

## Sleep in the Intensive Care Unit

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### Abstract

Sleep is an important physiologic process, and lack of sleep is associated with a host of adverse outcomes. Basic and clinical research has documented the important role circadian rhythm plays in biologic function. Critical illness is a time of extreme vulnerability for patients, and the important role sleep may play in recovery for intensive care unit (ICU) patients is just beginning to be explored. This concise clinical review focuses on the current state of research examining sleep in critical illness. We discuss sleep and circadian rhythm abnormalities that occur in ICU patients and the challenges

to measuring alterations in circadian rhythm in critical illness and review methods to measure sleep in the ICU, including polysomnography, actigraphy, and questionnaires. We discuss data on the impact of potentially modifiable disruptors to patient sleep, such as noise, light, and patient care activities, and report on potential methods to improve sleep in the setting of critical illness. Finally, we review the latest literature on sleep disturbances that persist or develop after critical illness.

**Keywords:** sleep disruption; critical illness; polysomnography; circadian rhythm

Sleep is a complex process influenced by biologic and environmental factors. Despite spending one third of our life asleep, the exact physiologic purpose of sleep is still to be elucidated (1). There is growing evidence that sleep disturbances are associated with adverse outcomes (2–4). The impact of sleep deprivation in critically ill patients is gaining attention, as is the link between sleep loss and delirium (5, 6). This review article focuses on what is known about sleep in patients admitted to an intensive care unit (ICU). We briefly review etiologies of sleep disruption and circadian rhythm abnormalities in the ICU, tools available to measure sleep in critically ill patients, sleep-promoting interventions in the ICU, and sleep

problems that may persist in survivors of critical illness.

### Sleep Abnormalities in ICU Patients

Sleep abnormalities occur frequently in the ICU (7). These abnormalities include sleep deprivation and disruption as well as abnormal sleep architecture. Factors affecting sleep in the ICU are numerous and are detailed below. Compared with healthy adults, studies characterizing sleep disturbances in ICU patients using polysomnography (PSG) have demonstrated prolonged sleep latency, sleep fragmentation, decreased sleep

efficiency, numerous arousals, a preponderance of stage 2 sleep, decreased or absent stage 3 (“deep”) sleep, and decreased or absent REM sleep (8–11). Although mean total sleep time does not differ markedly from healthy adults, approximately 50% of ICU sleep occurs during the daytime hours, with a marked shift toward light stages of sleep. These studies have been performed in a varying ICU settings and demonstrate remarkable consistency (multiple short bouts of sleep during the day and night, a relatively normal total sleep time, significant sleep fragmentation, and severe reductions in stage 3 and REM sleep) (7, 12).

Determining the best methods to score and stage sleep in critically ill patients has

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been the focus of recent research studies. Studies that have used PSG and standard Rechtschaffen and Kales (R&K) scoring reveal that sleep in ICU patients is abnormal, with less slow-wave and REM sleep, increased arousals, and altered circadian timing (10, 11, 13, 14). Some studies have also noted EEG patterns that do not reliably fit into any stage, rendering R&K less useful. This is due to an absence of K complexes or sleep spindles in 20 to 44% of ICU patients, making classification of stage 2 sleep challenging (15–17). In fact, interobserver reliability using R&K is poor for scoring stage 1 and 2 sleep, with better agreements for scoring REM sleep (15). Third, sedatives, analgesics, and vasopressors disrupt sleep and may affect EEG patterns (18–20). As a result of these challenges, alternative methods to classify sleep using EEG are being explored.

### Visual Categorization of EEG

Visual sleep staging using the sleep–wakefulness organization pattern classifies sleep into one of five patterns based on frequency and voltage of the EEG and recognition of classical sleep elements (e.g., sleep spindles, rapid eye movements, or saw tooth waves). Prior application of scoring sleep using the sleep–wake organization pattern has been limited primarily to patients with head injury. When applied to patients in the ICU, interobserver reliability was only moderate and was found to be worse when sleep was less typical of non-REM (NREM) or REM and appeared rudimentary or monophasic (15). Regardless, interobserver reliability using the sleep–wake organization pattern was better than R&K.

