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Sleep Disorders in Stroke Patients: A Literature Review

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ABSTRACT

Stroke was a major cause of death and long-term disability and was frequently accompanied by sleep disorders that affected rehabilitation and quality of life. Post-stroke sleep disturbances could precede stroke as a risk factor or emerge afterward as a consequence of central nervous system damage and various accompanying factors. This literature review was conducted to discuss the definition, epidemiology, etiology, physiology, pathophysiology, classification, clinical manifestations, diagnosis, management, and prognosis of sleep disorders in stroke based on a search of the scientific literature through Google Scholar and PubMed. The spectrum of sleep disorders in stroke patients included sleep-disordered breathing, insomnia, excessive daytime sleepiness, hypersomnia, restless legs syndrome, periodic limb movement disorder, circadian rhythm disorders, and parasomnia, associated with damage to brain structures regulating sleep, respiratory disturbances, psychological factors, medical comorbidities, and environmental factors during care. Diagnosis was established through history taking, screening instruments such as the Pittsburgh Sleep Quality Index and Epworth Sleepiness Scale, and supporting examinations such as polysomnography and actigraphy. Management included non-pharmacological approaches such as cognitive behavioral therapy for insomnia and continuous positive airway pressure, as well as pharmacological therapy in certain conditions. Sleep disorders were associated with slower neurological recovery, reduced quality of life, cognitive impairment, and an increased risk of recurrent stroke. This review concluded that sleep disorders were common but frequently underdiagnosed non-motor complications of stroke, highlighting the importance of early identification and appropriate management as part of comprehensive stroke care to optimize recovery and long-term prognosis.

1. INTRODUCTION

Stroke is one of the leading causes of death and long-term disability worldwide. In 2021, stroke was the third leading cause of death and disability globally, with approximately 93.8 million cases, including 11.9 million new cases. The global burden of stroke, measured in Disability-Adjusted Life Years (DALYs), also increased from 137 million in 2000 to 160 million in 2021 (World Health Organization, 2025). In Indonesia, based on the 2023 Indonesian Health Survey, the prevalence of stroke diagnosed by a physician among individuals aged ≥15 years was 8.3 per 1,000 population. The prevalence was higher in Jakarta, at 10.7 per 1,000 population (Kementerian Kesehatan RI, 2023). The substantial global and national burden of stroke highlights its continued importance as a major public health problem. In addition to causing neurological deficits involving motor, sensory, language, and cognitive functions, stroke can also result in various non-motor complications that affect rehabilitation and patients' quality of life.

One of the commonly encountered but still underrecognized complications is sleep disturbance. Sleep disturbances may occur before stroke as a risk factor or after stroke as a consequence of central nervous system damage and various accompanying factors. In sleep-related breathing disorders, particularly obstructive sleep apnea, recurrent episodes of apnea or hypopnea can cause intermittent hypoxia and sleep fragmentation, triggering sympathetic nervous system activation, systemic inflammation, and endothelial dysfunction, thereby contributing to an increased risk of stroke (Hoang-Anh et al., 2023; Joza & Boulos, 2024). Conversely, stroke may cause sleep disturbances through damage to brain structures involved in

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sleep-wake regulation, including the brainstem, thalamus, hypothalamus, basal ganglia, and diencephalic structures. Damage to these structures can disrupt the sleep-wake cycle and sleep architecture, resulting in various sleep disorders, including insomnia, hypersomnia, excessive daytime sleepiness, and sleep-related breathing disorders (Pérez-Carbonell & Bashir, 2020; Chen et al., 2024).

Sleep disorders in stroke patients encompass a broad spectrum of conditions, including sleep-disordered breathing such as obstructive sleep apnea and central sleep apnea, insomnia, excessive daytime sleepiness, hypersomnia, restless legs syndrome, periodic limb movement disorder, circadian rhythm disorders, and parasomnias. Each of these sleep disorders has distinct pathophysiological mechanisms, clinical characteristics, prevalence, consequences for patient function and recovery, and diagnostic and management approaches. Sleep disorders may occur across different stages of the stroke course, ranging from the acute to the chronic phase; therefore, the stage of the disease should be considered when evaluating the characteristics of sleep disorders in stroke patients. Accordingly, a comprehensive literature review is needed to understand the various forms of sleep disorders in stroke patients and their implications for clinical outcomes. Various studies have shown that sleep disorders are highly prevalent among stroke patients. A meta-analysis by Hasan et al. (2021) reported that sleep-disordered breathing was found in more than half of stroke patients, while insomnia was also reported to have a relatively high prevalence across different post-stroke phases. These findings indicate that sleep disorders are common clinical problems encountered in both the acute and chronic phases after stroke.

Sleep disorders in stroke patients have significant effects on clinical outcomes. These effects may vary depending on the type of sleep disorder. In sleep-disordered breathing, particularly obstructive sleep apnea, intermittent hypoxia, sleep fragmentation, sympathetic nervous system activation, systemic inflammation, and endothelial dysfunction may exacerbate neurological injury and hinder post-stroke recovery (Joza & Boulos, 2024). Meanwhile, disturbances in sleep quality or quantity may impair memory consolidation, cognitive function, synaptic plasticity, and neuroplasticity, all of which play important roles in functional recovery after stroke (Chennaoui et al., 2020). In patients with psychological disorders such as depression and anxiety, sleep disturbances, particularly insomnia, may worsen psychological conditions and subsequently reduce participation in rehabilitation and delay functional recovery (Caplan, 2016). Therefore, sleep disorders should not be regarded merely as additional complaints but should be considered as factors that may influence the recovery process and clinical outcomes of patients with stroke.

