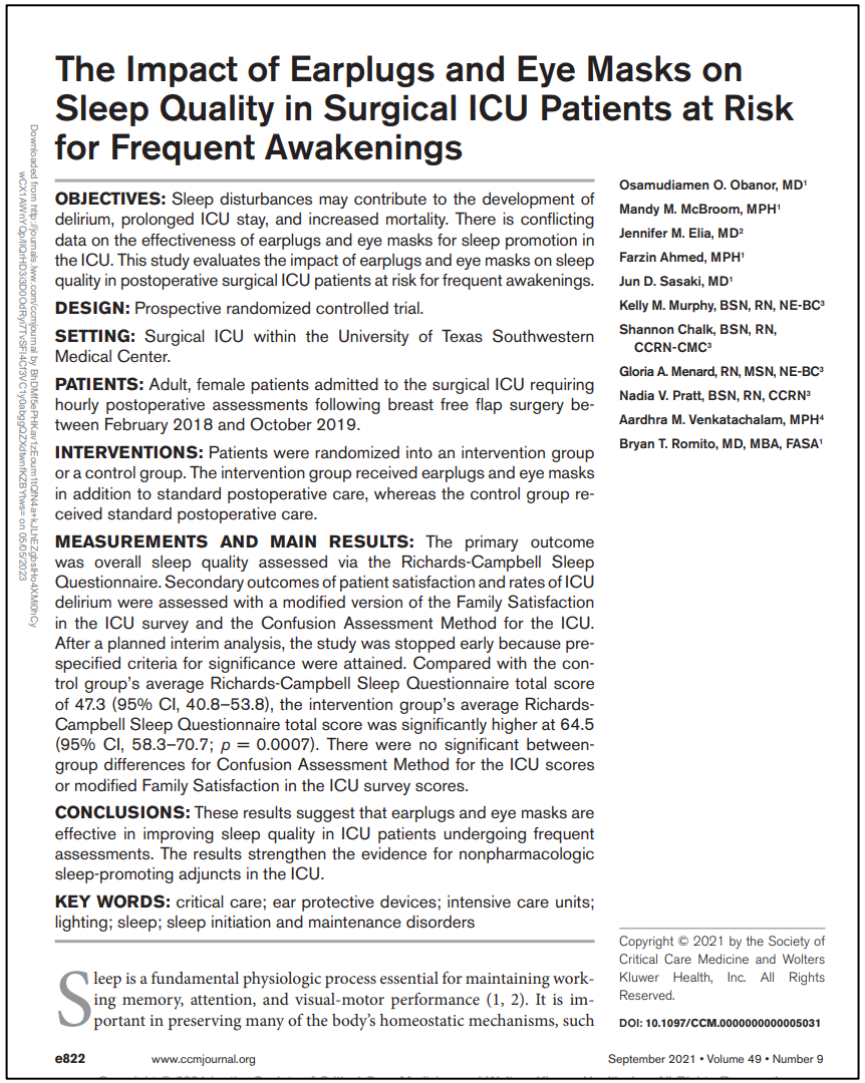


Sleep quality (TST)



Hu et al Cochran Database Syst Rev. 2015 Oct 6;2015(10):CD008808

↑ Richards-Campbell Sleep Questionnaire



The Impact of Earplugs and Eye Masks on Sleep Quality in Surgical ICU Patients at Risk for Frequent Awakenings

Osamudiamen O. Obanor, MD[1]
Mandy M. McBroom, MPH[1]
Jennifer M. Elia, MD[2]
Farzin Ahmed, MPH[1]
Jun D. Sasaki, MD[1]
Kelly M. Murphy, BSN, RN, NE-BC[3]
Shannon Chalk, BSN, RN, CCRN-CMC[3]
Gloria A. Menard, RN, MSN, NE-BC[3]
Nadia V. Pratt, BSN, RN, CCRN[3]
Aardhra M. Venkatachalam, MPH[4]
Bryan T. Romito, MD, MBA, FASA[1]

OBJECTIVES: Sleep disturbances may contribute to the development of delirium, prolonged ICU stay, and increased mortality. There is conflicting data on the effectiveness of earplugs and eye masks for sleep promotion in the ICU. This study evaluates the impact of earplugs and eye masks on sleep quality in postoperative surgical ICU patients at risk for frequent awakenings.

