Sleep in the patient with lung disease

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■ Normal sleep is associated with changes in respiration. The impact of sleep on patients with underlying lung disease may be significant depending on the severity of the underlying disease. Nocturnal oxygen desaturation may complicate the management of patients with chronic obstructive pulmonary disease, interstitial lung disease, and kyphoscoliosis. Nocturnal bronchospasm may develop in patients with asthma. The impact of sleep on these four disorders, as well as diagnostic and therapeutic considerations, are reviewed.

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SLEEP APNEA is now a well-recognized disorder of sleep characterized by hypoxemia and sleep fragmentation with resultant daytime somnolence. Less widely appreciated is the impact of sleep in patients with underlying respiratory disorders such as chronic obstructive pulmonary disease (COPD), asthma, interstitial lung disease (ILD), and extrinsic restrictive disorders such as kyphoscoliosis.

Normal individuals experience sleep-related changes in respiration, including decreases in minute ventilation, tidal volume, and inspiratory flow rates (an indirect measure of respiratory drive).[1,2] These changes vary according to the phases of sleep. Minute ventilation is decreased in all phases of sleep.[2] Rapid eye movement (REM) sleep may be divided into tonic (no eye movement) and phasic (eye movement) stages. Phasic REM sleep is characterized by rapid shallow breathing with a further drop in minute ventilation as compared with tonic REM sleep.[2]

Patients with underlying lung disease may have similar sleep-associated changes in respiration which, due to the altered baseline state, become clinically significant. Patients with different lung diseases respond differently to sleep, despite having similar awake levels of compromised gas exchange, as is seen in the following review detailing the impact of sleep on four broad categories of lung disease.

CHRONIC OBSTRUCTIVE PULMONARY DISEASE

An estimated 10 to 15 million Americans suffer from COPD.[3] It is currently the fifth leading cause of mortality in the United States. Physiologically, it is characterized by decreases in the forced expiratory volume in 1 second (FEV_1) and the ratio of FEV_1 to forced vital capacity (FVC). Classically, the disease is divided into two subtypes: a pure emphysematous form ("pink puffer" type) which is characterized by varying degrees of hypoxemia, with hypercarbia only developing late in the disease; and the chronic bronchitic ("blue bloater" type) with hypoxia and hypercarbia which reflect an altered respiratory drive superimposed upon the gas exchange abnormality.

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Oxygen desaturation

Sleep in COPD has been extensively studied and reviewed.[4,5] Oxygen desaturation is the most prominent sleep-related abnormality.[6–8] As in normal subjects, mild drops in oxygen saturation (SaO2) may occur during non-REM sleep, but the most profound drops occur during REM sleep.[6–8,9] In 18 patients with COPD, phasic REM sleep accounted for 19.7% of total REM sleep time and 4.6% of total sleep time but accounted for 81.7% of REM desaturations greater than 5%.[10]

Hypoventilation appears to account for the majority of observed drops in SaO2.[7,11–12] Other proposed mechanisms include a decrease in functional residual capacity (FRC), a change in ventilation perfusion ratios, and a decreased drive to breathe. Hudgel et al[9] compared seven COPD patients who experienced at least a 10% decrease in SaO2 during REM sleep, six COPD patients with only a minimal fall in SaO2, and five normal individuals. Electromyographically recorded respiratory muscle activity and minute ventilation fell in all three groups to a comparable degree. However, the COPD patients who experienced desaturation had longer episodes of hypopneic breathing (30 ± 8 seconds vs 13 ± 1 second); this accounted for the greater decrease in SaO2. Also, FRC dropped further in patients who had desaturation than in patients who did not have desaturation, since their longer duration of hypopnea allowed a further drop in end-expiratory volume.[9]

Decreased accessory muscle activity associated with REM sleep may also contribute significantly to nocturnal oxygen desaturation. The COPD patient's characteristic hyperinflated state places the diaphragm at a mechanical disadvantage; the patient is proportionately more dependent on the accessory muscles of respiration. Johnson and Remmers[12] measured a 76% decrease in scalene muscle activity from non-REM to REM, and a further 17% drop from tonic REM to phasic REM. Sternocleidomastoid activity also decreased, although this result was more variable.