Despite their high prevalence and substantial clinical impact, sleep disorders in stroke patients may remain undiagnosed and inadequately treated. One example is obstructive sleep apnea, which is commonly found in stroke patients. Gottlieb et al. (2021) found that 57% (16/28) of patients with chronic ischemic stroke had previously undiagnosed moderate-to-severe obstructive sleep apnea, although none of the patients reported a history of obstructive sleep apnea. This finding suggests that sleep disorders may not be identified based solely on patient-reported symptoms, and that objective sleep evaluation may be warranted in post-stroke patients. The limited attention given to sleep disorders may also be related to their diverse manifestations and the fact that they are often not the patient's primary complaint. Symptoms such as fatigue, daytime sleepiness, cognitive impairment, mood changes, and reduced participation in rehabilitation may overlap with manifestations of stroke itself, allowing sleep disorders to be overlooked when specific evaluation is not performed. This condition further emphasizes the need for a comprehensive synthesis of the literature on sleep disorders in stroke patients.

Sleep disorders in stroke patients have a broad spectrum, and their identification and diagnosis require an approach tailored to the suspected type of sleep disorder. Screening instruments can be used as an initial assessment, including the Pittsburgh Sleep Quality Index to assess subjective sleep quality, the Epworth Sleepiness Scale to assess excessive daytime sleepiness, and the STOP-BANG and Berlin Questionnaire to assess the risk of obstructive sleep

apnea. When further evaluation is warranted, objective examinations such as polysomnography can be used to assess obstructive sleep apnea, central sleep apnea, periodic limb movement disorder, sleep architecture, and parasomnias, while actigraphy can assist in assessing sleep-wake patterns and circadian rhythm disturbances.

The literature on sleep disorders in stroke patients has addressed various aspects, including the relationship between sleep disorders and stroke, underlying pathophysiological mechanisms, clinical manifestations, diagnostic approaches, management, and prognosis. However, these aspects need to be understood in an integrated manner because sleep disorders in stroke patients encompass a broad spectrum, with each type potentially having different clinical manifestations, diagnostic approaches, and management options. Therefore, a comprehensive synthesis of the literature integrating the bidirectional relationship between stroke and sleep disorders, underlying pathophysiological mechanisms, clinical manifestations, diagnostic approaches, treatment options, and their effects on patient outcomes is needed. Based on these considerations, this literature review aimed to synthesize the literature on the bidirectional relationship between stroke and sleep disorders, the underlying pathophysiological mechanisms, clinical manifestations, diagnostic approaches, treatment options, and the effects of sleep disorders on clinical outcomes and prognosis in stroke patients.

2. METHOD

This study employed a literature review methodology to identify and analyze scientific evidence on sleep disorders in stroke patients. The literature search was conducted using Google Scholar and PubMed from June 12, 2025 to August 19, 2026. The search strategy used combinations of the keywords “stroke,” “sleep disorders,” “post-stroke,” “insomnia,” “obstructive sleep apnea,” “sleep-disordered breathing,” “circadian rhythm,” and “sleep quality,” combined using the Boolean operators AND and OR. The search prioritized articles published within the previous five years, while several basic textbooks on sleep physiology and pathophysiology were also included as references for fundamental concepts despite being published more than five years earlier.

The study population focused on human patients with stroke, including those in the acute and chronic phases, with sleep disorders of various types as the main exposure. Information from eligible articles was extracted and grouped according to the type of sleep disorder, prevalence, pathophysiological mechanisms, screening and diagnostic methods, interventions or management, and prognosis. Data from the included studies were subsequently compared according to the post-stroke phase, type of sleep disorder, diagnostic instruments, and management modalities used. The findings were then narratively synthesized by identifying similarities, differences, and relationships among the studies. The outcomes assessed included prevalence, pathophysiological mechanisms, clinical manifestations, diagnostic accuracy, treatment effectiveness, and the relationship between sleep disorders and prognosis in stroke patients.

The inclusion criteria were articles published in Indonesian or English, available in full text, focusing on human stroke patients in the acute or chronic phase, and addressing the definition, epidemiology, etiology, physiology, pathophysiology, classification, clinical manifestations, diagnosis, management, and/or prognosis of sleep disorders in stroke patients. Eligible publications included original research articles, systematic reviews, meta-analyses, and narrative reviews published in indexed journals. The exclusion criteria were articles available only as abstracts without full-text access, editorials, opinion articles, or letters to the editor without substantive scientific data, studies involving animal subjects, duplicate articles, and articles not directly relevant to sleep disorders in stroke patients.

3. RESULT AND DISCUSSION

Result

Definition

Sleep disorders are a group of conditions that affect sleep quality, quantity, timing, or behavior during sleep, thereby impairing physical, mental, or social functioning and quality of life. Sleep disorders encompass a wide range of conditions, including insomnia, sleep-related breathing disorders, central disorders of hypersomnolence, circadian rhythm sleep-wake disorders, sleep-related movement disorders, and parasomnias (Miller & Howarth, 2023). Sleep is an essential physiological process for maintaining neurological, metabolic, immunological, and cognitive functions. Therefore, sleep disturbances may result in various health consequences, including impaired cognitive function, mood changes, reduced quality of life, and an increased risk of neurological and cardiovascular diseases (Chennaoui, Léger & Gomez-Merino, 2020).

In patients with stroke, sleep disorders are defined as various sleep abnormalities that occur before, during, or after stroke and may affect neurological recovery and clinical outcomes. Post-stroke sleep disorders may result from damage to brain structures involved in sleep-wake regulation, sleep-related breathing disturbances, circadian rhythm alterations, psychological disorders, and other medical factors associated with stroke (Pérez-Carbonell & Bashir, 2020). Sleep disorders are among the most common non-motor complications in stroke patients. The spectrum includes sleep-disordered breathing, such as obstructive sleep apnea and central sleep apnea, insomnia, excessive daytime sleepiness, hypersomnia, restless legs syndrome, periodic limb movement disorder, circadian rhythm disorders, and various alterations in sleep architecture that may affect rehabilitation and quality of life (Chen et al., 2024; Joza & Boulos, 2024).