DESIGN: Prospective randomized controlled trial.

SETTING: Surgical ICU within the University of Texas Southwestern Medical Center.

PATIENTS: Adult, female patients admitted to the surgical ICU requiring hourly postoperative assessments following breast free flap surgery between February 2018 and October 2019.

INTERVENTIONS: Patients were randomized into an intervention group or a control group. The intervention group received earplugs and eye masks in addition to standard postoperative care, whereas the control group received standard postoperative care.

MEASUREMENTS AND MAIN RESULTS: The primary outcome was overall sleep quality assessed via the Richards-Campbell Sleep Questionnaire. Secondary outcomes of patient satisfaction and rates of ICU delirium were assessed with a modified version of the Family Satisfaction in the ICU survey and the Confusion Assessment Method for the ICU. After a planned interim analysis, the study was stopped early because prespecified criteria for significance were attained. Compared with the control group's average Richards-Campbell Sleep Questionnaire total score of 47.3 (95% CI, 40.8–53.8), the intervention group's average Richards-Campbell Sleep Questionnaire total score was significantly higher at 64.5 (95% CI, 58.3–70.7; $p = 0.0007$). There were no significant between-group differences for Confusion Assessment Method for the ICU scores or modified Family Satisfaction in the ICU survey scores.

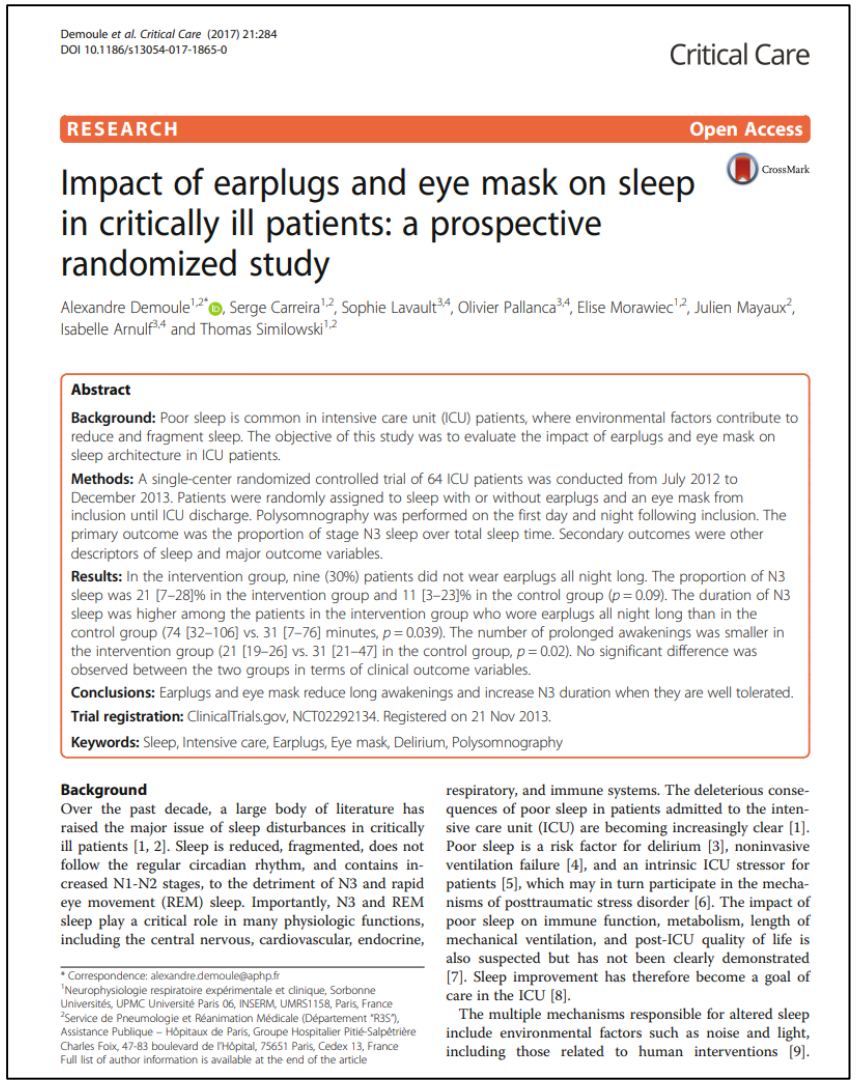
CONCLUSIONS: These results suggest that earplugs and eye masks are effective in improving sleep quality in ICU patients undergoing frequent assessments. The results strengthen the evidence for nonpharmacologic sleep-promoting adjuncts in the ICU.