The contribution of altered ventilation-perfusion relationships to oxygen desaturation has proven difficult to assess. The arterial carbon dioxide pressure (PaCO2) does not rise proportionally to the fall in arterial oxygen pressure (PaO2), suggesting a change in ventilation-perfusion ratios.[7] A decrease in FRC is likely to alter ventilation-perfusion relationships, making it probable that this mechanism contributes to sleep-related oxygen desaturation. However, the alveolar gas equation commonly used to differentiate hypoventilation from gas exchange abnormalities requires steady-state conditions not achieved during the irregular breathing pattern of REM sleep.[9,11] Catteral et al[7] measured PaO2 and PaCO2 values in four normal subjects during 90 seconds of voluntary hypoventilation. Arterial blood gas changes were similar to those observed in COPD patients with desaturation during REM sleep, suggesting that transient hypoventilation could account for all the observed changes. Thus, whereas alveolar hypoventilation is the predominant mechanism accounting for nocturnal oxygen desaturation, alterations in ventilation-perfusion relationships probably also contribute.

An altered respiratory drive may also contribute to nocturnal oxygen desaturation. Patients with baseline awake hypercarbia (blue bloaters) experience greater falls in SaO2 despite comparable awake PaO2 values and lung function.[13,14] REM-associated desaturation correlates negatively with both the awake hypercarbic ventilatory response and hypoxic ventilatory response.[15] Tatsumi et al postulate that the altered chemical control of breathing observed in the awake state may persist in the asleep state. Finally, sleep apnea and COPD may coexist but account for only a minority of cases of COPD-related nocturnal oxygen desaturation.[13]

Complications

Potential complications related to nocturnal hypoxemia include pulmonary hypertension,[16,17] increased myocardial stress,[14,18] ventricular ectopy,[19] sleep fragmentation,[6,20] and increased risk of sudden death.[21] However, convincing evidence linking these complications with transient falls in SaO2 is lacking. Patients with baseline hypoxemia and pulmonary hypertension experienced further increases in pulmonary arterial pressures during the transient falls in SaO2 accompanying REM sleep.[16] Both changes were prevented with low-flow oxygen therapy.[16] A more recent study compared pulmonary arterial pressures in 36 patients with oxygen desaturation (defined as a fall in SaO2 to at least 85% with more than 5 minutes of sleep time spent less than 90% saturated) vs 13 patients without desaturation.[17] Lung function was comparable in both groups. Daytime PaO2 levels were slightly higher in the patients without desaturation (82.4 mm Hg vs 70.0 mm Hg). Higher pulmonary arterial pressures and hemoglobin levels were found in those with desaturation, but it is not known whether this was caused by the desaturation.

Hypoxemia increases stress on the myocardium.[18] Electrocardiographic changes and ventricular ectopic

activity in hypoxemic patients may be improved with low-flow oxygen.[14] Small drops in SaO2 (SaO2 ≥ 80%) do not appear to increase ventricular ectopic activity, although more severe drops in a subset of patients may increase ectopic activity.[19] The clinical significance of this finding is unclear.

Sleep fragmentation and decreased sleep efficiency are characteristic of patients with COPD.[6,20] Arousals are associated with episodes of arterial desaturation.[20] Although nocturnal cough may be a frequent complaint of the COPD patient, cough rarely occurs during sleep and is seldom responsible for arousal from sleep. In one study, 85% of nocturnal cough episodes occurred during the awake state.[22] The hypoxic ventilatory response is reduced during sleep in normal patients[23] and is likely to be reduced in the patient with COPD. Sleep fragmentation may further impair the arousal response to respiratory stimuli, resulting in more profound drops in SaO2.[24]