Epidemiology

Sleep disorders are common complications in patients with stroke, occurring in both the acute and chronic phases, with a higher prevalence than in the general population. Hasan et al. (2021), in a systematic review and meta-analysis of 169 studies involving a total of 64,047 patients, reported that sleep-disordered breathing (SDB) was the most frequently identified sleep disorder among post-stroke patients, with mild SDB prevalence rates of 66.8% in the acute phase, 65.5% in the subacute phase, and 66.2% in the chronic phase. Insomnia was also frequently observed, with prevalence rates of 40.7% in the acute phase, 42.6% in the subacute phase, and 35.9% in the chronic phase. Other sleep disorders, such as periodic limb movements during sleep (PLMS) and restless legs syndrome (RLS), were reported at prevalences of 32.0% and 10.4%, respectively, in the acute phase, increasing to 48.2% and 13.7%, respectively, in the chronic phase, suggesting that sleep disorders may persist over the long term in patients with stroke.

Obstructive sleep apnea (OSA) is one of the most frequently encountered sleep disorders in patients with stroke. Joza and Boulos (2024) reported an OSA prevalence of approximately 65.5% among stroke survivors, with more than one-quarter of cases classified as severe. Similar findings were reported by Hoang-Anh et al. (2023), who found that OSA occurred in up to 70% of patients with stroke, with most patients with cerebral infarction and OSA having moderate disease severity based on the apnea-hypopnea index (AHI). These findings indicate that sleep-related breathing disorders are a highly prevalent clinical problem in the stroke population.

In addition to sleep-related breathing disorders, sleep disorders in general are common among patients with stroke due to neurological disturbances affecting sleep regulation. Zhang et al. (2023) reported that approximately 20–40% of patients with stroke experienced sleep disorders, while 50–70% had sleep-related breathing disorders. In that study, poor sleep quality was observed in 52.5% of patients at admission and remained present in 40.2% after four years of follow-up. The risk of OSA also remained high throughout the observation period, ranging from approximately 74.7% to 77.4%, suggesting that sleep disorders in stroke patients may persist over time.

These findings were supported by a population-based study by Jeffers et al. (2023) involving 46,404 adults in Canada, which showed that patients with a history of stroke had a higher prevalence of sleep disorders than the general population. Overall, 61.6% of stroke survivors reported at least one form of sleep disorder, compared with 48.2% of individuals without a history of stroke. The most frequently reported disturbances included unrefreshing sleep (41.1%), abnormal sleep duration, either too short or too long (28.9%), difficulty initiating or maintaining sleep (28.1%), and difficulty maintaining daytime alertness (13.0%). Among patients with acute stroke, sleep disorders were also frequently observed, without significant differences according to stroke type or lesion side. Kojic et al. (2022) reported that acute stroke patients with sleep apnea experienced sleep disorders of varying severity, indicating that sleep disorders may occur across a broad spectrum of patients with stroke.

The epidemiological data above demonstrate substantial variation in prevalence estimates across studies, depending on the type of sleep disorder assessed, post-stroke phase, study population, and diagnostic instrument used. A summary of the prevalence findings from several key studies is presented in Table I to facilitate comparison.

Table 1. Summary of the Prevalence of Sleep Disorders in Stroke Patients by Study.

Study (Year)	Study Design/Population	Sleep Disorder	Prevalence Findings
Hasan et al. (2021)	Meta-analysis of 169 studies (n= 64,047)	Sleep-disordered breathing (mild)	66.8% acute; 65.5% subacute; 66.2% chronic
Hasan et al. (2021)	Meta-analysis of 169 studies (n= 64,047)		40.7% acute; 42.6% subacute; 35.9% chronic
			32.0% / 10.4% acute; increasing to 48.2% / 13.7% chronic
Hasan et al. (2021)	Meta-analysis of 169 studies (n= 64,047)	Periodic limb movements during sleep (PLMS) / Restless legs syndrome (RLS)	Approximately 65.5%; more than one-quarter of cases were severe
			Up to 70%; most cases were moderate based on the apnea-hypopnea index (AHI)
Joza & Boulos (2024)	Narrative review of stroke survivors	Obstructive sleep apnea (OSA)	Approximately 65.5%; more than one-quarter of cases were severe
Hoang-Anh et al. (2023)	Study of patients with cerebral infarction	Obstructive sleep apnea (OSA)	Up to 70%; most cases were moderate based on the apnea-hypopnea index (AHI)
Zhang et al. (2023)	Post-stroke cohort study (4-year follow-up)	Sleep disorders / sleep-related breathing disorders	20–40% / 50–70%; poor sleep quality: 52.5% at admission and 40.2% at 4 years; high OSA risk: 74.7–77.4%
Jeffers et al. (2023)	Population-based cross-sectional study (n = 46,404; Canada)	Sleep disorders (≥1 type)	61.6% among stroke survivors vs. 48.2% among individuals without stroke

Etiology

Sleep disorders in patients with stroke are multifactorial and may arise from direct brain tissue damage as well as secondary factors associated with the post-stroke condition. Sleep disorders may occur as neurological manifestations resulting from lesions in structures involved in sleep regulation and may also be influenced by medical, psychological, and environmental

factors that arise during care and rehabilitation (Pérez-Carbonell & Bashir, 2020). The five etiological groups are described below. Stroke can cause damage to various structures of the central nervous system involved in sleep-wake regulation, including the brainstem, thalamus, hypothalamus, basal ganglia, and other diencephalic structures. Lesions in these areas can disrupt the balance of systems regulating the sleep-wake cycle, resulting in insomnia, hypersomnia, excessive daytime sleepiness, circadian rhythm disorders, and sleep-related breathing disorders (Pérez-Carbonell & Bashir, 2020).

