CHAPTER 39

Sleep disorders in neurodegenerative disorders and stroke


1 Glostrup Hospital, University of Copenhagen, Denmark; 2 Hospital Clinic of Barcelona, Spain; 3 University Hospital Zurich, Switzerland; 4 Evangelisches Johannes-Krankenhaus, Germany; 5 Medical University of Innsbruck, Austria; 6 University Hospital, Inselspital, Bern, Switzerland; 7 CHU Sart Tilman, Liège, Belgium; 8 Charles University of Prague, Czech Republic; 9 Division of Clinical Neurophysiology, Linköping, Sweden; 10 University Medical Centre, Ljubljana, Slovenia; 11 Dokuz Eylül University, Izmir, Turkey; 12 Hôpital de la Ville, Luxembourg; 13 Palia Pendeli Children’s Hospital, Athens, Greece; 14 High Medical School, Plovdiv, Bulgaria

The current guideline will focus on neurodegenerative disorders and stroke, with an emphasis on sleep breathing disorders in neurological disease, and is an update from a former review [1] in accordance to European Federation of Neurological Societies (EFNS) guidelines [2].

The review will cover three main areas:

1. tauopathies (Alzheimer’s disease, progressive supranuclear palsy, and corticobasal degeneration);
2. synucleinopathies (Parkinson’s disease, multiple system atrophy [MSA], and dementia with Lewy bodies [DLB]);
3. stroke, amyotrophic lateral sclerosis (ALS), myotonic dystrophy, myasthenia gravis, and spinocerebellar ataxias.

Search strategy

The literature search included PUBMED and the Cochrane Database. These were searched until 2009 or over as much of this range as possible, looking for the different sleep disorders and symptoms in each of the most frequent or relevant degenerative neurological disorders and stroke. Language of writing was restricted to European languages. Studies considered for inclusion were, when possible, randomized controlled trials of adult patients, in any setting, suffering a neurodegenerative disorder (motor neuron disease, Parkinson’s disease, Alzheimer’s disease) or stroke. There had to be an explicit...
Sleep Disorders

Complaints of insomnia, parasomnia, or hypersomnia in the study participants. We also included observational studies. Abstracts were selected by the chairmen and independently inspected by individual members of the task force; full papers were obtained where necessary. A classification of the different studies according to evidence levels for therapeutic interventions and diagnostic measures will be done in accordance with the guidance [2]. The panel will discuss what possible diagnostic tests and health care interventions could be recommended in each particular disease.

Method for reaching consensus

Where there was uncertainty, further discussion was sought by the panel. Data extraction and quality assessments were undertaken independently by the panel reviewers.

Sleep disorders

Classification of sleep disorders

The International Classification of Sleep Disorders version 2 (ICSD-2) lists 95 sleep disorders [3]. The ISCD-2 has eight major categories:

1. Insomnias
2. Sleep-related breathing disorders
3. Hypersomnias not due to a sleep-related breathing disorder
4. Circadian rhythm sleep disorders
5. Parasomnias
6. Sleep-related movement disorders
7. Isolated symptoms
8. Other sleep disorders.

Only a selected number of the sleep disorders related to neurological diseases will be mentioned in this paper.

Insomnia

Insomnias are defined by a complaint of repeated difficulties with sleep initiation, sleep maintenance, duration, consolidation, or quality that occurs despite adequate time and opportunity for sleep, and that result in some form of daytime impairment.

Insomnias can be divided into acute and chronic forms. The acute form, also termed adjustment insomnia, can usually be attributed to a well-defined circumstance, while chronic insomnia is often a consequence of conditional (psychophysiological) factors, is idiopathic, or is found in patients with psychiatric, medical, or neurological disorders. The latter may be due to degeneration or dysfunction of the central nervous system areas involved in sleep regulation, or due to motor or sensory symptoms produced by the disease (pain, reduced nocturnal mobility, nocturnal motor activity, etc.) that lower the threshold for arousal from sleep. Finally, insomnia may be caused by the alerting effects of the drugs employed in the treatment of neurological diseases.

Sleep-disordered breathing (SDB)

These disorders are characterized by disordered breathing during sleep. A uniform syndrome recommendation was suggested in 1999 by the American Academy of Sleep Medicine [4], which is included in ICSD-2:

1. Obstructive sleep apnoea syndrome (OSAS)
2. Central sleep apnoea–hypopnoea syndrome (CSAHS)
3. Cheyne–Stokes breathing syndrome (CSBS)
4. Sleep-related hypoventilation/hypoxaemic syndromes (SHVS).

