

# Sleep-Wake Patterns in Brain Injury Patients in an Acute Inpatient Rehabilitation Hospital Setting

David T. Burke, MD\*  
Mrugeshkumar K. Shah, MD\*  
Jeffrey C. Schneider, MD\*  
Brian Ahangar, MD†  
Samir-Al-Aladai, PhD

\*Harvard Medical School, Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, Boston, Massachusetts

†New York Medical College, Valhalla, New York

‡Harvard Medical School, Boston, Massachusetts

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## ABSTRACT

**Primary Objective:** To determine staff-documented sleep/wake patterns of hospitalized brain injury patients.

**Research Design:** Cohort study.

**Methods and Procedures:** Data on 17 patients were recorded hourly for a two-week period by staff as to the wakefulness of patients. In addition, demographic data and FIM scores were obtained.

**Main Outcomes and Results:** Seventeen patients experienced interrupted sleep 71% of the night. This was true of 66% of the patients with traumatic brain injury and 92% of those with anoxic brain injury. One hundred percent of the women had a sleep disturbance as compared with 64% of the men. Patients who were at least 60 years of age had interrupted sleep 90% of the time as compared to those who were less than 25

years of age (70%). FIM scores and methylphenidate were not associated with sleep/wake patterns.

**Conclusions:** To our knowledge, this pilot study is the first to assess the sleep/wake patterns of patients by staff review on an inpatient brain injury unit and its functional implications.

## INTRODUCTION

Sleep disturbances are common in the general population. Investigators have performed extensive research on sleep disturbances in healthy subjects. Research has shown that age, gender, and medical conditions influence the quantity and quality of sleep in the normal population.<sup>1-4</sup> Recent studies have also documented the prevalence of sleep disturbances in hospitalized patients.<sup>4,6</sup> However, few studies have examined sleep patterns in the acquired brain injury (ABI) population.

Cohen and colleagues studied self-reported sleep patterns of 22 inpatients and 77 outpatients with brain injury.

Seventy-three percent of the hospitalized patients with brain injury complained of sleeping problems.<sup>7</sup> Of those, 82% reported problems initiating and maintaining sleep. Fifty-two percent of the outpatients reported sleep problems; most of these cases of sleep disturbance involved excessive somnolence. Complaints were unrelated to age and length of coma, but were more prevalent in females. This study also found that patients with untreated sleep disturbances demonstrated poorer vocational outcome, more behavioral problems, more cognitive and communicative dysfunction, and greater incidence of anxiety and depression. It is important to note that this study did not verify patients' subjective loss of sleep with objective measures such as staff monitoring.

Another study by Clinchot and colleagues evaluated sleep disturbances in 86 brain injury patients 1 to 3 years after hospitalization.<sup>8</sup> Fifty percent of the patients noted difficulty sleeping, 65% woke too early, 25% slept more than usual and 45% experienced problems falling asleep. Eighty percent of the patients with sleep problems also reported fatigue. They found that the more severe the brain injury, the less likely that the subject would report sleep disturbances. Their data suggests that sleep problems occurred at a higher incidence in female patients, the elderly, and those with a history of alcohol abuse. However, all of these data were subjective.

Investigators who have looked at objective sleep patterns in brain injury have focused on electroencephalograph (EEG) monitoring. Various studies have characterized altered sleep architecture in brain injury patients, including decreased slow wave sleep, decreased REM sleep, and incomplete or absent vertex sharp waves and sleep spindles.<sup>9-11</sup> One study noted that abnormal sleep

patterns decreased as the time since injury increased.<sup>12</sup> These authors also found that REM sleep increased as cognition improved. However, none of these studies correlated patients' EEG patterns with subjective or objective sleep-wake cycles.

To our knowledge, there is no study that measures staff documented sleep-wake patterns of hospitalized brain injury patients. Therefore, we sought to objectively assess the sleep patterns of brain injury inpatients and compare the patterns of sleep with injury etiology (traumatic brain injury vs anoxia), functional impairment (FIM scores), cognitive impairment (Rancho Los Amigos score, cognitive FIM), time since injury, medication effect (methylphenidate), age, and gender.