### Spectral Analysis of EEG

Due to the inadequate agreement using visualization methods, computerized methods of scoring EEG were devised. Spectral analysis of EEG signals with Fast Fourier Transform quantifies EEG based on frequency with expression of sleep as a proportion of spectral frequency of theta, alpha, delta, and beta power (15). In one study, interobserver agreement for spectral analysis of sleep in critically ill patients revealed 100% agreement, which was significantly better than visual methods that staged sleep based on R&K and the sleep–wake organization pattern (15). In addition to reporting proportions of

spectral frequency, spectral analysis can be used to measure the spectral edge frequency 95% (SEF95), which is defined as the frequency below which 95% of the spectral power resides, with lower SEF95 indicating sleep and higher values indicating wakefulness (13). The SEF95 has also been used to assess circadian rhythmicity (13). Limitations include inconsistencies in the selection of epochs to include for analysis. Although spectral analysis seems to provide reliable agreement compared with other methods, further studies comparing spectral analysis alone or in conjunction with other methods to evaluate sleep in the ICU are needed.

### Alternative Scoring Strategies

Because abnormal EEG patterns are common in ICU patients, alternative scoring strategies to R&K are needed. Drouot and colleagues devised a new classification for sleep analysis that incorporates visual scoring and spectral analysis of the EEG (21). Two new states of sleep are proposed: pathologic wakefulness and atypical sleep. Pathologic wakefulness is determined and graded visually by assessment of the EEG reactivity (21). This method visually examines the background EEG rhythm in the occipital channel while the patient is awake with eyes closed followed by the patient's EEG reactivity to eye opening plus the peak EEG frequency using spectral analysis. Atypical sleep is defined by the absence of K complexes and sleep spindles with the presence of high-amplitude, continuous irregular delta frequency EEG without superimposed fast frequencies or rapid eye movements and with low-amplitude chin EMG (21, 22). This system was devised in ICU patients who were not on any sedation. Such a strategy for sleep analysis expands upon existing strategies using visual inspection and quantitative spectral analysis of EEG. Using this approach in the ICU, atypical sleep was predicted with a sensitivity of 100% and a specificity of 97% (21).

In addition to PSG findings of abnormal sleep, surveys of patients surviving critical illness indicate that sleep disturbances during their ICU course are one of the most frequent complaints (7, 12). These sleep abnormalities in critical illness may contribute to altered mental status and may affect patient recovery in the acute setting. A summary of sleep disturbances

noted in critically ill patients is presented in Table 1.

## Circadian Rhythm Alterations in Critically Ill Patients

Two primary processes, the endogenous circadian rhythm and homeostatic processes, control the normal sleep–wake cycle. The “biologic clock,” or circadian rhythm, controls the timing and duration of daily sleep–wake cycles. The homeostatic process regulates the length and depth of sleep and is determined by the previous timing, duration, and quality of sleep. Sleep and wakefulness result from an interaction between homeostatic mechanisms and endogenous circadian rhythms. The circadian timing system is comprised of a central pacemaker located in the suprachiasmatic nucleus and peripheral clocks located in tissues throughout the body. Circadian misalignment occurs when there is a mismatch between the endogenous circadian rhythm and behavioral cycles of sleep and wakefulness, as occurs in jet lag or shift work. This can result in sleep disruption when sleep is desired and decrements in alertness and performance when it is not.

There are compelling reasons to believe that disruptions of circadian rhythmicity may harm the critically ill patient in very specific ways. Abnormalities of circadian rhythmicity may disrupt sleep–wake cycles, resulting in sleep disruption and poor sleep quality. In addition, alterations in circadian rhythmicity may impair recovery by disrupting the coordinated activity of normal physiologic processes (23). Recent data suggest that endotoxin alters circadian clock gene expression in peripheral blood leukocytes, potentially uncoupling this expression from the activity of the central clock and interfering with the coordinated expression of the immune response (24).