Certain sleep disorders have also been associated with specific lesion locations. Lesions involving the dorsal brainstem or tegmentum, paramedian thalamus, and subcortical structures have been reported to be associated with post-stroke insomnia. In contrast, bilateral thalamic, diencephalic, and pontine lesions may cause hypersomnia or excessive daytime sleepiness due to disruption of arousal-regulating systems (Pérez-Carbonell & Bashir, 2020). Post-stroke sleep disorders may also result from alterations in respiratory control during sleep. Damage to respiratory centers in the central nervous system can lead to sleep-disordered breathing, including obstructive sleep apnea (OSA) and central sleep apnea (CSA). In addition to neurological injury, the development of OSA after stroke may be influenced by changes in upper airway muscle tone, a more frequent supine sleeping position, reduced pulmonary function, and comorbidities associated with stroke (Pérez-Carbonell & Bashir, 2020).

Psychological disorders are important contributors to sleep disorders in patients with stroke. Depression, anxiety, emotional stress, and mood disturbances are frequently observed after stroke and have a bidirectional relationship with sleep disorders. Patients with depression or anxiety are more susceptible to insomnia, whereas persistent sleep disturbances may worsen existing psychological conditions (Pérez-Carbonell & Bashir, 2020). Post-stroke depression is one of the most common neuropsychiatric complications in patients with stroke and may occur during both the acute and chronic phases. It is associated with altered sleep patterns, reduced sleep quality, and an increased occurrence of insomnia. The risk of depression is higher among patients with a previous history of depression, functional limitations, limited social support, or stroke lesions involving specific areas, particularly the left anterior hemisphere. In addition to affecting sleep quality, depression may hinder participation in rehabilitation, delay functional recovery, and worsen long-term clinical outcomes (Caplan, 2016).

In addition to depression, other emotional disturbances, such as anxiety, irritability, apathy, and post-stroke behavioral changes, may cause difficulty initiating or maintaining sleep. Therefore, evaluation of psychological conditions is an important component of managing sleep disorders in patients with stroke (Caplan, 2016). Various medical conditions accompanying stroke may contribute to the development of sleep disorders. Chronic pain, spasticity, nocturia, respiratory disorders, cardiovascular disease, diabetes mellitus, and certain medications may impair sleep quality. In addition, other sleep disorders, such as restless legs syndrome and periodic limb movement disorder, may cause sleep fragmentation and further impair sleep quality after stroke (Pérez-Carbonell & Bashir, 2020).

The care environment during the acute phase of stroke also contributes to the development of sleep disorders. Exposure to light and noise in hospital settings, repeated medical assessments during the night, limited mobility, and changes in daily routines may interfere with sleep initiation and maintenance. These factors may further exacerbate sleep disturbances arising from primary neurological damage (Pérez-Carbonell & Bashir, 2020).

Physiology

Sleep is an active physiological process that plays an important role in maintaining body homeostasis and central nervous system function. It has various restorative functions, including memory consolidation, metabolic regulation, tissue repair, maintenance of synaptic homeostasis, and modulation of immune and inflammatory responses. Sleep also contributes to neuroplasticity and brain recovery through various neuroendocrine mechanisms occurring throughout the sleep cycle (Chennaoui et al., 2020).

The sleep-wake cycle is regulated by the interaction between two major systems: the sleep-wake homeostatic system and the circadian rhythm system. The homeostatic system regulates sleep pressure, which increases with the duration of wakefulness, whereas the circadian rhythm system regulates the timing, structure, and consolidation of sleep, allowing individuals to remain awake during the day and maintain continuous sleep at night. The suprachiasmatic nucleus (SCN) in the hypothalamus serves as the primary circadian pacemaker and synchronizes internal biological rhythms with the 24-hour environmental cycle, particularly through exposure to light and darkness. Disruption of this system may result in altered sleep patterns, difficulty initiating sleep, frequent nocturnal awakenings, and impaired daytime alertness (Kim, Elkhadem & Duffy, 2022).

Normal sleep consists of two major phases: non-rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep. NREM sleep is divided into three stages: N1, N2, and N3. Stage N1 represents the transition from wakefulness to sleep, while stage N2 is characterized by the appearance of sleep spindles and K-complexes on electroencephalography. Stage N3, or slow-wave sleep, is the deepest stage of sleep and plays an important role in physical recovery, metabolic regulation, and declarative memory consolidation. In contrast, REM sleep is characterized by increased brain activity, rapid eye movements, and muscle atonia and contributes to emotional and procedural memory consolidation (Chokroverty & Ferini-Strambi, 2017).

Each sleep stage has distinct physiological effects on central nervous system activity, autonomic nervous system function, and cardiovascular and cerebrovascular physiology. NREM sleep is generally characterized by reduced sympathetic activity, blood pressure, and heart rate, whereas REM sleep is associated with increased brain activity and greater fluctuations in autonomic activity. The balance between these sleep stages is essential for maintaining optimal neurological function. Disruption of sleep architecture may impair vascular regulation, reduce cognitive function, and hinder neural tissue recovery, particularly in individuals with cerebrovascular disorders such as stroke (Rissardo et al., 2025). A normal sleep cycle lasts approximately 90–110 minutes and recurs four to five times during the night. N3 sleep is more predominant during the early part of the night, whereas REM sleep progressively increases in duration during subsequent cycles toward morning. This pattern is important for maintaining cognitive function, learning processes, emotional regulation, and physiological recovery (Chokroverty & Ferini-Strambi, 2017).

