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# Diagnosing sleep disordered breathing in patients with chronic pulmonary disease: which test for which patient?

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Shareable abstract (@ERSpublications)

**Overnight polysomnography should be the first-line diagnostic test in patients with severe respiratory disease. However, if access to polysomnography is limited, overnight polygraphy can be used as an alternative first-line diagnostic.** <https://bit.ly/3KlmFED>

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## Introduction

Sleep disordered breathing is frequent in the general population, as almost one billion people may have obstructive sleep apnoea (OSA) [1]. Hence, patients with chronic pulmonary disease are likely to have comorbid OSA. Indeed, two-thirds of patients with COPD are overweight or obese [2], a common risk factor of OSA. In patients with end-stage chronic pulmonary disease, nocturnal hypoventilation may also occur. Therefore, screening for sleep disordered breathing is relevant in patients with chronic pulmonary disease.

At any stage of the disease, identifying and treating comorbid OSA may reduce exacerbations, improve quality of sleep, prognosis, and quality of life [3]. For patients at the end-stage of their disease, identifying nocturnal hypoventilation could trigger noninvasive ventilation (NIV) initiation and improve their outcomes.

The diagnostic strategy of sleep disordered breathing may change depending on the severity and the type of respiratory disease. We will review the sleep specificity of the main chronic respiratory diseases, the diagnostic tools for sleep disordered breathing and when to use them.

## Sleep disordered breathing in chronic pulmonary diseases

### *Obstructive pulmonary disease*

Patients with COPD usually report poor sleep quality [4]. The prevalence of OSA in COPD patients is similar to that in the general population. However, patients with COPD–OSA overlap syndrome have a poorer prognosis [5] and lower quality of life [6] than those with COPD alone. Undiagnosed OSA increases the risk of acute exacerbation [7] and readmission rates [3, 8]. In patients with severe to very severe COPD, nocturnal hypoventilation occurs regardless of daytime hypercapnia [9]. However, screening for nocturnal hypoventilation remains limited to research purposes, as no trial has yet evaluated the benefit of correcting such nocturnal hypoventilation.

As for the general population, patients with asthma are more and more frequently overweight [10] and can therefore suffer comorbid OSA. Comorbid OSA is associated with an increased risk of an asthma exacerbation [11]. Untreated OSA may contribute to worsening daytime control of the disease [12] and should therefore be screened in patients with poorly controlled asthma. Initiating continuous positive airway pressure (CPAP) in patients with asthma and comorbid OSA improves the asthma-related quality of life [13] as well as nocturnal symptoms [14].



Diagnosis and management of sleep disordered breathing in obstructive pulmonary disease is further discussed in two recently published reviews [15, 16].

### ***Restrictive pulmonary diseases***

Restrictive pulmonary diseases are often associated with sleep disordered breathing [17, 18]. Indeed, functional residual capacity decreases during sleep [19], which can promote obstructive respiratory events [20] and contribute to hypoventilation [21].

Patients with restrictive pulmonary disease due to obesity are at high risk of OSA and should therefore be screened for OSA, especially before undergoing bariatric surgery. In this population, daytime arterial carbon dioxide tension ( $P_{aCO_2}$ ) measurement is also recommended to rule out obesity hypoventilation syndrome [22].

Patients with restrictive pulmonary disease due to a neuromuscular disorder are at high risk of developing hypoventilation and require close follow-up, particularly those suffering from a rapidly progressive disease such as amyotrophic lateral sclerosis [23]. Prevalence of OSA varies according to the underlying restrictive disease [24, 25]. In addition, patients with restrictive disease can develop central events related to heart failure [26].

Patients with restrictive disease secondary to an interstitial lung disease have a high prevalence of OSA [27]. However, the use of CPAP may have limited impact on disease progression and survival [28]. In patients with end-stage interstitial lung disease, hypoventilation may occur. However, NIV is rarely used.

### **Diagnostic tools for sleep disordered breathing**

Sleep monitoring devices are usually categorised into four different groups according to the number of measurements monitored and the place where the recording is performed [29]. Examples of overnight recordings can be found in figure 1.