Historically, the analysis of circadian rhythmicity in humans has relied on the analysis of the temporal patterns of one or more of the following phase markers: (1) core body temperature, (2) plasma melatonin or its metabolite urinary 6-sulfatoxymelatonin, or (3) plasma cortisol. Although these are robust markers of circadian rhythmicity in healthy subjects in highly controlled circumstances, there are particular challenges to their use in critically ill patients. Recent data support

**Table 1.** Sleep Disturbances in Critically Ill Patients

Patient-related factors	
Preexisting sleep disorders	
Pain	
Anxiety	
ICU-related factors	
Noise	
Light	
Patient care activities	
PSG findings in critically ill patients	
TST	Unchanged/decreased
TST occurring during daytime hours	50%
Sleep latency	Unchanged/increased
Sleep efficiency	Decreased
Sleep fragmentation	Increased
Arousals	Increased
NREM stage 1 (N1)	Increased
NREM stage 2 (N2)	Increased
NREM stage 3 (N3)	Decreased
REM	Decreased
Challenges with scoring PSG in critically ill patients	
NREM stage 1 and 2	Poor interobserver reliability with R&K
NREM stage 2	Difficulty classifying
Absence of K complexes	20–44%
Absence of sleep spindles	20–44%
Use of sedating medications	
Alternative PSG scoring strategies	
Pathologic wakefulness	Visual assessment of EEG reactivity using spectral analysis with eyes open and closed
Atypical sleep	Absence of K complexes and sleep spindles High-amplitude continuous irregular delta frequency EEG No fast frequencies, no REM Low-amplitude chin EMG

*Definition of abbreviations:* ICU = intensive care unit; NREM = non-rapid eye movement; PSG = polysomnographic; R&K = Rechtschaffen & Kales; REM = rapid eye movement; TST = total sleep time.

the use of core body temperature or 6-sulfatoxymelatonin as phase markers in critically ill patients. Fever, organ dysfunction, and medications may, however, render these measurements unreliable (13, 25).

A typical ICU presents numerous threats to circadian rhythmicity, including low daytime and high nighttime light. In addition, patients may enter the ICU with significant alterations in circadian rhythmicity due their underlying illness, medications, or preexisting sleep schedule. Older patients may be at particular risk for ICU circadian disruption because of a greater propensity for sleep abnormalities and age-related declines in circadian rhythmicity (26). There are no data on whether the circadian rhythm of critically ill patients can be entrained to the environment or if efforts to achieve this

would result in improved outcomes. Such an effort would necessitate improving the ICU environment for sleep and wakefulness through a multifaceted intervention designed not only to improve sleep but also to enhance daytime light exposure.

### Hormones, Cytokines, and Sleep Regulation

The neurochemical regulation of sleep is an emerging field of sleep research. Investigators are evaluating the effects of peptides, hormones, and cytokines on sleep regulation, including the consequences of sleep deprivation on circulating levels of these neurochemical modulators (27). A number of cytokines have been hypothesized to influence sleep regulation, including sleep promotion and inhibition

(28, 29) (Table 2). For a more detailed discussion of individual mechanisms and pathways of the cytokines and hormones and their effect of sleep regulation, see reviews by Krueger and colleagues (30) and Frenette and colleagues (31).

Although the complexity of critical illness makes this a particularly challenging physiology to study, there are many examples where the interaction between sleep and neurohumoral regulation could be clinically important to the recovery of the critically ill patient. Insulin resistance, for example, is common among the critically ill; it also occurs with experimental models of sleep loss and may be augmented by circadian misalignment (32). This potential relationship could be important in the ICU, where hyperglycemia has been linked to poor clinical outcomes.

### Risk Factors for ICU Sleep Deprivation

As depicted schematically in Figure 1, patient-specific factors and ICU environmental factors contribute to ICU sleep disruption.

Major patient factors for sleep deprivation in ICU patients are the type and severity of underlying illness, the pathophysiology of the acute illness, pain (from procedures or the underlying condition), and stress/anxiety (10, 12, 33). Although the exact relationship between sleep and ICU severity of illness is uncertain, it is likely important. One group demonstrated that increased sleep fragmentation is associated with increasing severity of illness. Another study, which compared ICU patients with healthy volunteers exposed to the same ICU environment, found that the critically ill patients had decreased total sleep time and a lower percentage of slow-wave sleep (34). This relationship between severity of illness and the ICU environment on sleep disturbance is complicated and needs more study.