KEY WORDS: critical care; ear protective devices; intensive care units; lighting; sleep; sleep initiation and maintenance disorders

DOI: 10.1097/CCM.0000000000005031

Sleep is a fundamental physiologic process essential for maintaining working memory, attention, and visual-motor performance (1, 2). It is important in preserving many of the body's homeostatic mechanisms, such

Obanor et al Crit Care Med. 2021;49:e822-e832



Demoule *et al. Critical Care* (2017) 21:284
DOI 10.1186/s13054-017-1865-0

Critical Care

RESEARCH Open Access

Impact of earplugs and eye mask on sleep in critically ill patients: a prospective randomized study

Alexandre Demoule[1,2*], Serge Carreira[1,2], Sophie Lavault[3,4], Olivier Pallanca[3,4], Elise Morawiec[1,2], Julien Mayaux[2], Isabelle Arnulf[3,4] and Thomas Similowski[1,2]

Abstract

Background: Poor sleep is common in intensive care unit (ICU) patients, where environmental factors contribute to reduce and fragment sleep. The objective of this study was to evaluate the impact of earplugs and eye mask on sleep architecture in ICU patients.

Methods: A single-center randomized controlled trial of 64 ICU patients was conducted from July 2012 to December 2013. Patients were randomly assigned to sleep with or without earplugs and an eye mask from inclusion until ICU discharge. Polysomnography was performed on the first day and night following inclusion. The primary outcome was the proportion of stage N3 sleep over total sleep time. Secondary outcomes were other descriptors of sleep and major outcome variables.

Results: In the intervention group, nine (30%) patients did not wear earplugs all night long. The proportion of N3 sleep was 21 [7–28]% in the intervention group and 11 [3–23]% in the control group ($p = 0.09$). The duration of N3 sleep was higher among the patients in the intervention group who wore earplugs all night long than in the control group (74 [32–106] vs. 31 [7–76] minutes, $p = 0.039$). The number of prolonged awakenings was smaller in the intervention group (21 [19–26] vs. 31 [21–47] in the control group, $p = 0.02$). No significant difference was observed between the two groups in terms of clinical outcome variables.

Conclusions: Earplugs and eye mask reduce long awakenings and increase N3 duration when they are well tolerated.

Trial registration: ClinicalTrials.gov, NCT02292134. Registered on 21 Nov 2013.

Keywords: Sleep, Intensive care, Earplugs, Eye mask, Delirium, Polysomnography

Background

Over the past decade, a large body of literature has raised the major issue of sleep disturbances in critically ill patients [1, 2]. Sleep is reduced, fragmented, does not follow the regular circadian rhythm, and contains increased N1-N2 stages, to the detriment of N3 and rapid eye movement (REM) sleep. Importantly, N3 and REM sleep play a critical role in many physiologic functions, including the central nervous, cardiovascular, endocrine, respiratory, and immune systems. The deleterious consequences of poor sleep in patients admitted to the intensive care unit (ICU) are becoming increasingly clear [1]. Poor sleep is a risk factor for delirium [3], noninvasive ventilation failure [4], and an intrinsic ICU stressor for patients [5], which may in turn participate in the mechanisms of posttraumatic stress disorder [6]. The impact of poor sleep on immune function, metabolism, length of mechanical ventilation, and post-ICU quality of life is also suspected but has not been clearly demonstrated [7]. Sleep improvement has therefore become a goal of care in the ICU [8].

The multiple mechanisms responsible for altered sleep include environmental factors such as noise and light, including those related to human interventions [9].

* Correspondence: alexandre.demoule@aphp.fr
[1]Neurophysiologie respiratoire expérimentale et clinique, Sorbonne Universités, UPMC Université Paris 06, INSERM, UMRS1158, Paris, France
[2]Service de Pneumologie et Réanimation Médicale (Département "R3S"), Assistance Publique – Hôpitaux de Paris, Groupe Hospitalier Pitié-Salpêtrière Charles Foix, 47-83 boulevard de l'Hôpital, 75651 Paris, Cedex 13, France
Full list of author information is available at the end of the article

Demoule et al Crit Care 2017;21:284.