For a more thorough review of SDB, see the EFNS guideline [1].

EDS not due to a sleep-related breathing disorder

Hypersomnias (EDS) is defined by the inability to stay fully alert and awake during the day, resulting in unintended lapses into sleep. EDS should be separated from fatigue, which refer to physical or mental weariness. The most common disorders in this group are narcolepsy, idiopathic hypersomnia, insufficient sleep, and the use of sedating medication. EDS is also commonly reported in patients with neurological disease including neurodegeneration, post-stroke, inflammation, tumour, injury, or brain trauma, and may be caused by degeneration of the sleep-wake centres, sleep fragmentation, or medication. Hypersomnia in a narrow sense is describing a prolonged major sleep episode, usually beyond 10 hours. This phenomenon is typical in ‘idiopathic hypersomnia with prolonged sleep time’, but is also reported in ‘non-organic hypersomnia’ (ISCD-2). The diagnostic work-up should always consider the possibility of sleep insufficiency syndrome or poor sleep hygiene.
b. abnormal REM sleep behaviours documented during polysomnography (PSG) monitoring;
• an absence of electroencephalographic (EEG) epileptiform activity during REM sleep unless RBD can be clearly distinguished from any concurrent REM sleep-related seizure disorder;
• the sleep disturbance not being better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use or substance use disorder.

The patient and those sharing the bed can be injured. RBD is observed in the majority of patients with MSA, in DLB, and in a significant proportion of patients with Parkinson’s disease. RBD is also commonly observed in diffuse Lewy body (DLB) and Machado–Joseph disease [8–19]. Patients with isolated RBD have a significant risk of developing Parkinson’s disease, DLB, or MSA, especially if other brainstem manifestations such as changes reduced smell, depression, mild cognitive impairment, or incontinence are present [6, 10, 20]. The occurrence of hallucinations in Parkinson’s disease is related to the presence of RBD [8]. Reduced striatal dopamine transporters have been observed in these patients [21]. RBDs are strongly linked to narcolepsy with cataplexy, especially in patients with hypocretin deficiency [22], and are further observed in a number of other diseases, for example stroke and multiple sclerosis. A confident diagnosis relies on a full PSG recording, preferably with a synchronized audiovisual recording.

There is a need for further clarification of the EMG abnormalities in RBD, with special emphasis on muscle tone, motor activity (number of movements, duration, and intensity), and their relation to sleep stages. These are currently undergoing clarification and evaluation.

Sleep-related movement disorders
Sleep-related movement disorders are characterized by relatively simple, usually stereotypic movements that disturb sleep to complex movements of different intensity, duration and periodicities or lack of it. Periodic limb movements (PLM), restless legs syndrome (RLS), bruxism, leg cramps, rhythmic movement disorders and other sleep-related movement disorders are classified under this group. Of these RLS and PLM are of particular interest in patients with neurodegenerative disorders. Of special focus is subdivision into different types of stage dependent movements during sleep, as observed in the
majority of neurodegenerative disorders, RBD and in
patients with narcolepsy with cataplexy. This area is cur-"...

Sleep disorders associated with neurological disease

Tauopathies
Patients with progressive supranuclear palsy, Alzheimer’s
disease, and corticobasal degeneration may complain of
significant sleep-related circadian disturbances, as well as
delay–wake and daytime problems [5, 23–29].
• Sleep/wake disturbances and disruption are commonly
observed in Alzheimer’s disease, with daytime sleep, sleep
attack and episodes of microsleep.
• Insomnia (sleep fragmentation and difficulties maintain-
ing sleep) is common, as are nocturnal wandering,
nocturnal confusion, ‘sundowning’ psychosis, and
nocturia.
• EDS, sleep attacks, and episodes of microsleep during
the daytime may be associated with cognitive problems.
• Sleep-related disorders such as RBD, RLS, PLMS,
nocturnal complex and dystonic movements, and cramps
may occur in progressive supranuclear palsy and cortico-
basal degeneration, but are rare in Alzheimer’s disease.
• Sleep breathing disorders are common in Alzheimer’s
disease and are associated with disease progression and
a poorer prognosis; however, the clinical significance of
diagnosing and treating them in this group of patients is
questionable.