Although patient-related factors likely play a large role in sleep disruption, one cannot discount the impact of the ICU environment. Noise in the ICU arises from multiple sources, including alarms, staff conversations, mechanical ventilators, pagers, and televisions. Noise has been implicated as an etiology of sleep disturbance in the ICU. Numerous studies

**Table 2.** Cytokines and Neurohumoral Regulators of Sleep

	Effect on NREM Sleep
IL-1	Promotion
IL-2	Possibly promotes*
IL-4	Inhibition
IL-6	Possibly promotes†
IL-10	Inhibition
IL-18	Promotion
TNF- $\alpha$	Promotion
TGF- $\beta$	Inhibition
IGF-1	Inhibition
GHRH	Promotion
CRH	Inhibition
NO	Promotion
Ghrelin	Promotion
VIP	Promotion

*Definition of abbreviations:* CRH = corticotropin-releasing hormone; GHRH = growth hormone-releasing hormone; IGF = insulin-like growth factor; NREM = non-rapid eye movement; TGF = transforming growth factor; TNF = tumor necrosis factor; VIP = vasoactive intestinal peptide.  
Data from References 27, 29, 85–91.  
\*Sleep induces increased circulating IL-2 levels.  
†May play a more important role in sleep regulation during pathologic states.

have demonstrated peak noise levels in excess of recommendations by the United States Environmental Protection Agency (45 dB during the day and above 35 dB at night). Mean noise levels in the ICU have been shown to be as high as 55 to 65 dB over a 24-hour period, and peak levels as high as 80 dB have been documented (17, 35). Studies have demonstrated a correlation with elevated noise levels and the number of patients awake on the wards (36). Although baseline noise is elevated above United States Environmental Protection Agency levels for most of a 24-hour period in the ICU, sound peaks  $\geq 80$  dB have been associated with arousals from sleep (37). Noise levels in the ICU are frequently well above acceptable levels; however, there are only a handful of studies that have attempted to link environmental noise to arousals and awakenings. Those studies that have correlated noise with arousals by PSG have found noise to be the etiology of the disturbance in 11 to 24% of the total number of arousals (17, 38). These data indicate that most of the arousals in patients in the ICU are not caused by noise, suggesting that other factors must be important in the sleep disruption in ICU patients.

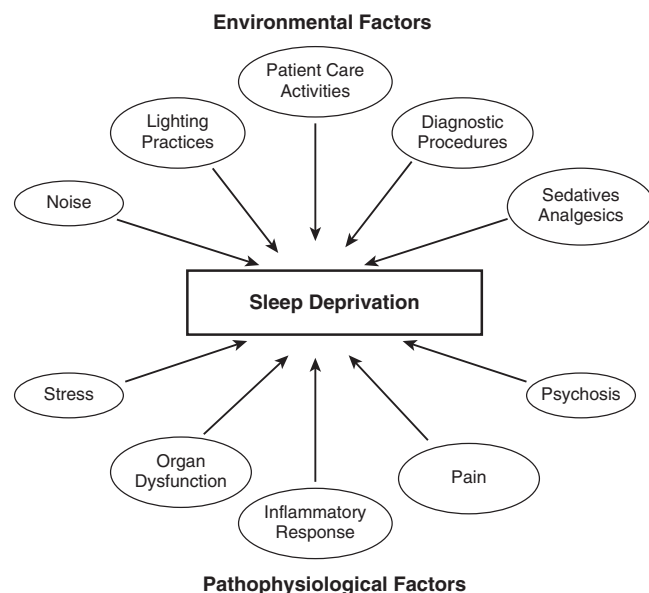
One such factor is abnormal light exposure. Nocturnal light levels in the ICU also contribute to sleep disruption. Light is important to maintaining a normal circadian rhythm. Studies that have measured light in the ICU have documented levels of over 1,000 lux (39). Nocturnal light levels as low as 100 to 500 lux can affect melatonin secretion, and nocturnal levels between 300 to 500 lux may disrupt the circadian pacemaker (40). Despite high levels of light, when ICU survivors were surveyed they reported that light did not disturb sleep as much as noise and patient care activities (12).