↑ N3
↓ Awakening

Pharmacologic intervention

- Melatonin and Ramelteon (melatonin receptor agonist)
- Analgesics or BZDs
- Dexmedetomidine
- Sedating antihistamines or antipsychotics

"Analgesics should be used to target pain control rather than sedation or sleep"

"Propofol and BZDs should be avoided because they suppress deep NREM and REM sleep "

"There is no currently recommended pharmacological sleep aid for critically ill patients"

Cochrane Library
Trusted evidence.
Informed decisions.
Better health.
Cochrane Database of Systematic Reviews

[Intervention Review]

Melatonin for the promotion of sleep in adults in the intensive care unit

Table 1. Single study outcome data: melatonin vs no agent *(Continued)*

Study	Measurement (tool)	Data* Intervention	Data* Control	Mean difference (95% CI)*	P value*
Bourne 2008	SEI, patient assessment (RCSQ)	mean (95% CI): 0.41 (0.24 to 0.59); n: 12	mean (95% CI): 0.50 (0.43 to 0.58); n: 12	−0.09 (−0.28 to 0.09)	0.32
Bourne 2008	SEI, nurse assessment (observations)	mean (95% CI): 0.45 (0.26 to 0.64); n: 12	mean (95% CI): 0.51 (0.35 to 0.68); n: 12	−0.06 (CI −0.29 to 0.17)	0.58
Ibrahim 2006	Duration of sleep, nurse assessment (observations)	median (range): 240 minutes (75 to 331.3); n: 14	median (range): 243.4 minutes (0 to 344.1); n: 18	not reported	0.98
Mistraletti 2015	Duration of sleep, nurse assessment (observations)	9 p.m. to midnight, mean (SD): 1.5 (± 1.6) hours; n: 41 midnight to 7 a.m., mean (SD): 4.5 (± 1.9) hours; n: 41	9 p.m. to midnight, mean (SD): 1.4 (± 1.3) hours; n: 41 midnight to 7 a.m., mean (SD): 4.3 (± 1.8) hours; n: 41	not reported	0.92 0.83

A systematic review does not support the use of melatonin

Lewis et al Cochran Database Syst Rev. 2018;5:CD012455.

The Effects of Melatonin Supplementation on Sleep Quality and Assessment of the Serum Melatonin in ICU Patients: A Randomized Controlled Trial

Joelma Villafanha Gandolfi, PharmD[1]; Ana Paula Altimari Di Bernardo, RP[1];

A multicenter RCT of 223 adults in ICUs
PO melatonin 10mg/d at 8 pm for seven days

Melatonin concentration

Time	Melatonin	Placebo	*p*
2:00	150 (125–2,125)	32.5 (18.8–35)	< 0.001
6:00	40 (33–100)	25 (12.5–35)	0.021
12:00	35 (30–50)	15 (5–35)	0.024
18:00	40 (32.5–75)	30 (10–40)	0.087

Data are presented as median and interquartile range. Melatonin concentration presented as pg/mL.

Sleep quality

RCSQ Sleep in the ICU	Melatonin (*n* = 96) (%)	Placebo (*n* = 96) (%)	RR (95% CI)
Very poor sleep (0–25 mm)	3 (3.1)	14 (14.6)	0.21 (0.06–0.72)
Poor sleep (26–50 mm)	17 (17.7)	15 (15.6)	1.13 (0.60–2.14)
Good sleep (51–75 mm)	32 (33.3)	34 (35.4)	0.94 (0.64–1.39)
Very good sleep (76–100 mm)	44 (45.8)	33 (34.4)	1.33 (0.94–1.89)

Gendolfi et al Crit Care Med 2020; 48:e1286–e1293

Antipsychotics

- Haloperidol – D2 receptor antagonist
- Risperidone, olanzapine, quetiapine (5-HT2 receptor inhibition)