Diagnosis

Several factors, including baseline awake SaO2 and PaCO2 levels, may suggest the presence of significant nocturnal hypoxemia.[25] The severity of nocturnal oxygen desaturation correlates with the awake level of SaO2; the most significant drops occur with awake SaO2 values of less than 90% that lie on the steep portion of the oxyhemoglobin dissociation curve. The likelihood of significant nocturnal desaturation is more difficult to predict in patients with an awake SaO2 greater than 90%. Fletcher et al[6] studied 135 patients with resting awake PaO2 levels greater than 60 mm Hg (more than 90% saturated). Of these patients, 37 (27%) were classified as "desaturators" based on a decrease in SaO2 to ≤ 90% for ≥ 5 minutes. Desaturators had lower PaO2 and higher PaCO2 levels and were more likely to have a history of chronic bronchitis. Unfortunately, there was significant overlap between groups, and no factor was individually predictive of significant nocturnal desaturation. Similarly, estimations of right ventricular hypertrophy were not predictive of nocturnal hypoxemia.[26]

The value of oxygen therapy in chronically hypoxemic patients has been well established.[27,28] However, the clinical impact of transient nocturnal oxygen desaturations is unclear. Although large drops in SaO2 may occur during REM sleep, the duration of each event is usually short, and the total time spent significantly below awake SaO2 levels may be a small fraction of total sleep time.[9] Therefore, the importance of doing sleep studies to document nocturnal desaturation is debatable. Connaughton et al[29] followed 97 patients with COPD for a period of 32 to 108 months (median 70 months). In 66 patients who did not receive long-term oxygen therapy, no index of nocturnal oxygenation was related to survival, and no difference in survival was noted among those with more severe nocturnal drops in SaO2. In the group as a whole, mean nocturnal SaO2 and lowest SaO2 were related to survival but did not add to the predictive value of the readily available percent of predicted vital capacity. At present, routine sleep studies are not recommended for COPD patients without signs or symptoms of sleep apnea or unexplained cor pulmonale.

Therapy

Oxygen therapy raises the mean and nadir nocturnal SaO2 levels. Oxygen therapy for nocturnal hypoxemia in COPD patients is safe, with only minimal increases in PaCO2 and decreases in pH reported.[30–32] Oxygen therapy may lengthen apneic episodes in patients with concomitant sleep apnea, with larger increases in PaCO2 in that subset of patients.[32] In 20 patients with COPD and sleep apnea, oxygen therapy minimally increased the frequency of ventricular ectopic activity in 3 patients.[30] Although the clinical impact appears to be small, sleep studies are recommended in patients with COPD and sleep apnea who are treated with oxygen.

The evidence of the impact of oxygen therapy on sleep quality is conflicting, with studies showing both improved[33] and unchanged[22,31] quality of sleep. Differences in study design and the severity of hypoxemia in the study population may account for these disparate results. Calverley et al,[33] in a study using a night of acclimatization in the sleep laboratory and randomizing the order of air and oxygen study nights, observed increased total sleep time and increased REM sleep in six hypercarbic/hypoxic patients (PaCO2, 50 mm Hg, and PaO2, 48 mm Hg). Therefore, oxygen therapy may improve sleep quality in patients with the most severe disturbances in gas exchange—the same group who would qualify for oxygen based on awake PaO2 levels.

Pharmacologic treatment strategies for nocturnal hypoxemia are limited in both number and effectiveness. Almitrine bismesylate is an investigational drug that increases PaO2 through improved ventilation-perfusion matching and ventilatory response to hypoxia. Sleep studies in patients on almitrine reveal improved nocturnal SaO2[34,35] which stems largely from a higher baseline PaO2, since the absolute drop in PaO2 is com-

parable after placebo or almitrine therapy.[34] Almitrine is not licensed in the United States, and its long-term benefits remain unknown.