Various neuroendocrine changes occur during sleep and support its restorative functions. Sleep, particularly slow-wave sleep, is associated with increased secretion of growth hormone, which contributes to tissue growth, protein synthesis, neuroprotection, and neuroplasticity. Sleep is also associated with increased secretion of melatonin and prolactin, accompanied by reduced sympathetic nervous system activity and suppression of the hypothalamic-pituitary-adrenal axis. These changes result in lower levels of cortisol, epinephrine, and norepinephrine, creating a physiological environment that supports tissue repair and neurological recovery (Chennaoui et al., 2020). Sleep also plays an important role in cognitive function. It contributes to memory consolidation, learning, attention, and executive function. Disturbances in sleep quality or quantity may impair neurogenesis, synaptic plasticity, and hippocampal function, resulting in reduced cognitive performance. Therefore, adequate sleep is an important component of neurological health and supports recovery following injury to the nervous system, including stroke (Chennaoui et al., 2020). When these physiological processes are disrupted by stroke lesions, a series of pathophysiological changes may occur, as described in the following section.

Discussion

Pathophysiology

Sleep disorders in patients with stroke occur through structural and functional changes in the central nervous system that affect normal sleep regulation. Stroke may disrupt sleep architecture by altering sleep stages, including prolonged non-rapid eye movement (NREM) sleep,

reduced rapid eye movement (REM) sleep, decreased sleep efficiency, and reduced total sleep time. These changes result from brain tissue damage affecting sleep-regulatory centers, leading to sleep fragmentation and reduced sleep quality (Chen et al., 2024). Stroke may also cause circadian rhythm disturbances through damage to the biological systems that regulate the sleep-wake cycle, including the suprachiasmatic nucleus (SCN) and clock-gene mechanisms. These disturbances may result in desynchronization of normal physiological rhythms, including alterations in circadian blood pressure patterns, impaired melatonin secretion, and disruption of the sleep-wake cycle, contributing to insomnia, difficulty maintaining sleep, and excessive daytime sleepiness (Kim et al., 2022). Post-stroke circadian rhythm disturbances have also been associated with altered biological regulation of the sleep-wake cycle resulting from central nervous system damage (Chen et al., 2024).

The location of a stroke lesion may also influence the development of sleep disorders. Damage to brain regions involved in sleep regulation, such as the thalamus, hypothalamus, brainstem, basal ganglia, frontal lobe, and reticular activating system, may disrupt the neural pathways involved in sleep-wake regulation, resulting in various sleep disorders, including insomnia, hypersomnia, and disturbances of specific sleep stages (Rissardo et al., 2025). Thalamic lesions may cause disturbances in slow-wave sleep, whereas brainstem lesions are more frequently associated with abnormalities in REM sleep (Chen et al., 2024).

Sleep disorders in patients with stroke are also frequently associated with sleep-disordered breathing, particularly obstructive sleep apnea (OSA) and central sleep apnea (CSA). In OSA, recurrent upper airway obstruction during sleep causes episodes of apnea or hypopnea, resulting in intermittent hypoxia, hypercapnia, sleep fragmentation, and changes in intrathoracic pressure (Hoang-Anh et al., 2023). These changes trigger sympathetic nervous system activation, oxidative stress, systemic inflammation, endothelial dysfunction, and alterations in cerebral hemodynamics, which may exacerbate neurological injury and hinder post-stroke recovery (Joza & Boulos, 2024). In contrast, CSA may result from dysfunction of respiratory regulatory centers in the central nervous system, leading to unstable ventilatory control characterized by alternating central apnea and hyperventilation, resulting in sleep fragmentation and reduced sleep quality.

In addition to structural and respiratory changes, stroke may cause cerebral hemodynamic disturbances and neurochemical alterations that are involved in sleep regulation. Cerebral ischemia may impair brain tissue perfusion, cause neurovascular unit dysfunction, and alter cerebral blood flow regulation, thereby disrupting the homeostasis of the brain microenvironment during sleep (Chen et al., 2024). Brain tissue damage may also disturb the balance of neurotransmitters involved in sleep regulation, including serotonin, norepinephrine, melatonin, and orexin. Reduced serotonin and melatonin levels may contribute to difficulties in sleep initiation and maintenance, whereas increased orexin activity may promote a state of hyperarousal that makes sleep more difficult (Chen et al., 2024).

Post-stroke inflammatory responses also contribute to the development of sleep disorders. Activation of microglia and astrocytes, accompanied by the release of inflammatory mediators such as interleukin-1β (IL-1β), interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP), may disrupt sleep homeostasis, affect NREM and REM sleep, and exacerbate sleep fragmentation (Chen et al., 2024). Thus, sleep disorders in patients with stroke result from multifactorial interactions among neurological injury, respiratory disturbances, neurochemical alterations, cerebral hemodynamic disturbances, and post-stroke inflammatory responses. These pathophysiological mechanisms ultimately manifest as diverse clinical forms of sleep disorders, as described in the following classification.

Classification

Sleep disorders are a heterogeneous group of conditions that affect sleep quality, quantity, or timing. In general, sleep disorders include insomnia, sleep-related breathing disorders, central disorders of hypersomnolence, circadian rhythm sleep-wake disorders, sleep-related movement

disorders, and parasomnias (Miller & Howarth, 2023). In patients with stroke, various sleep disorders may occur as a direct consequence of central nervous system damage or as a result of comorbid conditions. These disorders are not limited to sleep-related breathing disturbances but also include difficulties initiating or maintaining sleep, disturbances in sleep-wake regulation, and abnormal movements during sleep, all of which may affect quality of life, rehabilitation, and clinical outcomes (Hasan et al., 2021).

Various studies have shown that the most frequently encountered sleep disorders in patients with stroke include sleep-disordered breathing (SDB), insomnia, excessive daytime sleepiness or hypersomnia, restless legs syndrome (RLS), periodic limb movement disorder (PLMD), circadian rhythm disorders, and rapid eye movement (REM) sleep behavior disorder (RBD) (Chen et al., 2024). These six groups are described below. Sleep-disordered breathing is the most frequently encountered group of sleep disorders in patients with stroke. It is characterized by abnormal respiratory patterns during sleep that result in intermittent hypoxia, sleep fragmentation, and impaired sleep quality. The main forms of sleep-disordered breathing are obstructive sleep apnea (OSA) and central sleep apnea (CSA) (Hasan et al., 2021). OSA results from upper airway obstruction during sleep, whereas CSA results from impaired respiratory control within the central nervous system (Joza & Boulos, 2024).