Recommendations
Sleep disorders are commonly observed in patients with
tauopathies, and there should be an increased awareness of
these disorders. It is recommended to perform a detailed
medical history of sleep disorders in tauopathies, i.e.
insomnia, EDS, motor and dreaming activity, and SDB. PSG
recording, preferably with audiovisual recording, is suggested
for the diagnosis, especially when RBD and/or SDB is
suspected disorders (Level C).

Synucleinopathies
Parkinson’s disease, MSA, and DLB are often associated
with major sleep–wake disorders [13, 17, 28, 30–38]:
• Parkinson’s disease-related motor symptoms including
nocturnal akinesia, early-morning dystonia, painful
cramps, tremor, and difficulties turning in bed;
• treatment-related nocturnal disturbances (e.g. insom-
nia, confusion, hallucinations, and motor disturbances);
• sleep-related symptoms such as hallucinations and
vivid dreams (nightmares), insomnia (sleep fragmenta-
tion and difficulties maintaining sleep), nocturia, psy-
chosis, and panic attacks;
• EDS, sleep attacks, and episodes of microsleep during
waking hours;
• sleep-related disorders including RBD, RLS, PLMS,
nocturnal dystonic movements, cramps, and SDB. The
presence of RBD in Parkinson’s disease is associated with
cognitive and autonomic changes;
• laryngeal stridor and obstructive sleep apnoea, which
are commonly observed in patients with MSA and are
associated with a poorer prognosis. Continuous positive
airway pressure (CPAP) ventilation may improve respira-
tion and prognosis (Class III).

Recommendations
The majority of patients with synucleinopathies experience
one or more sleep disorders. It is recommended to perform a
detailed medical history of sleep disorders in tauopathies, i.e.
insomnia, EDS, motor, and dreaming activity, and SDB PSG
recording, preferably with audiovisual recording, is suggested
for the diagnosis, especially when RBD and/or SDB is
suspected (Level B).

Stroke
Patients with strokes, primarily infarctions, may suffer
from several sleep disorders and disturbances. Their
occurrence and manifestations may vary depending on
the specific neurological deficits [39–50]:
• SDB, especially OSAS and nocturnal oxygen desatur-
tions, have commonly (>50%) been found in patients
with acute stroke as well as after neurological recovery.
OSAS is a risk factor for stroke, and co-existing OSAS in
stroke patients may increase the risk of a further stroke.
The presence of SDB, especially OSAS, may worsen the
prognosis and increase the stroke re-occurrence risk. SDB
may be provoked by stroke, especially, after damage to the
respiratory centres in the brainstem or bulbar/
pseudobulbar paralysis due to brainstem. Pre-existing
sleep apnoea prior to stroke may present a risk factor for
stroke, with comorbid obesity, diabetes, coronary artery
disease and hypertension, and other cerebrovascular risk factors. There are several haemodynamic changes in sleep apnoea that may play a role in the pathogenesis of stroke development. Stroke and SDB are both common and are associated with significant morbidity and mortality.

- CPAP treatment for OSAS in may reduce the risk of cardio- and cerebrovascular complications (Class I) and potential re-occurrence of stroke, but the compliance is poor to moderate compared with the compliance in OSAS patients who have not had a stroke (B).
- Sleepiness and fatigue are commonly reported in patients after stroke and are often disabling symptoms.
- Other sleep disorders, such as insomnia, RBD, and PLMS, may be observed as part of or after stroke.

**Recommendations**

Sleep disorders, especially SDB, occur often in stroke patients. Screening for SDB and other sleep disorders is recommended as part of the stroke evaluation programme, especially in ischaemic stroke patients (Level A).

**Motor neuron, motor end plate, and muscle diseases**

SDB is observed in several neuromuscular diseases, including muscular dystrophy, myotonic dystrophy, myasthenia gravis, ALS, and post-polio syndrome. Although there may be differences, some general observations can be made. Hypoxaemia, especially during REM sleep, is commonly found. Severity is correlated to respiratory strength, and sleep-related hypoventilation is usually non-obstructive [51, 52].

Patients with ALS and other severe motor neuron diseases have progressive motor deterioration with progressive respiratory insufficiency. This may manifest primarily during sleep, where the motor drive is reduced. This is especially true for patients with the bulbar form of ALS or involvement of C3–C5 in the anterior horn [53, 54]. The prognosis is closely related to respiratory muscle strength [55]. Of note, sudden nocturnal death often occurs during sleep. Respiratory indices such as low nocturnal oxygen saturation are associated with a poorer prognosis [56, 57]. Patients with diaphragmatic involvement may have significantly reduced REM sleep [58]. The primary SDB in patients with ALS – as in other neuromuscular diseases – is therefore a sleep hypoventilation syndrome (SHVS), whereas OSAS is rare [53].