#### ***Overnight oximetry (type 4 sleep monitoring device)***

Overnight oximetry should be considered as a screening tool rather than a diagnostic tool, as it cannot distinguish obstructive and central respiratory events. However, by continuously monitoring peripheral oxygen saturation ( $S_{pO_2}$ ), it can provide useful information, including the frequency of oxygen desaturation, the mean oxygen saturation, and the time spent with a saturation <90%. Hence, apnoeas or hypopnoeas can be suspected on a nocturnal oximetry by the presence of rapid and repeated desaturation and recovery episodes over time (figure 1b). In patients who do not have a ventilation/perfusion mismatch, overnight oximetry can also identify nocturnal hypoventilation, as highlighted in figure 1a where prolonged desaturations suggest alveolar hypoventilation. In addition to oxygen measurements, overnight oximetry provides information on heart rate. Oximetry monitoring devices are cheap, easy to use and can be performed in the home setting without supervision.

#### ***Overnight capnography (type 4 sleep monitoring device)***

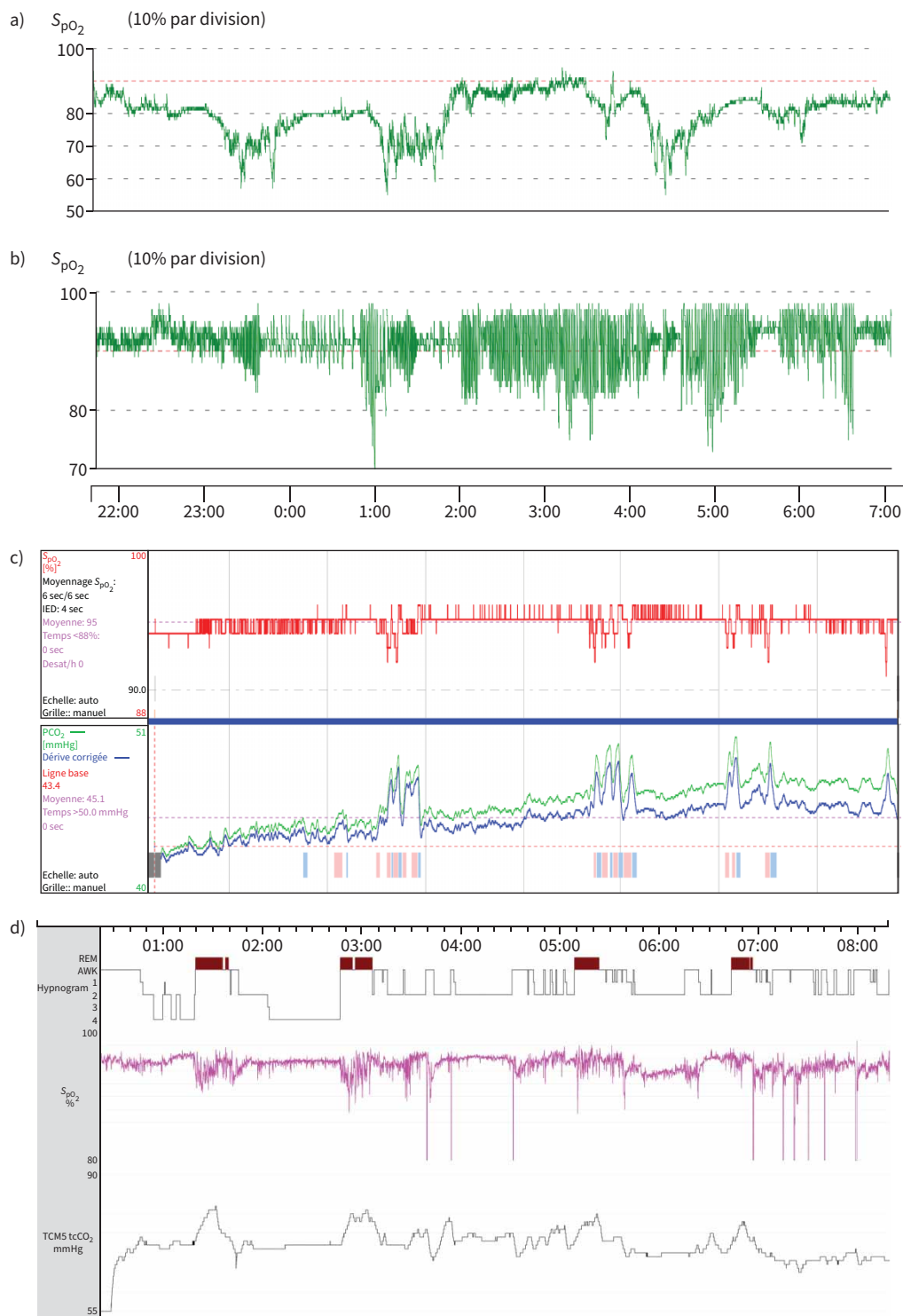
Overnight capnography allows continuous monitoring of transcutaneous carbon dioxide level ( $P_{tcCO_2}$ ) in addition to  $S_{pO_2}$ . Overnight capnography is easy to use and provides additional information compared with oximetry, including mean  $P_{tcCO_2}$  level overnight and times spent above  $P_{tcCO_2}$  thresholds (50 or 55 mmHg). Therefore, overnight capnography is essential for the diagnosis of nocturnal hypoventilation, as shown in figure 1c for a patient with amyotrophic lateral sclerosis displaying significant alveolar hypoventilation when looking at the  $P_{tcCO_2}$  trace with a close to normal oximetry trace. The limitations of overnight capnography include its cost (the test is more expensive than oximetry), a high failure rate, and a lack of consensus for the cut-offs defining hypoventilation.