Patient care activities, such as nursing procedures, lab draws, vital signs, imaging, and procedures, contribute to sleep disruption in the ICU. ICU patients can experience up to 60 interruptions nightly related to patient care activities (34, 41). Questionnaires devised by Freedman and colleagues (12) and by Little and colleagues (42) have aimed to identify factors associated with poor sleep in the ICU. In general, patients report sleep quality in the ICU to be poor and that sleep is disrupted by noise, care activities such as phlebotomy and monitoring of vital signs, and pain (12, 42). A majority of patients reported having abnormal sleep/wake cycles while in the ICU (42).

Mechanical ventilation and medications also may contribute to the sleep disruption of critically ill patients. Sleep in mechanically ventilated patients is highly

fragmented (16). Additionally, ventilated patients may experience dyssynchrony, especially during periods of NREM sleep (43). The ventilator mode may also play a role in sleep disruption. Although pressure support ventilation allows patients to determine their own respiratory rate and tidal volume, there are descriptions of central apneas when using this mode of ventilation. These central apneas may be prevented by increasing dead space, which can result in an increase in the arterial partial pressure of carbon dioxide (44). A recent study demonstrated that nocturnal proportional assist ventilation resulted in fewer episodes of patient-ventilator dyssynchronies and was superior to pressure support ventilation in relation to sleep quality (45).

Several medications, including vasopressors, antibiotics, sedatives, and analgesics, may have a negative impact on sleep quality and architecture. Although benzodiazepines have been shown to increase total sleep time, they result in abnormal sleep architecture. They prolong stage 2 NREM and decrease slow-wave sleep as well as REM sleep. In critically ill patients, propofol has been shown to suppress REM sleep and to worsen sleep quality (46). Analgesics have also been associated with abnormal sleep architecture when given at doses higher than 10 mg/h (morphine equivalent) (16). Inotropic medications can affect sleep through their effects on adrenergic receptors. Beta blockers, which



**Figure 1.** Factors related to sleep deprivation in critically ill patients.

are a frequently used medication in the ICU, can negatively affect sleep and may cause insomnia and nightmares due to suppressed REM sleep (47). Quinolone antibiotics have been reported to disrupt sleep by inhibition of  $\gamma$ -aminobutyric acid type A receptors in the brain (48).

Although all of these variables may contribute to the poor sleep of these patients, their importance lies in the fact that they are potentially modifiable. As such, interventions to limit these sleep disruptors may serve as the basis for future sleep-promoting protocols in the ICU.

### Physiologic Effects of Sleep Deprivation in the ICU

Sleep deprivation can affect the immune system, hormone levels, pulmonary mechanics, and neurocognition. Although controversial, sleep loss impairs defense mechanisms and may render ICU patients more susceptible to infection (49). Multiple studies have shown a modulation of immune function secondary to changes in sleep patterns (50, 51). The changes in the immune system with sleep deprivation in normal subjects are well described, but whether these immune changes affect the ability of patients to recover from illness or increase susceptibility to illness is not known.

Sleep deprivation results in extensive changes to homeostatic mechanisms and alters neuroendocrine control systems and has been shown to cause increases in thyroid hormone, norepinephrine, and cortisol levels with decreases in growth hormone levels and insulin resistance (52). The impact of sleep disturbance on glucose metabolism is critical because glucose regulation can have an impact on patient morbidity and mortality in select ICU populations (53).

Studies have shown that after 30 hours of sleep deprivation inspiratory muscle endurance is reduced, whereas FEV<sub>1</sub> and FVC are unaltered (54). Exercise performance has been shown to be negatively affected by sleep deprivation. Such data suggest that sleep deprivation may affect the respiratory muscle function of critically ill patients and may affect weaning in mechanically ventilated patients.

Delirium is common in ICUs (55, 56). Many of the cognitive consequences of sleep loss are similar to those found in the

delirious state. In healthy volunteers sleep deprivation has been shown to impair memory, attention, response time, and other aspects of neurologic function (5). The relationship between sleep deprivation and delirium in the ICU is currently unproven (57). However, because sleep deprivation affects cognitive function, a connection between delirium and sleep deprivation in critically ill patients may exist (6).