Insomnia is a sleep disorder characterized by difficulty initiating or maintaining sleep, early morning awakening, or sleep that is not restorative. It is one of the most common non-respiratory sleep disorders in patients with stroke and may arise from neurological injury, psychological disturbances, or environmental factors during care and rehabilitation (Chen et al., 2024). This group is characterized by excessive daytime sleepiness or an increased need for sleep. In patients with stroke, these disorders may result from lesions involving brain structures responsible for maintaining wakefulness, such as the thalamus, hypothalamus, and brainstem (Chen et al., 2024). Sleep-related movement disorders are characterized by abnormal movements during sleep that may cause sleep fragmentation. The disorders most commonly reported in patients with stroke are restless legs syndrome (RLS) and periodic limb movement disorder (PLMD) (Hasan et al., 2021). Restless legs syndrome is characterized by a strong urge to move the legs, usually accompanied by uncomfortable sensations, whereas periodic limb movement disorder is characterized by repetitive and stereotyped limb movements during sleep.

Circadian rhythm sleep-wake disorders result from a misalignment between the internal biological rhythm and the expected sleep-wake cycle. In patients with stroke, these disorders may occur because of damage to brain structures involved in circadian rhythm regulation or changes in activity patterns during care and rehabilitation (Chen et al., 2024). Parasomnias are a group of sleep disorders characterized by abnormal behaviors, experiences, or phenomena occurring during sleep. In patients with stroke, one of the most frequently reported forms is rapid eye movement (REM) sleep behavior disorder, in which physiological muscle atonia during REM sleep is lost, resulting in movements that correspond to the content of dreams (Chen et al., 2024). The six groups of sleep disorders described above have distinct and overlapping clinical manifestations, as discussed in the following section.

Clinical Manifestations

The clinical manifestations of sleep disorders in patients with stroke vary considerably depending on the type of sleep disorder, cerebral lesion location, stroke severity, and accompanying comorbidities. Symptoms may occur during nighttime sleep or manifest as daytime functional disturbances that affect quality of life, cognitive function, and the post-stroke rehabilitation process (Pérez-Carbonell & Bashir, 2020). Patients with sleep-disordered breathing commonly experience loud snoring, witnessed episodes of sleep apnea, sudden awakenings due to choking or shortness of breath, non-restorative sleep, morning headaches, and excessive daytime sleepiness. In patients with stroke, these disorders may contribute to fatigue, impaired concentration, and poorer neurological recovery (Joza & Boulos, 2024). Post-stroke insomnia is characterized by difficulty initiating or maintaining sleep, frequent nighttime awakenings, early morning awakening, or non-restorative sleep. These complaints are often accompanied by fatigue,

impaired concentration, reduced memory, irritability, and impaired daily functioning. Insomnia is also frequently associated with depression, anxiety, chronic pain, and environmental factors during care (Liao et al., 2026).

Excessive daytime sleepiness is characterized by excessive sleepiness during the day, causing patients to fall asleep easily during daily activities. In more severe cases, hypersomnia may occur, characterized by a substantially increased need for sleep. Patients may experience difficulty maintaining alertness, reduced attention, impaired concentration, and decreased performance in daily activities (Chen et al., 2024). Restless legs syndrome is characterized by a strong urge to move the legs, usually accompanied by uncomfortable sensations such as tingling, pulling, burning, or other unpleasant feelings in the legs. Symptoms typically worsen during rest and at night and improve with movement. In contrast, periodic limb movement disorder is characterized by repetitive and involuntary limb movements during sleep, which may cause sleep fragmentation and reduce sleep quality (Hasan et al., 2021).

Circadian rhythm disorders may manifest as changes in sleep-wake patterns, difficulty sleeping at the expected time, frequent nighttime awakenings, or excessive sleepiness at inappropriate times. Patients may also experience impaired concentration, fatigue, and reduced social and daily functioning due to a mismatch between the internal biological rhythm and the external environment (Kim et al., 2022). Parasomnias in patients with stroke may present as abnormal behaviors occurring during sleep. One of the commonly reported forms is rapid eye movement sleep behavior disorder, which is characterized by loss of physiological muscle atonia during REM sleep, allowing patients to talk, shout, kick, strike, or perform other movements corresponding to dream content. This condition may potentially cause injury to the patient or bed partner (Chen et al., 2024).

In addition to manifestations specific to each type of sleep disorder, stroke patients with sleep disorders commonly experience general symptoms such as fatigue, reduced quality of life, impaired cognitive function, memory disturbances, mood changes, reduced participation in rehabilitation, and impaired daily activities. Therefore, early identification of sleep-related symptoms is important as part of a comprehensive evaluation of patients with stroke (Pérez-Carbonell & Bashir, 2020). The diversity of these clinical manifestations necessitates a systematic diagnostic approach, as described in the following section.

Diagnosis

The diagnosis of sleep disorders in patients with stroke is based on a combination of history taking, clinical evaluation, screening instruments, and ancillary examinations when indicated. Evaluation of sleep disorders is important because many cases remain undiagnosed despite their potential effects on rehabilitation, cognitive function, and quality of life in post-stroke patients (Joza & Boulos, 2024). History taking is the initial step in the diagnosis of sleep disorders in patients with stroke. The evaluation includes the patient's sleep pattern, sleep duration, sleep quality, difficulty initiating or maintaining sleep, frequency of nocturnal awakenings, feeling refreshed upon awakening, and the presence of excessive daytime sleepiness. A history of snoring, witnessed episodes of sleep apnea, repetitive limb movements during sleep, and abnormal behaviors during sleep should also be assessed (Pérez-Carbonell & Bashir, 2020). In addition, factors that may affect sleep, such as depression, anxiety, pain, medication use, comorbidities, and environmental conditions that may impair sleep quality, should be evaluated (Liao et al., 2026).