#### ***Overnight respiratory polygraphy (type 3 sleep monitoring device)***

Overnight respiratory polygraphy adds respiratory efforts and airflow to oximetry. This allows you to distinguish obstructive from central respiratory events. Overnight respiratory polygraphy is widely available and can be easily performed in the home setting. However, as it cannot evaluate sleep stages or micro-arousals, and the frequency of respiratory events can be underestimated.

#### ***Overnight polysomnography (type 1 or 2 sleep monitoring device)***

Overnight polysomnography is the gold standard to assess sleep disordered breathing as it provides an assessment of sleep stages (using electroencephalography, electro-oculography and chin electromyography), sleep structure, sleep efficiency and sleep disruption (arousals, wake time after sleep onset). Type 2 polysomnography is performed in the home setting and is unsupervised, whereas type 1



**FIGURE 1** a) Overnight oximetry in a patient with amyotrophic lateral sclerosis and severe nocturnal hypoventilation, showing a prolonged, continuous oxygen desaturation, culminating in three major dips (possibly corresponding to rapid eye movement (REM) sleep or the supine position). b) Overnight oximetry in a patient with obesity, showing recurrent, brief desaturations, a pattern suggestive of obstructive sleep apnoea. c) Overnight oxi-capnography in a patient with Duchenne muscular dystrophy, showing nocturnal hypoventilation probably occurring during REM sleep (red line: oximetry; green line: raw transcutaneous  $CO_2$  measurements; blue line: corrected transcutaneous  $CO_2$ ). d) Overnight polysomnography in a patient with advanced COPD, showing nocturnal hypoventilation (predominant during REM sleep) and altered sleep structure (black line at the top: hypnogram; pink line: oximetry; black line at the bottom: transcutaneous  $CO_2$  measurements).

polysomnography is performed in hospital with a sleep technician monitoring the patient. The main limitations of overnight polysomnography are its costs and its availability given the prevalence of respiratory diseases.