Management of these patients should therefore include relevant questions regarding symptoms suspicious for SDB. Common symptoms of nocturnal hypoventilations include insomnia, headache, and daytime somnolence [59].

Oximetry has been suggested for the identification of and screening for sleep-related hypoventilation in patients with ALS, but its value is limited to identifying nocturnal desaturations that may occur during non-REM and REM sleep [57, 60, 61]. Care should be taken because pCO may increase before desaturations are observed, especially in patients with additional chronic obstructive lung disease. Nocturnal oximetry has been suggested as valuable for screening and for evaluating the treatment effect [53, 57]. There has been no validation of the diagnostic yield between a full PSG, respiratory polygraphy, and nocturnal oximetry in these patients. It is, however, important to identify early symptoms of respiratory failure in sleep, as these patients are able to compensate their hypercapnia during wakefulness for a long time. This is the at which one should bring in a regular measurement of respiratory parameters [62–66].

**Recommendations**

SDB often occurs in patients with motor neuron, motor end plate, and muscle diseases, and should be considered in all patients. Minimum evaluation should include PSG eventually combined with additional carbon dioxide analysis, and eventually supplied with serial polygraphy or oximetry measures for the identification of sleep-related hypoventilation during the disease course (Level B).

**Genetic neurodegenerative disorders**

Other neurodegenerative disorders of genetic cause may present several sleep disturbances. Subjects with SCA-3 (Machado–Joseph disease) may also complain of RLS, periodic leg movements, vocal cord paralysis, and RBD [9, 11, 18, 67, 68]. In patients with Huntington’s disease, the involuntary movements tend to diminish during sleep [69]. Sleep disturbances, including disturbed sleep...
pattern with an increased sleep onset latency, reduced sleep efficiency, frequent nocturnal awakenings, and more time spent awake with less slow wave sleep, have been reported. These abnormalities correlate in part with the duration of illness, severity of clinical symptoms, and degree of atrophy of the caudate nucleus [70]. The sleep phenotype of Huntington’s disease may also include insomnia, advanced sleep phase, periodic leg movements, RBDs, and reduced REM sleep, but not narcolepsy. Reduced REM sleep may precede chorea. Mutant huntingtin may exert an effect on REM sleep and motor control during sleep [71]. However, other studies have not reported specific sleep disorders in Huntington patients [72].

Recommendations
Sleep disorders occur in several genetic neurological diseases. The patients should be questioned, and further evaluation of these disorders should rely on a clinical judgement (Level C).

Management of sleep disorders in neurological diseases

Diagnostic techniques in sleep disorders
Diagnostic procedures for sleep diagnosis include PSG, partial time PSG, partial polygraphy (or respiratory polygraphy), and limited channel polygraphy: oximetry determining arterial oxygen saturation/pulse and actimetry. Daytime sleepiness may be evaluated with the Multiple Sleep Latency Test (MSLT) or Maintenance of Wakefulness Test (MWT). Many of the tests are increasingly easy to perform in or outside hospital due to technological advantages. Consequently, diagnostic procedures may be more easily performed as part of the diagnostic program for neurological patients. An overview of these tests is presented in table 39.1.

Treatment of SDB in neurological diseases

Treatment of OSAS
CPAP is a well-documented treatment for moderate and severe OSAS (apnoea–hyperpnoea index ≥15/h) and improves nocturnal respiratory abnormalities, daytime function, and cognitive problems [73–78] (Class I). There is no significant difference regarding treatment effect or changes in subjective variables between fixed-pressure CPAP and auto-adjusted CPAP [79, 80] (Class I).

CPAP and bi-level positive airway pressure ventilation is potentially useful in patients with SDB in stroke [40], despite negative reports [81]. The evidence on whether this influences quality of life, daytime symptoms, rehabilitation, morbidity, and mortality is, however, limited, which needs further clarification [49] (Class II).

Severe SDBs, including laryngeal stridor in patients with MSA, may be treated with CPAP/bi-level CPAP. Recent studies suggest that treatment with CPAP for MSA patients with laryngeal stridor showed high CPAP tolerance, no recurrence of stridor, no major side effects, and a subjective improvement in sleep quality, and that there is an increased survival time for MSA patients without stridor [31, 82]. CPAP is therefore an effective, non-invasive, long-term therapy for nocturnal stridor (Level C) and may prevent worsening of stridor under increasing dopaminergic dosages.