Comprehensive history taking should be complemented by standardized screening instruments and objective ancillary examinations to improve diagnostic accuracy. Subjective sleep quality can be assessed using the Pittsburgh Sleep Quality Index (PSQI), which evaluates sleep quality over the preceding month, with higher scores indicating poorer sleep quality (Zhang et al., 2023). Excessive daytime sleepiness can be assessed using the Epworth Sleepiness Scale (ESS), which measures the likelihood of falling asleep in various everyday situations and is commonly used to evaluate excessive daytime sleepiness and suspected sleep-disordered

breathing (Joza & Boulos, 2024). In patients suspected of having obstructive sleep apnea (OSA), screening questionnaires such as the STOP-BANG Questionnaire and the Berlin Questionnaire can be used to identify individuals at high risk of sleep-related breathing disorders (Rissardo et al., 2025).

Polysomnography (PSG) is the gold standard for the diagnosis of various sleep disorders, particularly sleep-disordered breathing (Pérez-Carbonell & Bashir, 2020). It records multiple physiological parameters during sleep, including electroencephalographic activity, eye movements, muscle activity, cardiac rhythm, airflow, respiratory effort, and oxygen saturation, allowing identification of obstructive sleep apnea, central sleep apnea, periodic limb movement disorder, sleep architecture abnormalities, and various forms of parasomnia (Joza & Boulos, 2024). In addition to polysomnography, actigraphy can be used to assess sleep-wake patterns and circadian rhythm disturbances over longer periods using a portable device that records motor activity for several days to several weeks (Kim et al., 2022). In patients with suspected post-stroke cognitive impairment associated with sleep disturbances, neuropsychological assessment may be performed to evaluate memory, attention, and executive function that may be affected by poor sleep quality (Zhang et al., 2023).

The choice of screening instruments and ancillary examinations should be tailored to the suspected type of sleep disorder being evaluated. A summary of the instruments, their assessment targets, and key characteristics is presented in Table II to facilitate appropriate selection of diagnostic modalities in clinical practice.

Table 2. Screening Instruments and Ancillary Examinations for the Evaluation of Sleep Disorders in Stroke Patients.

Instrument/Examination	Assessment Target	Key Characteristics	Source
Pittsburgh Sleep Quality Index (PSQI)	Subjective sleep quality	Assesses sleep quality over the previous month; higher scores indicate poorer sleep quality	Zhang et al., 2023
Epworth Sleepiness Scale (ESS)	Excessive daytime sleepiness	Measures the likelihood of falling asleep in various everyday situations; often used as an initial screening tool for sleep-disordered breathing	Joza & Boulos, 2024
STOP-BANG Questionnaire	Risk of obstructive sleep apnea	Screening questionnaire for identifying individuals at high risk of sleep-related breathing disorders	Rissardo et al., 2025
Berlin Questionnaire	Risk of obstructive sleep apnea	Screening questionnaire for identifying individuals at high risk of sleep-related breathing disorders	Rissardo et al., 2025
Polysomnography (PSG)	OSA, CSA, PLMD, sleep architecture, and parasomnias	Gold standard; records electroencephalography, eye movements, muscle activity, cardiac rhythm, airflow, and oxygen saturation	Pérez-Carbonell & Bashir, 2020; Joza & Boulos, 2024
Actigraphy	Sleep-wake patterns and circadian rhythm disturbances	Portable device that records motor activity over several days to weeks	Kim et al., 2022

Based on Table 2, screening instruments such as the PSQI, ESS, STOP-BANG Questionnaire, and Berlin Questionnaire are practical and easy to implement during the initial evaluation because

they are questionnaire-based and do not require specialized equipment, making them suitable for initial screening in inpatient and outpatient settings. In contrast, polysomnography and actigraphy are objective examinations that provide more detailed physiological data but require specialized equipment and access to sleep laboratory services, which may not be uniformly available across healthcare facilities. Therefore, a stepwise diagnostic approach beginning with history taking and screening questionnaires, followed by objective examinations when indicated, may represent the most efficient strategy in routine clinical practice.

Definitive diagnosis is established based on clinical criteria and the results of ancillary examinations according to the type of sleep disorder identified. In insomnia, the diagnosis is based on difficulty initiating or maintaining sleep accompanied by daytime functional impairment. In sleep-disordered breathing, the diagnosis is determined by polysomnographic findings, particularly the apnea-hypopnea index (AHI), which is used to determine the severity of the disorder. Meanwhile, the diagnosis of restless legs syndrome, periodic limb movement disorder, hypersomnia, and circadian rhythm disorders is based on a combination of clinical symptoms and appropriate objective examinations (Pérez-Carbonell & Bashir, 2020). Once the diagnosis has been established, appropriate management based on the type and severity of the sleep disorder should be initiated, as described in the following section.

Management

Non-Pharmacological Management

Non-pharmacological approaches are recommended as initial therapy, particularly in patients with post-stroke insomnia. Cognitive behavioral therapy for insomnia (CBT-I) is considered a first-line treatment aimed at modifying maladaptive thoughts and behaviors that contribute to sleep disturbances (Chen et al., 2024). This intervention includes stimulus control, sleep restriction, cognitive restructuring, and relaxation techniques to improve sleep quality (Liao et al., 2026). Education on healthy sleep habits, or sleep hygiene, also plays an important role in the management of post-stroke sleep disorders (Chen et al., 2024). Such education includes maintaining a regular sleep schedule, avoiding caffeine or stimulants before bedtime, limiting the use of electronic devices before sleep, and creating a comfortable and conducive sleep environment (Liao et al., 2026). In addition, light therapy and increased daytime physical activity may help improve circadian rhythm disturbances that are frequently observed in patients with stroke (Rissardo et al., 2025).