### Tools to Measure Sleep in Critically Ill Patients

Sleep in critically ill patients can be assessed using a variety of tools. Although polysomnography (PSG) is the gold standard for sleep assessment in the outpatient setting, its utility in the ICU is met with numerous challenges (10, 11). First, performance of EEG requires skilled personnel to apply equipment and interpret data. Additional expenses can be incurred due to the need for extended PSG recordings because sleep may not be isolated to nocturnal periods. Second, there are numerous challenges in scoring sleep in ICU patients. Although the traditional scoring of sleep in ambulatory patients uses R&K, such scoring rules are difficult to apply in ICU patients.

#### Actigraphy

Actigraphy measures body movement via an internal accelerometer and sleep time using the manufacturer's proprietary algorithm. The actigraph is an automated watch that can be worn on the wrist or ankle and is a valid tool to measure rest-wake patterns and total rest time (58, 59). In normal healthy adult populations, actigraphy has significant correlation and agreement with PSG (60). Its primary use in clinical practice is in the assessment of circadian rhythms in a non-critically ill population; however, a few studies have used actigraphy to measure sedation/agitation in the ICU (61). These studies indicate that actigraphy correlates with nurse-directed observation of agitation, sleep, and sedation in alert and calm patients (62). Actigraphy also correlates with validated assessment tools for sedation (63). Its greatest potential for use may be as an objective measurement of sedation/agitation levels over a continuum, allowing clinicians to identify increased agitation and to prompt further

investigation; however, additional research is needed (64).

#### Sleep Assessment by Survey

Patient and nurse assessments of sleep by questionnaires have been used in the ICU. The Richards-Campbell Sleep Questionnaire (RCSQ) is a brief, five-item questionnaire that uses a visual analog scale to assess sleep depth, latency, awakenings, percentage of time awake, and quality of sleep (65). The RCSQ has been validated against PSG in alert and oriented critically ill male patients, and the questionnaire can be completed by the patient or the nurse (65, 66). Studies examining reliability measures between patient and nurse assessments of sleep using the RCSQ are mixed. Two studies indicate that nurses overestimate sleep quality compared with their patients (67, 68), whereas another study reported a high degree of correlation between patient and nurse assessments of sleep quality (69). Nurse-derived assessments of sleep overestimate total sleep time and sleep efficiency and underestimate the number of awakenings compared with PSG (70). The pitfalls of patient reporting of sleep are potential inaccuracies in data due to the use of sedation and delirium (71).

Despite ongoing research, limited scoring methods exist to assess and interpret sleep in ICU patients, with most studies reporting small sample sizes and study-related variability in the ICU population. Because ongoing research imparts understanding of how environmental and pathophysiological factors affect sleep, the field of sleep analysis will continue to evolve. For the clinician at the bedside, using sleep survey questionnaires is the easiest method to assess patients' sleep, despite their limitations.

### Sleep-Promoting Interventions in the ICU

A critical next step is to test the effect of nonpharmacologic and pharmacologic strategies to improve sleep and strengthen circadian rhythmicity of critically ill patients. A challenge for ICU sleep research is the need to deliver timely and appropriately aggressive 24-hour care to critically ill patients while identifying strategies that allow for the preservation of sleep and the enhancement of day-night routines.

The impact of noise reduction strategies on sleep in the ICU remains controversial and not well studied. Some studies have reported improvements in sleep with the use of earplugs, with fewer arousals and increased REM duration (72). However, another study demonstrated that although a reduction in noise increased sleep quantity, it did not change sleep architecture or the arousal index (34).

In healthy patients exposed to simulated ICU noise and light, provision of earplugs and eye masks resulted in an increase in REM sleep, shorter REM latency, fewer arousals, and elevated melatonin levels (73). Studies in nonsedated, nonventilated, critically ill patients have demonstrated subjective improvements in sleep with the use of earplugs (72). Several small studies have examined a variety of relaxation techniques to improve sleep in ICU patients. Critically ill male patients demonstrated improved quantity and quality of sleep when provided a 6-minute back massage (74). In a study of patients undergoing surgery who were exposed to ocean sounds to simulate white noise and compared with a usual-care control group, the intervention patients demonstrated subjective improvements in sleep measured by the RCSQ.