Progesterone is a respiratory stimulant that augments alveolar ventilation in a subset of patients with COPD—an effect that persists during sleep.[36,37] Again, the long-term clinical benefit remains unknown. Aminophylline is a bronchodilator with the ability to increase respiratory drive and improve diaphragmatic function. In one study of 11 patients, aminophylline did not alter nocturnal oxygen saturation.[38] Protriptyline, a non-sedating tricyclic antidepressant, decreases REM sleep. In a non-randomized study of protriptyline in 14 COPD patients, REM sleep time was decreased and the nadir SaO2 value improved.[39] Side effects complicate the use of progesterone, aminophylline, and protriptyline and the long-term benefits of decreased morbidity and mortality remain unproven.

Finally, intermittent nasal positive pressure ventilation may hold some promise as a means of noninvasively supporting the patient with significant CO2 retention.[40] This means of nocturnal support requires further investigation.

Factors that may adversely affect nocturnal oxygenation include benzodiazepine use, which may increase the frequency of sleep-disordered breathing events and nocturnal desaturation.[41] Although benzodiazepines have been reported to increase sleep time[42] and adverse clinical changes have been minimal,[41,43] care should be exercised in the use of these compounds.[4] Alcohol may also increase the number and duration of apneic events in patients with COPD.[44]

Interestingly, whereas hypercarbia may predict the presence of significant nocturnal desaturation, both alcohol intake and habitual snoring may be risk factors for the development of hypercarbia. Chan et al studied 19 eucapnic and 14 hypercapnic patients.[45] Lifetime alcohol intake, habitual snoring, and small upper airway size were all significantly more prevalent in the hypercapnic group. The possibility that CO2 retention might be reversed or prevented by eliminating alcohol intake and eliminating snoring in COPD patients remains to be explored.

In summary, nocturnal oxygen desaturation is common in patients with COPD, particularly in those with awake hypoxemia, CO2 retention, and a history of chronic bronchitis. The clinical significance of transient drops in SaO2 is unknown. Sleep studies are not routinely indicated, unless coexistent sleep apnea is suspected. Oxygen therapy is the treatment of choice and is primarily dictated by the awake level of SaO2.

ASTHMA

Diurnal variations

Normal individuals experience a diurnal variation in flow rates, with peak and nadir flows occurring around 4 PM and 4 AM, respectively. The change in flow rates is small, averaging 8%.[46] Asthmatic patients may suffer an exaggeration of this diurnal variation in flow rates leading to sleep fragmentation and nocturnal awakenings[47]—a subject that has been well reviewed.[4,48,49] Nocturnal asthma symptoms are common: in the United Kingdom, 74% of 7,729 asthmatic patients who responded to a survey reported awakening at least once per week, and 64% reported awakening at least three times per week.[50] Nocturnal awakenings correlate with the overnight fall in peak expiratory flow rates (PEFR).[51] Fifty percent of patients awakening nightly were on corticosteroid medications, and no specific medical regimen was associated with a significant decrease in nocturnal symptoms.[50] The frequency of asthmatic attacks requiring treatment is higher at night, as are asthma-related deaths.[52]

The diurnal decrease in flow rates appears to relate to circadian rhythms, as well as to the actual sleep state. Data concerning the relative importance of each are conflicting. Catterall et al[53] studied 12 asthmatic patients after a night of sleep and a night without sleep. PEFR fell 38% ± 6% following the asleep night compared with 20% ± 4% following the awake night, suggesting that both factors play a role. Ballard et al,[54] in a similar study of six asthmatic patients using esophageal and supraglottic catheters to determine lower airway resistance, noted no difference in the fall in FEV_1 between the two nights (34.0% ± 11.3% per sleep night, 37.6% ± 10.7% per awake night); however, lower airway resistance did increase more rapidly during the sleep night. The failure to see a difference in morning FEV_1 despite a greater increase in lower airway resistance was attributed to an acute fall in resistance with changing from the asleep to the awake state. Hetzel and Clark[55] further disrupted the sleep of 21 asthmatic patients by including an exercise period in the middle of the night and were still unable to prevent the 6 AM fall in PEFR. In conclusion, sleep is often in phase with circadian rhythms, and while sleep alone appears not to cause the drop in flow rates, it may exacerbate the drop in flow rates that is linked to circadian rhythms.