## **METHODS**

Patients were selected from the acquired brain injury (ABI) program at a free-standing rehabilitation hospital in the USA. Patients were included if they had a diagnosis of acquired brain injury and were between the ages of 18 and 85. Staff, including nurses, physical therapists, occupational therapists, and speech language pathologists, collected data once per hour concerning the wakefulness of their patients. Data were collected at the therapy gym or the patient's hospital room. At each hour, staff recorded whether the patient appeared to be awake or asleep. Patients with eyes closed and regular breathing were considered sleeping. Staff designated 1 of 5 sleep-wake categories for each patient: peaceful sleep (PS), restless sleep (RS), awake-calm (AC), awake-agitated (AA) and awake-drowsy (AD). For data analysis, all responses of PS and RS were considered sleep and other responses (AC, AA, AD) were considered awake.

Data were recorded 24 hours of the day and for a 2-week evaluation period.

A chart review was performed on all patients subject to data collection. Their charts were reviewed for gender, age, diagnosis, time since injury, significant past medical history, medications, Rancho Los Amigos (RLA) scores, cognitive FIM scores, and overall FIM scores. The 24-hour period of data collection was arbitrarily separated into sleep and wake intervals. The time of normal sleep was designated from 10 PM to 6 AM. Appropriate wakefulness was designated from 8 AM to 6 PM. The data collected outside of these intervals were not included in the analysis. Data were reviewed for all patients who were inpatients during the 2-week study interval. This included patients who were present from 3 to 15 days of the study period.

The percentage of nights the patient was found awake during the period of designated sleep time was calculated for each individual. Additionally, sleep patterns were compared for injury etiology (anoxia vs traumatic brain injury), age (less than 25 vs greater than 60), gender, and time since injury (less than 3 months vs greater than 3 months). We also compared the sleep patterns of patients with low functioning level (RLA score of 2 or 3) and high functioning level (RLA score of 7 or 8). Also, the sleep patterns of patients with the 5 lowest FIM and cognitive FIM scores were compared to those with the 5 highest FIM, and cognitive FIM scores, respectively.

## RESULTS

Seventeen brain-injured patients satisfied inclusion criteria. The study population ranged in age from 18 to 84 and included 14 men and 3 women. The etiology of their injuries included traumatic brain injury (11 patients), anoxia (3 patients), cerebrovascular accident (1 patient), tumor (1 patient), and subarachnoid hemorrhage (1 patient). Their

time since injury ranged from 2 weeks to 2 years.

Overall, the 17 patients experienced interrupted sleep 65% of the nights (Table 1). TBI patients experienced 56% interrupted sleep where as anoxic brain injury patients experienced 92% interrupted sleep. Women (100%) had significantly more interrupted sleep than men (58%). Patients younger than 25 (56%) encountered fewer sleeping problems than those older than 60 (89%).

We stratified our analysis among 3 functional scoring systems, the FIM, cognitive FIM, and RLA scores. The patients with the 5 highest FIM scores (average FIM = 84) demonstrated less sleep disruption (52%) than those with the 5 lowest FIM scores (average FIM = 24) (74%). Looking at the 5 highest (average cognitive FIM = 20) and lowest cognitive FIM scores (average cognitive FIM = 8), patients with higher cognitive FIM scores (55%) experienced fewer sleep disturbances than those with lower scores (79%). Additionally, patients with higher RLA score (47%) experienced fewer sleep interruptions than those with lower RLA score (69%).

Brain injury patients receiving methylphenidate (67%) experienced a similar frequency of sleep interruptions as those not receiving the medication (65%). Our last analysis examined patients whose brain injury occurred less than 3 months ago (60%) and those whose injury occurred more than 3 months ago (78%).