#### **Respiratory extended overnight polysomnography (combined with $P_{tCO_2}$ and respiratory electromyography)**

In patients with chronic pulmonary disease, polysomnography recordings should also include transcutaneous capnography due to the limits of  $S_{pO_2}$  measurement in chronic hypoxaemic diseases. Polysomnographic recordings identify during which sleep stage hypoventilation occurs (usually during rapid eye movement sleep, during which activity of accessory respiratory muscle is lost (figure 1d)). In addition, one may assess the inspiratory muscles activity during sleep, mostly using neck inspiratory muscles (scalene or sterno-cleido-mastoidian muscles) as the diaphragm muscle activity is poorly accessible at the body surface [30, 31].

#### **Diagnostic strategy for sleep disordered breathing in patients with chronic pulmonary disease**

In its clinical practice guideline, the American Academy of Sleep Medicine strongly recommends the use of polysomnography for the diagnosis of OSA in patients with significant respiratory disease, potential respiratory muscle weakness due to neuromuscular conditions, awake hypoventilation or suspicion of sleep-related hypoventilation [29]. In many countries, polysomnography is mandatory when setting up long-term home NIV. However, this recommendation is difficult to follow as access to overnight polysomnography is limited and generates a loss of chance given the time spent waiting for the polysomnography. Therefore, alternative strategies should be offered to patients to ensure that the potential diagnosis of OSA is not missed due to inaccessibility of polysomnography. Table 1 provides a proposal for the indications of the different tests available according to the pathologies and the clinical situations.

#### **Diagnostic strategy in patients with obstructive pulmonary disease**

In patients with COPD, overnight oximetry poorly identifies comorbid OSA [32]. Therefore, it should not be used. In patients where OSA is not suspected, assessment of the time spent with a saturation <90%

**TABLE 1** The authors' proposal for the use of overnight tests to diagnose sleep disordered breathing in patients with chronic pulmonary disease

Patients with	Overnight oximetry	Overnight standalone capnography	Overnight polygraphy	Overnight polysomnography with capnography	Overnight polysomnography with capnography and MSLT
COPD	No indication	No indication	OSA screening	<ul style="list-style-type: none"> <li>OSA screening<sup>#</sup></li> <li>If other sleep disorders are suspected<sup>¶</sup></li> </ul>	No indication
Asthma	No indication	No indication	OSA screening	<ul style="list-style-type: none"> <li>OSA screening<sup>#</sup></li> <li>If other sleep disorders are suspected<sup>¶</sup></li> </ul>	No indication
Obesity	No indication	No indication	OSA screening	<ul style="list-style-type: none"> <li>OSA screening<sup>#</sup></li> <li>If other sleep disorders are suspected<sup>¶</sup></li> </ul>	Hypersomnia screening in rare "hypothalamic" obesity (e.g. Prader-Willi syndrome)
Myotrophic lateral sclerosis	Regular (4 times per year) screening for hypoventilation onset	If available, (4 times per year) screening for hypoventilation onset	OSA screening	<ul style="list-style-type: none"> <li>OSA screening<sup>#</sup></li> <li>If other sleep disorders are suspected<sup>¶</sup></li> </ul>	No indication
Other neuromuscular diseases	No indication	Screening (once per year) for hypoventilation onset	OSA screening	<ul style="list-style-type: none"> <li>OSA screening<sup>#</sup></li> <li>If other sleep disorders are suspected<sup>¶</sup></li> </ul>	Hypersomnia screening in myotrophic dystonia
Interstitial lung disease	No indication	No indication	OSA screening	<ul style="list-style-type: none"> <li>OSA screening<sup>#</sup></li> <li>If other sleep disorders are suspected<sup>¶</sup></li> </ul>	No indication

OSA: obstructive sleep apnoea; MSLT: multiple sleep latency tests. <sup>#</sup>: if polysomnography is largely available in the local centre or if overnight polygraphy did not confirm the clinical suspicion of OSA; <sup>¶</sup>: periodic limb movements, insomnia.

using overnight oximetry is not clinically relevant as no benefit of overnight oxygen therapy has been shown [33, 34]. When overnight polysomnography is not available, home polygraphy can be used to diagnose comorbid OSA in COPD patients [35]. A similar approach may be applied for patients with asthma; however, no study has assessed any diagnostic strategy in this population. In patients with end-stage COPD, there is no indication to perform overnight capnography to detect nocturnal hypoventilation, as until now all randomised controlled trials suggesting a benefit of NIV used daytime  $P_{aCO_2}$  (and not overnight capnography) as a criterion for NIV initiation [36, 37].