In some patients, for example those with neuromuscular disorders, CPAP may be difficult to accept, and bi-level positive airway pressure ventilation may be used [83] (Class IV).

There is evidence suggesting that oral appliance use improves subjective sleepiness and SDB compared with controls in patients with OSAS without neurological disease (Level B). Nasal CPAP is apparently more effective in improving SDB than oral appliance use (Level B). There are no data regarding the use of oral appliances in patients with neurological diseases, so caution should be applied concerning the use of oral appliances in patients with OSAS [84, 85] (Level C).

Surgical treatment has a limited effect on OSA [86, 87] (Class III). There are no studies suggesting that surgery in the upper airway has any effect on OSAS in patients with neurological diseases.

Drug treatments have no positive effect on OSAS [88] (Class II). There is no study available indicating that medication has any treatment effect for OSAS in patients with neurological diseases.

Although some patients with OSAS present an increased weight and a negative lifestyle profile (in terms of tobacco, alcohol, and physical activity), no controlled
studies have evaluated the effect of intervention against these factors [89] (Class IV). No studies have addressed the effect of lifestyle interventions on OSAS in patients with neurological diseases.

**Treatment of CSAHS**

Case series have shown that CPAP treatment does not influence the carbon dioxide response in CSAHS, despite a reduction in apnoeas, an increase in \( p_aO_2 \), and a reduction in subjective sleepiness [90–92] (Class IV). Probably due to the rareness of the disease, there are no randomized studies regarding CSAHS and treatment. Drug treatment with acetazolamide and theophylline has furthermore been suggested [93], but the evidence for their use is poor (Class IV).

**Treatment of CSBS**

Initially, CPAP was used in patients with central apnoea/CSBS and cardiac insufficiency [94–97], but in recent years adaptive insufficiency [94–97], but in recent years adaptive ventilation has been found to be effective,
probably via an increased preload in patients with significant cardiac failure, and to reduce the respiratory abnormalities, although the long-term prognosis is not known [98, 99] (Class IV). A recent randomized controlled study suggests that the use of non-invasive adaptive ventilation may improve daytime function and respiratory and cardiac measures [100] (Class II). The experience with the use of adaptive ventilation, CPAP or bi-level CPAP in patients with Cheyne–Stokes respiration due to central respiratory failure, for example brainstem lesions, is sparse, and the evidence level is poor (Class C).

**Treatment of sleep hypoventilation syndrome**

Treatment includes nasal intermittent positive-pressure ventilation (NIPPV) with bi-level positive airways pressure (variable positive airways pressure), non-invasive volumetric ventilation, and eventually invasive ventilation, under the control of nocturnal respiratory parameters [101] (Class IV). CPAP is not the primary treatment, as the motor effort is mostly reduced in these patients, which may lead to worsening of the SDB. NIPPV may reduce sleep disturbances, increase cognitive function, and prolong the period to tracheostomy [102, 103] (Class IV). Current evidence about the therapeutic benefit of mechanical ventilation is weak but consistent, suggesting alleviation of the symptoms of chronic hypoventilation in the short term. Evidence from a single randomized trial of non-invasive ventilation with a limited number of participant suggests a prolonged survival and improved quality of life in people with ALS, especially among those with minor bulbar involvement, but not in patients with severe bulbar impairment [104, 105] (Class III).

**Follow-up**

Although there is no evidence on when and how the follow-up of treatment with CPAP and NIPPV should be executed, we recommend regular follow-up of the treatment with control of compliance and treatment effect (Class IV).

**Ethical aspects**

Treatment of patients with severe neurological diseases such as ALS and MSA with NIPPV includes medical and ethical problems that should be addressed. Adequate involvement of the patients and family, and the treatment, its use, and its limitations, should be carefully discussed early in the course of the disease. It is important to clarify the limitations of the treatment, and the discussion should include careful debate regarding whether such treatment should be offered, its initiation, the need for tracheotomy, whether invasive ventilation should be offered, and discontinuation [106, 107].