Several studies have examined the relationship of sleep stage to the development of bronchoconstriction.[54,56–59] The various findings included the following: sleep stage did not affect nocturnal bronchospasm[54]; patients had greater decreases in flows after awakening from REM sleep compared with non-REM sleep[59]; fewer asthma attacks occurred in stage III-IV sleep, as determined noninvasively[58]; and peak values for lower airway resistance occurred during stage III-IV sleep, as determined with invasive measures.[57] Technical differences between the studies probably account for the disparate results. Bellia et al[57] observed that asthmatic attacks rarely awaken patients from stage III-IV sleep and attributed this to a poor arousal response to increased airway resistance and to a proportionately small amount of time spent in this sleep stage. These factors may account for the failure of other studies using noninvasive measures to observe bronchospasm during stage III-IV sleep. At present, the full impact of sleep stage on asthma remains unknown.

Pathophysiology

A variety of mechanisms have been implicated in the development of nocturnal asthma. Plasma catecholamine levels and cortisol levels undergo a circadian variation. The fall in plasma epinephrine levels coincides with the drop in PEFR; infusion of epinephrine may modify the drop in flow rates.[60] Cortisol levels reach nadir levels around midnight, 4 hours ahead of the nadir values in peak flow rates.[60] In view of the potential lag effect, circulating cortisol levels may play a role, although exogenous steroids did not prevent the morning drop in PEFR.[61]

Resting bronchomotor tone in normal patients is vagally mediated, and cholinergic activity may be higher at night. Treatment with intravenous atropine or inhaled ipratropium results in nocturnal bronchodilatation but does not completely block the early morning fall in PEFR.[62,63] Therefore, cholinergic activity appears to play a role but is not the sole factor governing nocturnal bronchospasm.

Gastroesophageal reflux may trigger bronchospasm,[64,65] and reflux may be more common in patients with nocturnal wheezing.[66] The clinical importance of gastroesophageal reflux-mediated bronchospasm is debated.[67,68] Tan et al[69] studied 15 asthmatic patients with nocturnal asthma, 10 of whom had esophagitis as determined by a positive Bernstein test. Spontaneous acid reflux or simulated acid reflux did not alter overnight decreases in FEV_1 or increases in airway resistance. Gastroesophageal reflux may play a small but relatively insignificant role in the development of nocturnal asthma. Patients most likely to benefit from treatment are those with symptomatic reflux-associated respiratory symptoms.[65]

Nasal continuous positive airway pressure results in improved control of nocturnal asthma symptoms in asthmatic patients with obstructive sleep apnea or snoring.[70] Vibration of the upper airway has been suggested as a potential triggering mechanism.[70] Nocturnal exposure to allergens and inhalation of cold air may also contribute to nocturnal symptoms in individual asthmatic patients.[4]

The importance of airway inflammation in the pathogenesis of asthma is well recognized: airway inflammation has been associated with bronchial hyperreactivity and poor asthmatic control. A preliminary study demonstrated a nocturnal increase in inflammatory cells obtained by bronchoalveolar lavage in patients with nocturnal asthma, which might explain the circadian variation in airway hyperreactivity.[71]

Several observations suggest the importance of airway inflammation in the development of nocturnal bronchospasm. The percent drop in overnight PEFR correlates with the percent of predicted FEV_1 measured at both 4 PM and 4 AM,[51] and with the degree of bronchial reactivity as determined by methacholine challenge or histamine challenge at both 4 PM and 4 AM.[51,72] Furthermore, bronchial hyperreactivity increases from 4 PM to 4 AM as determined by methacholine challenge.[51] Also, the likelihood of developing a late asthmatic response (the asthmatic response associated with an influx of inflammatory cells that develops several hours after an allergen exposure[73]) is greater when allergen exposure occurs at 8 PM than at 8 AM.[74] The response following evening exposure is more severe and of longer duration than that following morning exposure.