#### ***Diagnostic strategy in patients with restrictive pulmonary disease***

In patients with restrictive pulmonary disease due to obesity, overnight polygraphy should be used as a first-line diagnostic tool. However, overnight polysomnography followed by multiple sleep latency tests should be performed in patients with rare (mostly hypothalamic) causes of obesity, including type 1 narcolepsy, craniopharyngioma, neurosarcoidosis and Prader–Willi syndrome (who suffer from comorbid central hypersomnia and narcolepsy) [38]. In the general obese population, there is no indication for capnography monitoring alone.

Overnight capnography is probably only useful in patients with restrictive pulmonary disease associated with a neuromuscular disorder, and especially in those with a rapidly progressive disease for which the regular recommended overnight monitoring cannot be performed by overnight polysomnography [23]. However, given the technical challenges associated with home capnography, a pragmatic approach is to perform regular home oximetry in patients with rapidly progressive neuromuscular disease. When overnight capnography can be performed, in this clinical condition, the cut-off for significant nocturnal hypoventilation is debatable [39] and may have different clinical impacts according to the underlying disease [40]. In patients with restrictive pulmonary disease associated with an interstitial lung disease, given the lack of dedicated trials, OSA should primarily be screened with the use of overnight polygraphy.

Finally, overnight polysomnography (followed by multiple sleep latency tests) needs to be performed in some groups of patients including those suffering from myotonic dystrophy who, in addition to weak muscles, have impaired central breathing control and secondary narcolepsy [41].

#### **Conclusion**

Overnight polysomnography remains the best tool to diagnose sleep disordered breathing in patients with chronic respiratory diseases. However, given its limited availability and the prevalence of respiratory disease, a pragmatic approach considering the local environment is needed to avoid delays in diagnosis.

#### **Key points**

- Overnight oximetry should not be used to diagnose sleep disordered breathing in patients with chronic pulmonary disease.
- Overnight capnography as a stand-alone diagnostic tool should only be used in patients with neuromuscular disease.
- Overnight polysomnography should be the first-line diagnostic test in patients with severe respiratory disease when sleep disordered breathing is suspected. However, if access to polysomnography is limited, overnight polygraphy can be used as a first-line diagnostic tool.

#### **Self-evaluation questions**

1. Can overnight oximetry can be used as a reliable tool to assess sleep disordered breathing in patients with chronic pulmonary disease?
2. Is overnight polygraphy recommended as a first-line diagnostic tool for sleep disordered breathing in patients with amyotrophic lateral sclerosis?
3. Is overnight polysomnography recommended as a first-line diagnostic tool for sleep disordered breathing in patients with daytime hypercapnia?