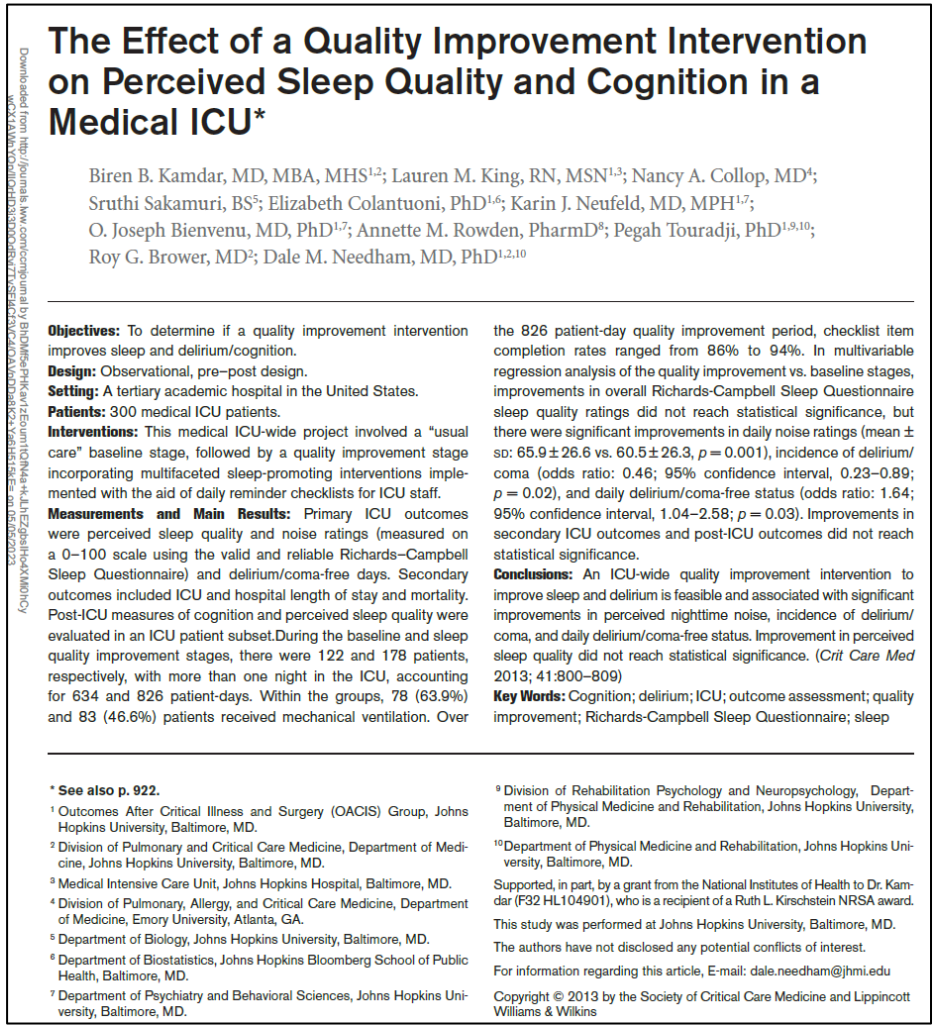
- These agents increase TST, N2 sleep
- Haloperidol and olanzapine increase N3 sleep

Pisani and D'Ambroiso. CHEST 2020; 157(4):977-984

Sleep-promoting multicomponent bundle

- A bundle approach is recommended.
- It emphasizes non-pharmacologic interventions
- It discourages the use of sedating drugs.
- But it suggests judicious use of zolpidem or antipsychotics.

Pisani and D'Ambroiso. CHEST 2020; 157(4):977-984



The Effect of a Quality Improvement Intervention on Perceived Sleep Quality and Cognition in a Medical ICU*

Biren B. Kamdar, MD, MBA, MHS[1,2]; Lauren M. King, RN, MSN[1,3]; Nancy A. Collop, MD[4]; Sruthi Sakamuri, BS[5]; Elizabeth Colantuoni, PhD[1,6]; Karin J. Neufeld, MD, MPH[1,7]; O. Joseph Bienvenu, MD, PhD[1,7]; Annette M. Rowden, PharmD[8]; Pegah Touradji, PhD[1,9,10]; Roy G. Brower, MD[2]; Dale M. Needham, MD, PhD[1,2,10]