In summary, patients with greater degrees of airflow obstruction and bronchial hyperreactivity are more likely to develop nocturnal symptoms. The possible role of a diurnal variation in airway inflammation requires further exploration.

Therapy

Therapy is aimed at better control of daytime asthmatic symptoms. Since nocturnal symptoms correlate with the degree of underlying bronchial reactivity, factors which decrease bronchial hyperreactivity should also improve control of nocturnal symptoms. Anti-inflammatory agents (specifically, inhaled corticosteroids or cromolyn sodium) can block develop-

ment of the late asthmatic response and decrease bronchial hyperreactivity.[75,76] The therapeutic response to inhaled steroids is directly related to dose, and higher doses than are conventionally prescribed may be required for optimal control. Sustained-release theophylline preparations given at bedtime provide better control of nocturnal symptoms than do inhaled beta agonists alone, with peak plasma theophylline levels coinciding with the drop in flow rates.[77,78] Ipratropium bromide, an anticholinergic, has a longer duration of action than currently available inhaled beta agonists and may be useful for the treatment of nocturnal symptoms.

In summary, nocturnal asthma symptoms are common and probably reflect an exaggeration of normal diurnal variations in flow rates. Symptoms are most prominent in patients with the greatest degree of bronchial reactivity. Factors that contribute to poor daytime control may contribute to an exacerbation of nocturnal symptoms via the mechanism of increased bronchial reactivity. Therapy is aimed at optimizing the anti-asthmatic regimen, which should include an anti-inflammatory medication such as inhaled steroids.

INTERSTITIAL LUNG DISEASE

Sleep-associated disorders in patients with ILD consist primarily of oxygen desaturation and sleep fragmentation.[79,80] However, the clinical impact of these sleep-associated changes is significantly less in ILD than that observed in other pulmonary diseases.

Oxygen desaturation occurs predominantly during REM sleep.[81–83] In one study, 141 of 153 desaturation episodes greater than 4%, and all 24 episodes greater than 10%, occurred during REM sleep.[81] While the difference between mean awake SaO2 and nadir SaO2 values may be significant (eg, 91.3% mean and 83.0% nadir,[83] and 92.9% mean and 83.2% nadir[79]), the clinical impact of oxygen desaturation is unclear.

Bye et al[82] described seven non-snoring patients with ILD, six of whom exhibited 8% ± 3% falls in SaO2. The falls were transient, lasting an average of 28 ± 12 seconds for a mean total duration of 6.4 ± 3.9 minutes. The remaining patient had a fall in SaO2 to between 80% and 85% that persisted for the entire period of REM sleep (26 minutes). Midgren et al[83] described a similarly insignificant impact of sleep on oxygen desaturation, noting a 0.5% difference between mean awake SaO2 and mean asleep SaO2 (mean awake 91.3%, mean asleep 90.8%). The drop was considerably less than that noted in the same patients during moderate exercise. Patients who snore or have obstructive apnea may exhibit more profound drops in SaO2.[80,82]

The fall in SaO2 correlates with the awake SaO2[79,81,83] but not with lung volumes.[83] The most profound drops occur with baseline SaO2 values ≤ 90% that lie on the steep portion of the oxyhemoglobin dissociation curve. Nocturnal oxygen desaturation also correlates inversely with the hypercarbic ventilatory response.[81]

Patients with ILD exhibit increased respiratory frequency and minute ventilation while awake; however, data from sleep studies are conflicting. Some investigators[80] noted no change in ventilatory patterns during non-REM sleep. On the other hand, Shea et al,[84] in a study that controlled for the development of hypoxemia, noted decreased respiratory frequency and decreased minute ventilation during non-REM sleep. Transcutaneous carbon dioxide (PtcCO2) did not rise significantly despite the drop in minute ventilation. The authors suggested that the increased minute ventilation observed during the awake state was a conscious response to vagal afferent information that is suppressed during non-REM sleep.[84]