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## References

- 1 Benjafield AV, Ayas NT, Eastwood PR, *et al.* Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. *Lancet Respir Med* 2019; 7: 687–698.
- 2 Verberne LDM, Leemrijse CJ, Swinkels ICS, *et al.* Overweight in patients with chronic obstructive pulmonary disease needs more attention: a cross-sectional study in general practice. *NPJ Prim Care Respir Med* 2017; 27: 63.
- 3 Sterling KL, Pépin J-L, Linde-Zwirble W, *et al.* Impact of positive airway pressure therapy adherence on outcomes in patients with obstructive sleep apnea and chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2022; 206: 197–205.
- 4 Zeidler MR, Martin JL, Kleerup EC, *et al.* Sleep disruption as a predictor of quality of life among patients in the subpopulations and intermediate outcome measures in COPD study (SPIROMICS). *Sleep* 2018; 41: zsy044.
- 5 Marin JM, Soriano JB, Carrizo SJ, *et al.* Outcomes in patients with chronic obstructive pulmonary disease and obstructive sleep apnea: the overlap syndrome. *Am J Respir Crit Care Med* 2010; 182: 325–331.
- 6 Zhang P, Chen B, Lou H, *et al.* Predictors and outcomes of obstructive sleep apnea in patients with chronic obstructive pulmonary disease in China. *BMC Pulm Med* 2022; 22: 16.
- 7 Li SQ, Sun XW, Zhang L, *et al.* Impact of insomnia and obstructive sleep apnea on the risk of acute exacerbation of chronic obstructive pulmonary disease. *Sleep Med Rev* 2021; 58: 101444.
- 8 Channick JE, Jackson NJ, Zeidler MR, *et al.* Effects of obstructive sleep apnea and obesity on 30-day readmissions in patients with chronic obstructive pulmonary disease: a cross-sectional mediation analysis. *Ann Am Thorac Soc* 2022; 19: 462–468.
- 9 Holmedahl NH, Øverland B, Fondenes O, *et al.* Sleep hypoventilation and daytime hypercapnia in stable chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis* 2014; 9: 265–275.
- 10 Peters U, Dixon AE, Forno E. Obesity and asthma. *J Allergy Clin Immunol* 2018; 141: 1169–1179.
- 11 Kong D-L, Qin Z, Shen H, *et al.* Association of obstructive sleep apnea with asthma: a meta-analysis. *Sci Rep* 2017; 7: 4088.
- 12 Teodorescu M, Polomis DA, Teodorescu MC, *et al.* Association of obstructive sleep apnea risk or diagnosis with daytime asthma in adults. *J Asthma* 2012; 49: 620–628.
- 13 Lafond C, Sériès F, Lemièrre C. Impact of CPAP on asthmatic patients with obstructive sleep apnoea. *Eur Respir J* 2007; 29: 307–311.
- 14 Ciftci TU, Ciftci B, Guven SF, *et al.* Effect of nasal continuous positive airway pressure in uncontrolled nocturnal asthmatic patients with obstructive sleep apnea syndrome. *Respir Med* 2005; 99: 529–534.
- 15 Wang R, Mihaicuta S, Tiotiu A, *et al.* Asthma and obstructive sleep apnoea in adults and children – an up-to-date review. *Sleep Med Rev* 2022; 61: 101564.
- 16 McNicholas WT. COPD-OSA overlap syndrome: evolving evidence regarding epidemiology, clinical consequences, and management. *Chest* 2017; 152: 1318–1326.
- 17 Aboussouan LS. Sleep-disordered breathing in neuromuscular disease. *Am J Respir Crit Care Med* 2015; 191: 979–989.
- 18 Khor YH, Ryerson CJ, Landry SA, *et al.* Interstitial lung disease and obstructive sleep apnea. *Sleep Med Rev* 2021; 58: 101442.
- 19 Hudgel DW, Devadatta P. Decrease in functional residual capacity during sleep in normal humans. *J Appl Physiol* 1984; 57: 1319–1322.
- 20 Van de Graaff WB. Thoracic influence on upper airway patency. *J Appl Physiol (1985)* 1988; 65: 2124–2131.
- 21 Hudgel DW, Martin RJ, Capehart M, *et al.* Contribution of hypoventilation to sleep oxygen desaturation in chronic obstructive pulmonary disease. *J Appl Physiol* 1983; 55: 669–677.
- 22 Mokhlesi B, Masa JF, Brozek JL, *et al.* Evaluation and management of obesity hypoventilation syndrome. An Official American Thoracic Society Clinical Practice Guideline. *Am J Respir Crit Care Med* 2019; 200: e6–e24.

