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ORIGINAL ARTICLE

Trajectories of sleep changes during the acute phase of traumatic brain injury: A 7-day actigraphy study

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Background/Purpose: To examine trajectories of change in sleep during the acute phase of traumatic brain injury (TBI), and whether specific demographic and disease characteristics predicted the initial levels of sleep and the trajectories of change in sleep parameters.
Methods: This was a prospective observational study. Fifty-two patients with first-ever TBI were enrolled. Sleep parameters were measured using actigraphy for 7 consecutive days after admission. Hierarchical linear modeling was used for data analyses in 52 TBI patients and in a subgroup of mild TBI patients ($n = 31$).
Results: Participants had significant lower sleep efficiency, longer wake time after sleep onset, and longer 24-hour total sleep time (TST) than the normative data (all $p < 0.05$). Seventy-two percent of participants experienced prolonged 24-hour TST. Both daytime and 24-hour TST showed a significant downward trend across the study period. An initial Glasgow Coma Scale score < 11 significantly predicted the slope of change of daytime TST over time. Without initial loss of consciousness and age < 40 years were independent predictors of the change pattern of 24-hour TST over time. In the mild TBI subgroup, 24-

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hour TST significantly and gradually declined over time. Gender significantly predicted the trajectory of 24-hour sleep duration.
Conclusion: Poor sleep efficiency and longer sleep duration are common symptoms in acute TBI patients. Both head injury severity and age predicted the trajectories of daytime and 24-hour sleep duration during the acute phase of TBI, whereas gender predicted the trajectories of 24-hour sleep duration in the mild TBI subgroup.

Introduction

Traumatic brain injury (TBI) is an important public health problem, and the global incidence rate of TBI is estimated to be 200/100,000/year.[1] Survivors of TBI often suffer from long-term physical and psychological problems which in turn may affect a person's ability to return to work and resumption of daily activities.[2,3] Posttraumatic hypersomnia (PTH) and insomnia are common sleep complaints reported by chronic and post-acute TBI survivors, with prevalence rates of 20-90% and 30-70%.[4–8] Sleep complaints reported by TBI survivors have been associated with prolonged rehabilitation unit stay,[9] heightened depression and anxiety symptoms,[4] and reduced health-related quality of life.[8]

Most of the available research has focused on sleep complaints of TBI patients during the chronic rehabilitation stage.[4–8] A small number of studies reported that disturbed nighttime sleep and excessive daytime sleepiness (EDS) may occur in the subacute stage as well.[9,10] However, little is known regarding the change in sleep patterns during the period immediately following TBI. Most importantly, past studies mainly used a cross-sectional approach to investigate this matter. The trajectories of TBI-associated change in sleep patterns during the period immediately following TBI remain uninvestigated. Therefore, the current study was designed to examine trajectories of change in sleep parameters in individuals with TBI during the period immediately following trauma. Age, body mass index (BMI), pain at night, severity of head injury, depression, and anxiety symptoms have been identified as significant predictors of sleep disturbance in TBI survivors during the subacute or the rehabilitation period in earlier studies.[5–7,10–13] Nonetheless, predictors of the trajectories of change in sleep patterns during the early phase of TBI have not yet been explored.

Sleep plays an essential role in the recovery of physical functioning during the period immediately after TBI. Knowledge of the trajectories of change in sleep after TBI and their predictors may provide insights into the development of effective interventions for this patient population. Therefore, the purpose of this study was to examine the following: (1) different trajectories of change in sleep parameters during the acute phase of TBI, and (2) whether specific demographic and disease characteristics predicted the initial levels of sleep and the trajectories of change in sleep parameters. We hypothesized that the manifestations of change in sleep are diverse and are affected by the severity of head injury, and may decline over time during the acute phase after TBI.

Methods

Participants

This study was a prospective observational study. Participants were recruited from three neurological wards of a 3000-bed hospital located in northern Taiwan. Patients were eligible to participate if they were between 18 years and 65 years of age, newly diagnosed with a computed tomography (CT)-proven first-time closed brain injury, and admitted to the neurosurgical ward. Patients were excluded if they were shift workers, had a previous TBI, a history of psychiatric disease, sleep disturbance, or alcohol abuse prior to TBI, suffered from traumatic injuries to other parts in addition to TBI, or were admitted to the intensive care unit (ICU) immediately following TBI.

Measurements

Objective data of sleep parameters were obtained by actigraphy using the quantitative ActiGraph (ActiGraph, Pensacola, FL, USA), a watch-like accelerometer that can differentiate between sleep and waking based on the amount of movement. In brief, for each 60-second epoch interval, data samples taken from the accelerometer inside the device at a rate of 30 Hz were first filtered then accumulated prior to being stored in memory. Data were analyzed using ActiLife software (ActiGraph, version 5.3.0). Automatic scoring of sleep was performed on actigraphical data from each epoch, using the Cole-Kripke algorithm[14] to determine minute-by-minute asleep/awake status. Actigraphic measurements of sleep are comparable to those of PSG,[15,16] and are suitable to study the sleep patterns of TBI patients.[17,18] In order to determine daytime and nighttime sleep duration, a 7-day sleep diary was used to facilitate actigraphic data analysis.

Sleep variables

Nighttime sleep variables including nighttime total sleep time (TST), sleep onset latency (SOL), sleep efficiency (SE), and wake time after sleep onset (WASO) were investigated in the current study. Nighttime TST referred to the amount of actual sleep time that occurred in the nighttime period defined by actigraphy and the sleep diary. SE was the ratio of TST to the total time spent in bed. The total time spent in bed was estimated by using the bedtime and wake time recorded by primary caregivers or participants. SOL was defined as the period from bedtime indicated by the primary caregivers or participants to the beginning of sleep.