In patients with sleep-disordered breathing, particularly obstructive sleep apnea (OSA), continuous positive airway pressure (CPAP) is the primary recommended therapy (Chen et al., 2024). CPAP maintains upper airway patency during sleep, thereby reducing episodes of apnea and hypopnea, improving oxygenation, and reducing sleep fragmentation (Chen et al., 2024). The use of CPAP in stroke patients with OSA has been shown to improve excessive daytime sleepiness and quality of life (Joza & Boulos, 2024). CPAP therapy has also been associated with improved post-stroke neurological recovery and may potentially reduce the risk of long-term cardiovascular complications (Rissardo et al., 2025).

Another important component of non-pharmacological management is the optimization of daytime activities and rehabilitation programs. Stroke survivors may experience reduced physical activity, prolonged daytime napping, and irregular daily routines, all of which can negatively affect nocturnal sleep and circadian regulation. Therefore, rehabilitation programs should incorporate appropriate daytime physical activity, exposure to natural light, and structured daily routines according to the patient's functional capacity. Avoiding prolonged daytime naps and encouraging regular social and rehabilitative activities may further promote sleep consolidation at night. These interventions are particularly relevant because sleep disturbances after stroke are often influenced by a combination of neurological impairment, reduced mobility, environmental factors, and changes in daily routines.

Pharmacological Therapy

Pharmacological therapy may be considered when sleep-related symptoms persist despite adequate non-pharmacological interventions (Chen et al., 2024). Agents that may be used include melatonin and melatonin receptor agonists, particularly in patients with circadian rhythm disturbances or reduced melatonin secretion after stroke (Chen et al., 2024). Other options for selected conditions include benzodiazepines, non-benzodiazepine hypnotics, and dual orexin receptor antagonists (DORAs) (Liao et al., 2026). However, these medications should be used cautiously because they may cause excessive sedation, cognitive impairment, increased fall risk, and interactions with other therapies being used by stroke patients (Liao et al., 2026).

In addition to interventions directly targeting sleep disorders, management of associated factors and comorbidities is an important component of treatment (Liao et al., 2026). Depression, anxiety, chronic pain, nocturia, and sleep-related breathing disorders may contribute to the development or persistence of post-stroke sleep disorders and therefore should be appropriately identified and managed (Liao et al., 2026). A multidisciplinary approach involving neurologists, rehabilitation physicians, psychiatrists, psychologists, other healthcare professionals, and the patient's family is required to achieve optimal treatment outcomes (Chen et al., 2024). Comprehensive management may improve sleep quality, thereby supporting rehabilitation, improving quality of life, and optimizing long-term prognosis. The success of this approach ultimately contributes to the patient's prognosis, as discussed in the following section.

Prognosis

Sleep disorders in patients with stroke are associated with poorer clinical outcomes in both the short and long term. Hasan et al. (2021) reported that undiagnosed or untreated sleep disorders may hinder optimal neurological recovery and increase the risk of recurrent stroke. Similarly, Rissardo et al. (2025) reported that sleep disorders in stroke patients are associated with slower neurological recovery, reduced quality of life, and an increased risk of poor clinical outcomes. Jeffers et al. (2023) also showed that sleep disorders may reduce quality of life, increase post-stroke fatigue, and interfere with the rehabilitation process. Obstructive sleep apnea (OSA), one of the most common sleep disorders in patients with stroke, is closely associated with stroke severity and poorer functional outcomes. Hoang-Anh et al. (2023) found a positive correlation between OSA severity based on the apnea-hypopnea index (AHI) and National Institutes of Health Stroke Scale (NIHSS) and modified Rankin Scale (mRS) scores, indicating that greater severity of sleep-related breathing disorders was associated with more severe neurological deficits and greater disability. In addition, Joza and Boulos (2024) reported that stroke patients with OSA tended to require longer rehabilitation and had less optimal functional recovery.

In addition to affecting neurological function and rehabilitation, sleep disorders also affect cognitive function after stroke. Zhang et al. (2023) reported that both short nighttime sleep duration (<7 hours) and long sleep duration (>8 hours) were risk factors for post-stroke cognitive impairment. In that study, sleeping less than 7 hours was associated with an increased risk of cognitive impairment at both 6 months and 4 years after stroke. Zhang et al. (2023) also found that poor sleep quality and daytime sleepiness were associated with long-term cognitive impairment in patients with stroke.

4. CONCLUSION

Sleep disorders are common non-motor complications in patients with stroke and encompass a broad spectrum, particularly sleep-disordered breathing, insomnia, and circadian rhythm sleep-wake disorders. Their occurrence is influenced by interactions among damage to brain structures and networks involved in sleep regulation, respiratory disturbances, neurochemical and hemodynamic alterations, inflammation, comorbidities, psychological factors, and environmental factors during care. Sleep disorders in patients with stroke are associated with impaired cognitive function, reduced quality of life, suboptimal rehabilitation, and poorer clinical outcomes and should therefore be considered an important component of stroke evaluation and management.

Early identification through history taking and appropriate screening instruments, followed by diagnostic evaluation based on the suspected type of sleep disorder, is necessary to determine appropriate management. Treatment should be individualized and multidisciplinary, incorporating non-pharmacological and pharmacological interventions as indicated and integrating them with stroke rehabilitation. Nevertheless, evidence regarding the effectiveness of sleep disorder interventions on long-term neurological outcomes remains limited. Further longitudinal studies and clinical trials, particularly in post-stroke populations in Indonesia, are needed to strengthen the evidence regarding strategies for screening, diagnosis, and management of sleep disorders and their effects on recovery and quality of life in stroke patients

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