Objectives: To determine if a quality improvement intervention improves sleep and delirium/cognition.
Design: Observational, pre–post design.
Setting: A tertiary academic hospital in the United States.
Patients: 300 medical ICU patients.
Interventions: This medical ICU-wide project involved a "usual care" baseline stage, followed by a quality improvement stage incorporating multifaceted sleep-promoting interventions implemented with the aid of daily reminder checklists for ICU staff.
Measurements and Main Results: Primary ICU outcomes were perceived sleep quality and noise ratings (measured on a 0–100 scale using the valid and reliable Richards–Campbell Sleep Questionnaire) and delirium/coma-free days. Secondary outcomes included ICU and hospital length of stay and mortality. Post-ICU measures of cognition and perceived sleep quality were evaluated in an ICU patient subset.During the baseline and sleep quality improvement stages, there were 122 and 178 patients, respectively, with more than one night in the ICU, accounting for 634 and 826 patient-days. Within the groups, 78 (63.9%) and 83 (46.6%) patients received mechanical ventilation. Over the 826 patient-day quality improvement period, checklist item completion rates ranged from 86% to 94%. In multivariable regression analysis of the quality improvement vs. baseline stages, improvements in overall Richards-Campbell Sleep Questionnaire sleep quality ratings did not reach statistical significance, but there were significant improvements in daily noise ratings (mean ± SD: 65.9 ± 26.6 vs. 60.5 ± 26.3, $p = 0.001$), incidence of delirium/coma (odds ratio: 0.46; 95% confidence interval, 0.23–0.89; $p = 0.02$), and daily delirium/coma-free status (odds ratio: 1.64; 95% confidence interval, 1.04–2.58; $p = 0.03$). Improvements in secondary ICU outcomes and post-ICU outcomes did not reach statistical significance.
Conclusions: An ICU-wide quality improvement intervention to improve sleep and delirium is feasible and associated with significant improvements in perceived nighttime noise, incidence of delirium/coma, and daily delirium/coma-free status. Improvement in perceived sleep quality did not reach statistical significance. (*Crit Care Med* 2013; 41:800–809)
Key Words: Cognition; delirium; ICU; outcome assessment; quality improvement; Richards-Campbell Sleep Questionnaire; sleep

* See also p. 922.

[1] Outcomes After Critical Illness and Surgery (OACIS) Group, Johns Hopkins University, Baltimore, MD.
[2] Division of Pulmonary and Critical Care Medicine, Department of Medicine, Johns Hopkins University, Baltimore, MD.
[3] Medical Intensive Care Unit, Johns Hopkins Hospital, Baltimore, MD.
[4] Division of Pulmonary, Allergy, and Critical Care Medicine, Department of Medicine, Emory University, Atlanta, GA.
[5] Department of Biology, Johns Hopkins University, Baltimore, MD.
[6] Department of Biostatistics, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD.
[7] Department of Psychiatry and Behavioral Sciences, Johns Hopkins University, Baltimore, MD.
[9] Division of Rehabilitation Psychology and Neuropsychology, Department of Physical Medicine and Rehabilitation, Johns Hopkins University, Baltimore, MD.
[10] Department of Physical Medicine and Rehabilitation, Johns Hopkins University, Baltimore, MD.

Supported, in part, by a grant from the National Institutes of Health to Dr. Kamdar (F32 HL104901), who is a recipient of a Ruth L. Kirschstein NRSA award.
This study was performed at Johns Hopkins University, Baltimore, MD.
The authors have not disclosed any potential conflicts of interest.
For information regarding this article, E-mail: dale.needham@jhmi.edu

Kamdar et al. Crit Care Med. 2013; 41:800–809

[Critical Care Original Research]

CHEST

The Effect of a Quality Improvement Intervention on Sleep and Delirium in Critically Ill Patients in a Surgical ICU

Joseph E. Tonna, MD; Anna Dalton, DNP; Angela P. Presson, PhD; Chong Zhang, MS; Elizabeth Colantuoni, PhD; Kirsten Lander, MSN, RN; Sullivan Howard, BS; Julia Beynon, MHI, BSN, RN; and Biren B. Kamdar, MD, MHS

BACKGROUND: Delirium is a deleterious condition affecting up to 60% of patients in the surgical ICU (SICU). Few SICU-focused delirium interventions have been implemented, including those addressing sleep-wake disruption, a modifiable delirium risk factor common in critically ill patients.