**Drug treatment**

**Treatment of EDS in neurological diseases**

Several groups of patients with neurological diseases commonly complain of EDS. The aetiology may be secondary to the neurological disease or its medication (dopaminergic or benzodiazepine drugs), or the consequence of concomitant sleep disorders such as sleep apnoea, nocturnal motor phenomena, etc. In patients in whom these factors cannot be modified, stimulants such as methylphenidate or modafinil may be used as symptomatic therapy. Modafinil was primarily introduced to treat EDS in narcolepsy [108–113]. Case studies [114, 115] and double-blind controlled studies [116, 117] suggest that modafinil reduces EDS in Parkinson’s patients (Class B–II) despite the fact that Ondo et al.’s study did not prove the long-term effect of modafinil in Parkinson’s disease [118]. Modafinil has also been suggested in ALS [119] and post-stroke depression [120, 121], but no controlled studies are available (Class IV). Furthermore, modafinil has been used for the treatment of residual EDS in OSAS undergoing CPAP treatment without neurological comorbidity [122]. There is some evidence that other centrally acting drugs such as methylphenidate or modafinil may have similar effects [123], but there have been no comparisons between modafinil and methylphenidate. EDS in Parkinson’s disease was successfully reduced by sodium oxybate [124] (Class II).

**Other drug and non-pharmacological treatment of sleep disorders in neurological diseases**

Treatment of sleep disorders in neurodegenerative diseases is often complex and may involve different strategies. Parkinson’s disease-related motor symptoms can be treated with long-acting DA agonists to obtain continuous DA receptor stimulation during the night. On the other hand, nocturnal disturbances may be related to treatment, and therefore continued monitoring of treatment effect should offered.
Some sleep disorders, such as RLS and PLMS, may be controlled by DA agents, and others, such as insomnia and EDS, may be improved by reducing dopaminergic stimulation (Class IV).

Clonazepam or donepezil, possibly prescribed with melatonin, has been suggested based on case series for the treatment of RBD. No controlled studies are available [33, 125].

Patients with dementias often present circadian disturbances that may be relieved by melatonin and light therapy [126–142] (Class IV).

In selected cases, treatment with hypnotics are mentioned to be useful, but the evidence is limited and care should be undertaken in terms of chronic use, the risk of falls, daytime sedation, confusion, and the risk of worsening of SDB in the elderly.

**Recommendations**

1. Patients with neurological diseases often have significant sleep disorders that affect sleep and daytime function, with increased morbidity and even mortality. Many of these disorders are treatable. Therefore, increased awareness should be directed toward sleep disorders in patients with neurodegenerative, cerebrovascular, and neuromuscular diseases. Despite this, there are limited number of studies with a high evidence level.

2. PSG is a diagnostic minimum for the diagnoses of sleep disorders in patients with neurological diseases.

3. In patients with nocturnal motor and behaviour manifestations, a full video-PSG/video-EEG-PSG is recommended.

4. Respiratory polygraphy has a moderate sensitivity and specificity in the diagnosis of OSAS without neurological diseases, but its value for the diagnosis of other SDBs or in neurological patients with suspected OSAS has not been evaluated compared with the gold standard of PSG. Consequently, respiratory polygraphy may be used as a method for detecting OSAS, but the value of its use for SDB in patients with neurological diseases needs further validation.

5. Oximetry has a poor sensitivity/specificity for the identification of OSAS in patients without neurological diseases. Oximetry cannot differentiate between obstructive and central sleep apnoea and is insufficient to identify stridor. Oximetry alone is not recommended for the diagnosis of SDB in neurological disorders.

6. Patients with SDB, muscle weakness, and cardiac or pulmonary comorbidity may present a sleep hypoventilation syndrome that manifests early as increased carbon dioxide. $P_aCO$ should be measured in such cases during sleep recordings.

7. Fixed-pressure CPAP/auto-adjusted CPAP is the most effective treatment for OSAS. This probably also includes patients with OSAS and neurological diseases. However, there is a need for further evaluation of the effect of CPAP in patients with OSAS and neurological diseases.

8. Bi-level/Variable positive-airway pressure ventilation, NIPPV, and volumetric ventilation are useful for SDBs such as central apnoeas, Cheyne-Stokes breathing, and alveolar hypoventilation.

9. There is a clear need for further studies focusing on the diagnostic procedures and treatment modalities in neurological patients with sleep disorders.

**Conflicts of interest**

None reported.

**References**


Sleep Disorders


143. American Thoracic Society. Clinical indications for noninvasive positive pressure ventilation in chronic respiratory failure due to restrictive lung disease, COPD, and noctur-