- 23 Georges M, Perez T, Rabec C, *et al.* Proposals from a French expert panel for respiratory care in ALS patients. *Respir Med Res* 2022; 81: 100901.
- 24 Ragette R, Mellies U, Schwake C, *et al.* Patterns and predictors of sleep disordered breathing in primary myopathies. *Thorax* 2002; 57: 724–728.
- 25 Pincherle A, Patruno V, Raimondi P, *et al.* Sleep breathing disorders in 40 Italian patients with myotonic dystrophy type 1. *Neuromuscul Disord* 2012; 22: 219–224.
- 26 Lemay J, Sériès F, Sénéchal M, *et al.* Unusual respiratory manifestations in two young adults with Duchenne muscular dystrophy. *Can Respir J* 2012; 19: 37–40.
- 27 Gille T, Didier M, Boubaya M, *et al.* Obstructive sleep apnoea and related comorbidities in incident idiopathic pulmonary fibrosis. *Eur Respir J* 2017; 49: 1601934.
- 28 Adegunsoye A, Neborak JM, Zhu D, *et al.* CPAP adherence, mortality, and progression-free survival in interstitial lung disease and OSA. *Chest* 2020; 158: 1701–1712.
- 29 Kapur VK, Auckley DH, Chowdhuri S, *et al.* Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: an American Academy of Sleep Medicine clinical practice guideline. *J Clin Sleep Med* 2017; 13: 479–504.
- 30 Redolfi S, Grassion L, Rivals I, *et al.* Abnormal activity of neck inspiratory muscles during sleep as a prognostic indicator in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2020; 201: 414–422.
- 31 Arnulf I, Similowski T, Salachas F, *et al.* Sleep disorders and diaphragmatic function in patients with amyotrophic lateral sclerosis. *Am J Respir Crit Care Med* 2000; 161: 849–856.
- 32 Lajoie A-C, Sériès F, Bernard S, *et al.* Reliability of home nocturnal oximetry in the diagnosis of overlap syndrome in COPD. *Respiration* 2020; 99: 132–139.
- 33 Lacasse Y, Sériès F, Corbeil F, *et al.* Randomized trial of nocturnal oxygen in chronic obstructive pulmonary disease. *N Engl J Med* 2020; 383: 1129–1138.
- 34 Chaouat A, Weitzenblum E, Kessler R, *et al.* A randomized trial of nocturnal oxygen therapy in chronic obstructive pulmonary disease patients. *Eur Respir J* 1999; 14: 1002–1008.
- 35 Chang Y, Xu L, Han F, *et al.* Validation of the Nox-T3 portable monitor for diagnosis of obstructive sleep apnea in patients with chronic obstructive pulmonary disease. *J Clin Sleep Med* 2019; 15: 587–596.
- 36 Köhnelein T, Windisch W, Köhler D, *et al.* Non-invasive positive pressure ventilation for the treatment of severe stable chronic obstructive pulmonary disease: a prospective, multicentre, randomised, controlled clinical trial. *Lancet Respir Med* 2014; 2: 698–705.
- 37 Murphy PB, Rehal S, Arbane G, *et al.* Effect of home noninvasive ventilation with oxygen therapy vs oxygen therapy alone on hospital readmission or death after an acute COPD exacerbation: a randomized clinical trial. *JAMA* 2017; 317: 2177–2186.
- 38 Duis J, Pullen LC, Picone M, *et al.* Diagnosis and management of sleep disorders in Prader-Willi syndrome. *J Clin Sleep Med* 2022; 18: 1687–1696.
- 39 Ognà A, Quera Salva M-A, Prigent H, *et al.* Nocturnal hypoventilation in neuromuscular disease: prevalence according to different definitions issued from the literature. *Sleep Breath* 2016; 20: 575–581.
- 40 Orlikowski D, Prigent H, Quera Salva M-A, *et al.* Prognostic value of nocturnal hypoventilation in neuromuscular patients. *Neuromuscul Disord* 2017; 27: 326–330.
- 41 Yu H, Laberge L, Jausse I, *et al.* Daytime sleepiness and REM sleep characteristics in myotonic dystrophy: a case-control study. *Sleep* 2011; 34: 165–170.

### Suggested answers

1. Incorrect, overnight polysomnography should be performed ideally with capnography in patients with advanced chronic pulmonary disease.
2. Incorrect, overnight polygraphy is not sufficient to diagnose the early stage of nocturnal hypoventilation in patients with amyotrophic lateral sclerosis.
3. Correct.