RESEARCH QUESTION: What is the effect on delirium and sleep quality of a multicomponent nonpharmacologic intervention aimed at improving sleep-wake disruption in patients in the SICU setting?

STUDY DESIGN AND METHODS: Using a staggered pre-post design, we implemented a quality improvement intervention in two SICUs (general surgery or trauma and cardiovascular) in an academic medical center. After a preintervention (baseline) period, a multicomponent unit-wide nighttime (ie, efforts to minimize unnecessary sound and light, provision of earplugs and eye masks) and daytime (ie, raising blinds, promotion of physical activity) intervention bundle was implemented. A daily checklist was used to prompt staff to complete intervention bundle elements. Delirium was evaluated twice daily using the Confusion Assessment Method for the Intensive Care Unit. Patient sleep quality ratings were evaluated daily using the Richards-Campbell Sleep Questionnaire (RCSQ).

RESULTS: Six hundred forty-six SICU admissions (332 baseline, 314 intervention) were analyzed. Median age was 61 years (interquartile range, 49-70 years); 35% of the cohort were women and 83% were White. During the intervention period, patients experienced fewer days of delirium (proportion ± SD of ICU days, 15 ± 27%) as compared with the preintervention period (20 ± 31%; $P = .022$), with an adjusted pre-post decrease of 4.9% (95% CI, 0.5%-9.2%; $P = .03$). Overall RCSQ-perceived sleep quality ratings did not change, but the RCSQ noise subscore increased (9.5% [95% CI, 1.1%-17.5%; $P = .02$).

INTERPRETATION: Our multicomponent intervention was associated with a significant reduction in the proportion of days patients experienced delirium, reinforcing the feasibility and effectiveness of a nonpharmacologic sleep-wake bundle to reduce delirium in critically ill patients in the SICU.

Tonna et al. Chest 2021;160:899-908

Clinical Practice Guidelines for the Prevention and Management of Pain, Agitation/Sedation, Delirium, Immobility, and Sleep Disruption in Adult Patients in the ICU

Devlin et al. Crit Care Med. 2018;46:e825

- *Question:* How does sleep in critically ill adults differ from normal sleep in healthy adults? ↓ N3, ↓ REM, ↓ sleep quality
- *Question:* Is sleep different in critically ill adults if delirium (vs no delirium) is present? ↓ REM, ↑ daytime sleep
- *Question:* Is sleep different in critically ill adults who are mechanically ventilated (vs not MV)? Worsening sleep fragmentation, architecture
- *Question:* What is the prevalence of unusual or dissociative sleep patterns in critically ill adults? Highly variable
- *Question:* What risk factors that exist before the onset of critical illness affect sleep quality in critically ill adults in the ICU? Sleep aid, poor sleep
- *Question:* Which ICU-acquired risk factors affect sleep quality in critically ill adults? Pain, anxiety, noise, light, medications….
- *Question:* Do sleep and circadian rhythm alterations "during" an ICU admission affect outcomes during and/or after the ICU stay in critically ill adults? Its association with ICU outcomes is not known
- *Question:* Should physiologic monitoring be routinely used clinically to evaluate sleep in critically ill adults? No
- *Question:* Should assist-control ventilation be used at night (vs pressure support ventilation) to improve sleep in critically ill adults? Yes
- *Question:* Should an adaptive mode of ventilation be used at night (vs pressure support ventilation) to improve sleep in critically ill adults? No recommendation
- *Question:* Among critically ill adults requiring NIV, should an NIV-dedicated ventilator (vs a standard ICU ventilator with NIV capacity) be used to improve sleep? Either one is okay
- *Question:* Should aromatherapy, acupressure, or music be used at night (vs not using it) to improve sleep in critically ill adults? No
- *Question:* Should noise and light reduction strategies (vs not using these strategies) be used at night to improve sleep in critically ill adults? Yes
- *Question:* Should a sleep-promoting medication (i.e., melatonin, dexmedetomidine, or propofol) (vs no use of a medication) be used to improve sleep in critically ill adults? No recommendation for melatonin and DMDT, but propofol is not recomended
- *Question:* Should a sleep-promoting protocol be used to improve sleep in critically ill adults? Yes

Devlin et al. Crit Care Med. 2018;46:e825

감사합니다.