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Respiratory Physiology During Sleep **497**

Daniel R. Smith and Teofilo Lee-Chiong, Jr.

The respiratory system provides continuous homeostasis of partial pressures of arterial oxygen, carbon dioxide, and pH levels during constantly changing physiologic conditions. During wakefulness, volitional influences can override this automatic control. Modifications occur in the regulation and control of respiration with the onset of sleep. Consequences of these alterations of respiratory control can result in the pathogenesis of sleep-related breathing disorders and limit the usual respiratory compensatory changes to specific disease states. This article reviews the normal physiology of respiration in both awake and sleep states, and discusses the effects of common disease processes and medications on the respiratory physiology during sleep.

Sleep and Obstructive Lung Diseases **505**

Michael E. Ezzie, Jonathan P. Parsons, and John G. Mastronarde

Asthma and chronic obstructive pulmonary disease (COPD) are common obstructive lung diseases affecting millions of people in the United States. Because sleep disorders are also common, it is not surprising that many people with obstructive lung disease also suffer from sleep disorders. People with COPD and those with asthma, however, have worse sleep quality and more sleep-related problems when compared with people with other chronic health problems. In addition, a pathologic relationship may exist between obstructive sleep apnea and obstructive lung diseases. This article focuses on the epidemiology, pathogenesis, and clinical implications of sleep disturbances in asthma and COPD.

Sleep and Breathing in Restrictive Thoracic Cage and Lung Disease **517**

Joseph Kaplan

Restriction in pulmonary function is characterized by reduction in absolute lung volumes. The prototypical restrictive diseases include disorders of the chest wall and lung parenchyma and are characterized by significant respiratory abnormalities during sleep. Sleep may be disturbed by frequent respiratory-related arousals and hypoxemia may be profound, especially during rapid eye movement sleep. Patients with sleep-associated hypoventilation often suffer significant daytime functional sequelae and lowered survival rates. Although supplemental oxygen

therapy may alleviate the nocturnal hypoxemia, nocturnal intermittent positive pressure ventilation with or without oxygen seems to improve daytime function and offers a survival advantage in severe disease.

Obesity Hypoventilation Syndrome

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Meena Khan, Karen L. Wood, and Nitin Y. Bhatt

Obesity hypoventilation syndrome is a combination of obesity, unexplained daytime hypercapnia, and sleep-disordered breathing. It is associated with such symptoms as dyspnea, excessive daytime sleepiness, and impaired cognition. The disorder can result in pulmonary hypertension, severe hypoxemia, cor pulmonale, respiratory failure, and increased mortality. While the etiology is still incompletely understood, the combined effects of obesity, sleep-disordered breathing, and altered leptin levels all likely interact to result in a decreased ventilatory drive. Standard treatment consists of positive airway pressure (continuous positive airway pressure or bi-level positive airway pressure) combined with long-term weight management.

Sleep in Patients with Respiratory Muscle Weakness

541

Himanshu Desai and M. Jeffery Mador

The physiologic effects of sleep on respiratory muscle activity and breathing are described. The evidence of disruption of sleep architecture, SDB and nocturnal oxygenation in patients with respiratory muscle weakness is reviewed. Finally, the more specific findings in various diseases, and the evaluation and management of these conditions, are described.

Pulmonary Arterial Hypertension and Sleep

551

Namita Sood

This article discusses the causes, symptoms, effects, evaluation, and treatment of pulmonary arterial hypertension. It critically reviews the literature concerning its relationship to hypoxia, pulmonary circulation, obstructive sleep apnea, pulmonary hypertension, and overlap syndrome. It points out the need for evaluation of patients with persistent hypoxia or post-treatment symptoms for pulmonary arterial hypertension. Also, it notes that patients with underlying lung disease may not benefit from the standard treatment. It concludes that future studies need to define these conditions and to evaluate patients systematically and using standardized criteria.

Chronic Noninvasive Positive-Pressure Ventilation: Considerations During Sleep

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Murtuza M. Ahmed and Richard J. Schwab

Noninvasive ventilation (NIV) has become a proven and accepted treatment for respiratory failure from a variety of underlying causes. NIV during sleep can improve gas exchange in both acute and chronic respiratory failure. During sleep, numerous physiologic changes take place that increase the work of breathing and can therefore worsen sleep quality. These include decrements in tidal volume, worsening of gas exchange, and altered lung mechanics. While institution of NIV has been shown to improve nocturnal P_{aCO_2} and P_{aO_2} levels and reduce the work of breathing, less is known regarding its effects on sleep and sleep quality. This article reviews data from case series, uncontrolled studies, randomized clinical trials, and meta-analyses. While there is some controversy, the predominance of data suggests that NIV can significantly improve several measures of sleep quality and duration in patients with chronic respiratory failure from numerous underlying causes. Studies have demonstrated improvements in total sleep time, sleep efficiency, subjective sleep

quality, and overall quality of life in patients using NIV. In patients with the obesity hypoventilation syndrome, NIV is a cornerstone of therapy, improving daytime hypersomnolence as well as gas exchange. The data for NIV in patients with chronic obstructive pulmonary disease are conflicting and it is unclear if these patients have overall improvements with NIV use. Implementation of chronic NIV is discussed, along with indications and contraindications to therapy.

Sleep in the Intensive Care Unit

569

Steven Kadiev and Naeem Ali

The current evidence indicates that acutely ill patients admitted in the intensive care unit (ICU) suffer sleep disturbances that include sleep deprivation (SD), sleep disruption, and, more specifically, decreased or absent slow-wave and rapid eye movement (REM) sleep. Quantifying sleep quality and duration in ICU patients is problematic because subjective and objective sleep measures have inherent weaknesses, and minimal thresholds for sleep have not been established. Sedation and analgesia are often implemented for patient comfort and to provide tolerance to medical interventions and mechanical ventilation. Secondarily, these drugs induce a sleep-like state. However, increased sedation results in disrupted sleep architecture that may impede the normal restorative functions of sleep. Therefore, other interventions should be implemented for critically ill, ICU patients so that restorative sleep can occur.

Management of Insomnia in Patients with Chronic Pulmonary Disease

581

James D. Geyer, Megan E. Ruitter, and Kenneth L. Lichstein

Following a discussion of the impact of sleep disorders, the clinical management of chronic obstructive pulmonary disorder is discussed, as are asthma and obstructive sleep apnea. Restrictive lung diseases are outlined. The behavioral management of insomnia appears to improve sleep and the implications are detailed. Finally, the pharmacologic treatment of insomnia for patients who have chronic pulmonary disease is reviewed in detail.

Sleep Problems in Children with Respiratory Disorders

589

Mark Splaingard

Sleep problems are common in many pediatric respiratory diseases including chronic lung disease of infancy, asthma, cystic fibrosis, sickle cell lung disease, and respiratory insufficiency due to neuromuscular disease and scoliosis. Given the adverse neurocognitive and physiologic effects associated with a deranged night's sleep, the goal of this article is to enhance the physician's ability to anticipate, recognize, and appropriately manage a variety of sleep-related problems including sleep-disordered breathing, gas exchange abnormalities, insomnias, and circadian rhythm disturbances in order to improve children's function and quality of life.

Central Alveolar Hypoventilation Syndromes

601

Hiren Muzumdar and Raanan Arens

Although respiratory abnormalities and autonomic dysfunction in patients with congenital central alveolar hypoventilation disorders persist throughout life, the prognosis for these children has improved considerably in recent years. This improvement may be attributed to wider recognition of such disorders, specialized centers treating such children, and improved technology to treat and monitor these children throughout life.