The mechanism of oxygen desaturation in patients without obstructive apnea relates to REM-associated hypopnea. Decreased chest and abdominal wall movement occur in the majority of cases.[81] Two factors may explain why oxygen desaturation is clinically less important in a patient with ILD compared with COPD: first, patients with ILD in the supine position may have improved ventilation-perfusion matching, since fibrosis tends to predominate in the bases, with an orthodeoxic effect accounting for a lower upright PaO2[83]; second, unlike in COPD, diaphragmatic function is preserved in the patient with ILD, so the impact of REM-sleep-induced hypotonia on chest and abdominal wall muscles is proportionally less in the ILD population.

Sleep studies are not routinely indicated in ILD patients without signs or symptoms suggesting sleep apnea syndrome. Oxygen therapy should be dictated by the awake level of PaO2.

KYPHOSCOLIOSIS

Patients with kyphoscoliosis suffer from extrinsic restrictive disease which, depending on the severity, may lead to hypoxemia, hypercarbia, and respiratory failure. Impaired respiratory muscle function may contribute to the development of respiratory failure.[85] Disease progression is slow, with patients living into the

sixth decade.[86] Several studies have examined the impact of sleep in these patients.[87–91]

Oxygen desaturation occurs during sleep, with significant drops occurring during REM sleep.[87–91] Desaturation correlates with awake SaO2 (R = 0.98),[87,89] inversely with awake PaCO2 (R = –0.87), and inversely with the fall in vital capacity from sitting to supine (R = –0.74).[87] Oxygen desaturation did not correlate with the severity of the spinal angle deformity.[89] The drop in SaO2 during REM sleep may be significant with mean nocturnal SaO2 ranging from 71% to 91% in one study.[88] Sawicka et al[89] documented equally severe drops in SaO2 in 11 patients with nonparalytic kyphoscoliosis and 10 patients with paralytic kyphoscoliosis. The mean SaO2 during REM sleep was 71%, with 4 patients reaching levels less than 50%.

Similar to sleep-related changes in other respiratory diseases, hypoventilation appears to account for the significant drops in oxygen saturation. Diaphragmatic dysfunction, particularly in the patient with the paralytic form of kyphoscoliosis, may limit the compensatory response to chest wall and abdominal muscle hypotonia that develops during REM sleep.[89] With the exception of one study which examined patients with complaints of daytime somnolence,[90] obstructive sleep apnea appears to be no more common in this subpopulation.

Sleep-associated desaturation may be more severe in patients with scoliosis vs other respiratory diseases. Midgren[91] retrospectively compared sleep studies in patients with COPD, ILD, and scoliosis. Mean SaO2 values during REM sleep were 90.1% ± 4.5% in COPD, 86.7% ± 7.4% in ILD, and 80.5% ± 11.4% in scoliosis. Therefore, sleep studies to document the severity of nocturnal oxygen desaturation may be more important in patients with kyphoscoliosis. Nocturnal oxygen therapy is the treatment of choice. Kyphoscoliosis patients with baseline hypercarbia may develop unacceptable rises in PaCO2 while on oxygen therapy and may require the institution of nocturnal ventilation.[87]

CONCLUSION

Normal sleep-associated changes in respiration may produce clinically significant adverse consequences in patients with underlying respiratory disease. As a rule, nocturnal symptoms are related to the severity of the underlying lung disease. Therapy is aimed at optimizing baseline lung function; therapy for isolated nocturnal symptoms must be individualized. The clinical importance of treating transient drops in nocturnal SaO2 in patients with COPD, ILD, and kyphoscoliosis remains unknown; however, sustained drops in SaO2 should be treated. Nocturnal bronchospasm in asthmatic patients may reflect poor control of the underlying disease and warrants a more aggressive therapeutic approach.

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