## DISCUSSION

In normal healthy adults the average length of sleep varies between 7 hours 25 minutes and 8 hours and 23 minutes depending on age.<sup>13</sup> Sleep disturbances are common, especially with increasing age. In one study, 90% of 25 year-old men reported uninterrupted sleep, whereas 100% of 95 year-old men reported interrupted sleep.<sup>1</sup> Seventy

**Table 1. Percent of Nights with Interrupted Sleep by Variable**

| Variable                   | Mean*       | Percent of nights with disrupted sleep* |
|----------------------------|-------------|---|
| All subjects               |             | 65.5 (35.4)                             |
| Male                       |             | 58.1 (34.7)                             |
| Female                     |             | 100 (0)                                 |
| TBI                        |             | 56.5 (40.2)                             |
| Anoxic                     |             | 92.3 (7.1)                              |
| Age < 25                   | 20.8 (1.9)  | 56.0 (47.1)                             |
| Age > 60                   | 69.6 (10.8) | 89.4 (9.2)                              |
| -                          | -           | -                                       |
| ≤3 month since injury      | -           | 60.2 (39.4)                             |
| > 3 months since injury    | -           | 78.2 (21.3)                             |
| Methylphenidate use        | -           | 67 (38.1)                               |
| No Methylphenidate use     | -           | 64.6 (35.7)                             |
| Five highest FIM           | 83.6 (21.1) | 51.8 (36.0)                             |
| Five lowest FIM            | 24 (5.9)    | 73.8 (38.3)                             |
| Five highest cognitive FIM | 20.4 (5.5)  | 54.6 (33.8)                             |
| Five lowest cognitive FIM  | 7.6 (1.5)   | 78.8 (40.0)                             |
| RLA score = 7 or 8         | 7.6 (0.5)   | 47 (45.2)                               |
| RLA score = 2 or 3         | 2.6 (0.5)   | 68.8 (39.7)                             |

\*Standard deviation

percent of the 509 men in this study reported difficulty getting to sleep and more than 40% reported wakefulness during the night. In another study of 2446 subjects, 18% of 65 to 74 year-olds complained of waking before 5 AM and 25% reported disturbed sleep.<sup>2</sup> However, less than 10% of men between 15 and 65 years old complained of sleep disturbances.

In addition to age-related sleep disturbances, various sleep disorders effect sleep patterns in the overall population. Insomnia is a common problem defined as a subjective sense that sleep is inadequate. It is associated with difficulty falling asleep, difficulty staying asleep, early morning awakening, and a sense

that sleep is non-restorative.<sup>3</sup> One study showed that 54% of adult men and 61% of adult women suffered from insomnia during a 3-month interval.<sup>13</sup> They also determined the prevalence of insomnia in 1006 metropolitan households at 32.2%. Aside from age and insomnia, particular settings influence sleep.

Studies have shown that patients in hospitals and nursing homes exhibit high rates of sleep disturbances. Ancoli demonstrated that patients in nursing homes experienced extremely fragmented sleep, and were rarely asleep for more than an hour at a time.<sup>14</sup> Although the patients' age is a major component of their sleep disturbance, other contributing factors include chronic bed

rest, circadian rhythm disturbances, noise, and lighting. These findings are supported by a study of 203 intensive care unit patients who exhibited poor sleep quality and daytime sleepiness. The etiologies of these sleep disturbances include noise, diagnostic testing, human interventions, and lighting, all common components of daily hospital care.<sup>5</sup> In another study evaluating the quality of sleep in a medical hospital unit, noise made by other patients and the medical staff (47%) and the patients own disease (30%) contributed most significantly to the patient's impaired quality of sleep.<sup>4</sup> Of the 134 patients in this study, 51% experienced a reduction in total sleep after entering the hospital. This was attributed to increased awakenings (37%), poorer sleep quality (31%), and the need for sleeping pills (26%). A recent literature review of sleep in acute care settings found that sleep disturbances are common and a highly variable experience and emphasized the need for further studies on this subject.<sup>6</sup>

In our review of the literature concerning sleep and brain injury we found no studies that evaluated patients' sleep-wake cycle with objective data. Studies using subjective patient-derived data document a high incidence of sleep disturbances after brain injury.<sup>7,8</sup> The frequency of sleep disturbances are comparable to that seen in the elderly population.<sup>1,2,14</sup> In fact, one author hypothesized that brain injury represents early aging of the sleep wake cycle because of similarities seen in sleep disturbance in the healthy elderly population.<sup>8</sup>