Various investigators have studied the introduction of quiet times. A nonrandomized controlled trial of quiet time demonstrated reductions in noise and increased sleep in patients in the experimental group (36). Patients, visitors, and healthcare providers also reported satisfaction with the quiet time intervention. A pre–post observational sleep-promoting quality improvement project in the ICU demonstrated a decrease in perceived noise and a reduction in delirium days but did not demonstrate improved sleep as measured by the RCSQ (75).

Circadian rhythm abnormalities and reduced levels of melatonin have been documented in critical illness. A randomized controlled trial in a small number of patients showed that patients who received 10 mg of oral melatonin versus placebo demonstrated improved nocturnal sleep efficiency as measured by bispectral index (76).

Sleep-promoting interventions will need to be multipronged and focus on reducing nighttime sleep disruption and maintaining a normal circadian rhythm (77). Such a protocol may necessarily need to limit daytime sleep. Hypnotics have not been well studied in critically ill patients.

Many of them have, however, been associated with delirium and should be avoided. Antipsychotics and antidepressants are sometimes used to reduce their sedating side effects; however, such medications have significant side effects, including delirium, making their use problematic (78). Their effect on the sleep of critically ill patients is unknown.

Implementation of ICU sleep protocols will require culture change, which will need to be individualized to accommodate the work flows of each institution and critical care setting. This will require education of ICU physicians, nurses, and other ancillary staff along with the measurement of performance and compliance with the protocol.

### Sleep after Critical Illness

Poor sleep, which develops during an acute illness, can persist for an extended period of time after discharge and is one of the most frequently cited stressful experiences for patients who have been critically ill (12, 42, 68, 79). The etiology of abnormal sleep during recovery from critical illness is multifactorial. Until recently, however, the sleep and circadian rhythms of survivors of critical illness had received little scrutiny. There is accumulating evidence that sleep disturbances are common in this patient population (80–82). McKinley and colleagues documented moderate to severe self-reported sleep problems in 50% of all respondents 1 week after hospital discharge (80). Although sleep quality generally improved over time, nearly one third of all subjects continued to experience moderate to severe problems at 26 weeks.

Sleep disturbances can be distressing to patients and have been shown to be associated with reduced quality of life in survivors of acute lung injury (82). Physical and cognitive rehabilitation may also be impaired when patients suffer from excessive sleepiness and low energy. In addition, sleep and circadian processes have been implicated in the pathogenesis of a variety of neuropsychiatric diseases that occur commonly after critical illness, including cognitive impairment, depression, anxiety, and post-traumatic stress disorder (83). In the study by McKinley and colleagues, the presence of sleep problems at Week 26 was independently associated with poor psychological recovery (80). Orwelius and

colleagues similarly noted a relationship between poor sleep at 6 and 12 months and low quality-of-life scores (81).

The causes of these sleep disturbances are not clear. Given that ICU survivors frequently suffer from a number of active medical problems, it is possible that the presence of sleep disturbances in this population simply marks unresolved illness. Evidence to support this assertion comes from a study in which subjects reported that sleep quality after being in the ICU was similar to retrospectively assessed sleep quality before critical illness (81). However, it is possible that the modern critical care experience—including acute illness, a nontherapeutic environment for sleep and wakefulness, and exposure to multiple medications affecting neurotransmitter balance—engenders new sleep disturbances that persist in some subjects after intensive care. This is similar to the development of new or worsening cognitive function after critical illness and reflects shared mechanisms in the brain (84). Thus, there is a need for well-designed prospective studies that characterize sleep and circadian disruption throughout critical illness and recovery while examining their relationship to long-term neuropsychiatric outcomes.

### Conclusions

The relationship between the poor sleep in critically ill patients and their ultimate outcomes remains unknown but potentially important. Poor sleep may contribute to the larger problem of brain dysfunction in the ICU, of which delirium is a manifestation. A multidisciplinary approach to understanding and treating the problem will require commitment on the part of ICU practitioners and hospital administrators, which in turn may lead to significant improvement in ICU care and patient outcomes. ■

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