Sleep disruptions are a significant problem for brain injury patients, occurring 65% of the time in this study. This figure is similar to subjective data from other studies (range 50-73% sleep disturbances).<sup>7,8</sup> The results of this study found that anoxic brain injury, low FIM

scores, low cognitive FIM scores, low RLA scores, old age and female gender were all predictors of increased sleep disturbances. Of these factors, only female gender demonstrated statistical significance, confirming other studies' findings.<sup>7,8</sup> All other parameters were not statistically significant due in part to the small sample size. However, this pilot study illustrates interesting suggestions about the sleep-wake cycle in brain injury that warrant future investigation to clarify their significance.

There are various limitations to this study. First, the statistical analysis was limited by the small data set. Future studies should include more subjects to attain greater statistical power. Second, subjective data was not collected; therefore, we were unable to directly compare subjective patient-derived data with objective patient-independent data. Third, it may have been difficult for staff to determine whether a patient was sleeping or resting quietly. To eliminate such bias in future studies, we recommend verifying sleep patterns with EEG monitoring.

Our finding that patients with mild brain injury (measured by FIM and RLA scores) experienced fewer sleep problems contradicts Clinchot's findings that more severely brain injured patients reported less sleep disturbances.<sup>8</sup> This disparity may be related to the subjective study design. It is possible that more severely injured patients are not capable of reliably reporting their sleep patterns, thereby misrepresenting the incidence of sleep disturbances in this segment of the brain injury population.

This pilot study demonstrates that there are significant sleep disturbances in ABI patients. Furthermore, given a lack of statistical power, this study raises a series of questions concerning prognostic factors related to sleep in ABI patients. This is the first study to objectively measure sleep-wake patterns in

ABI patients and how they relate to function and medication use. However, future studies are warranted to clarify the details of sleep disturbances in brain injury.

## REFERENCES

1. Laird DA. The sleep habit of 509 men of distinction. *Am Med.* 1931;37:271-275.
2. Carskadon M, Dement W. Normal human sleep: An overview. In: Kryger M, Roth T, Dement W, eds. *Principles and Practice of Sleep Medicine.* 3rd ed. Philadelphia, Pa: W.B. Saunders; 2000:15-25.
3. Goetz, C.G. Insomnia. In: Goetz CG, ed. *Textbook of Clinical Neurology.* 1st ed. Philadelphia, Pa: W.B. Saunders; 1999.
4. Yinnon A, Ilan Y, Tadmor B, et al. Quality of sleep in the medical department. *Br J Clin Prac.* 1992;46:88-91.
5. Freedman N, Kotzer N, Schwab R. Patient perception of sleep quality and etiology of sleep disruption in the intensive care unit. *Am J Respir Crit Care Med.* 1999;159:1155-1162.
6. Redeker NS. Sleep in acute care settings: an integrative review. *J Nursing Scholosh.* 2000;32:31-38.
7. Cohen M, Oksenberg A, Snir D, et al. Temporally related changes of sleep complaints in traumatic brain injury patients. *J Neurol Neurosurg Psychiatry.* 1992;55:313-315.
8. Clinchot DM. Defining sleep disturbance after brain injury. *Am J Phys Med Rehab.* 1998;77:291-295.
9. George B. Night sleep disorders during recovery of severe head injuries. *Neurochirurgie.* 1981;27:35-38.
10. Markland ON, Dyken ML. Sleep abnormalities in patients with brain stem lesions. *Neurology,* 1976;26:769-776.
11. Harda M. Sleep in brain-damaged patients an all night sleep study of 105 cases. *Kumamoto Med J.* 1976;29:110-127.
12. Ron S. Time-related changes in the distribution of sleep stages in brain injured patients. *Electroencephalograph Clin Neurophysiol.* 1980;48:432-441.
13. Partinen M. Epidemiology of sleep disorders. In: Kryger MH, Roth T, Dement WC, eds. *Principles and practice of sleep medicine.* Philadelphia, Pa: W.B. Saunders; 1994:437-452.
14. Ancoli-Israel S. Sleep problems in older adults: Putting myths to bed. *Geriatrics.* 1997;52:20-30.