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The History of Polysomnography **313**

Maryann Deak and Lawrence J. Epstein

Similar to the first anatomists or the first radiographers, sleep scientists and physicians used electroencephalography and later polysomnography as means of ''peering in'' to the workings of the human body with the hope of gaining understanding. The rapid advancement of sleep research, made possible by the development of polysomnography, permitted not only a deeper understanding of normal sleep, but a more complete picture of the pathologic processes that affect sleep. After 20 years, not only has polysomnography been fine-tuned as a research tool and vital diagnostic test, but it has also made possible the creation of a new medical specialty and a new allied health field.

Generating a Signal: Biopotentials, Amplifiers, and Filters **323**

Patrick Sorenson

Understanding the underlying science of the generation of electrophysiologic signals is necessary to monitor and interpret sleep studies accurately. There are many factors that can alter a signal observed on a polysomnogram. Armed with the knowledge of how an electrophysiologic signal is generated and recorded, those who study sleep and its disorders are expected to be able to separate true from artifactual signals, and know the difference between accurate signal data and unexpected alterations in these signals. At any step in the process the diagnostic accuracy of a polysomnogram may be altered or unreliable, which, if not detected and corrected, could adversely affect the care of the patient.

Recording Sleep: The Electrodes, 10/20 Recording System, and Sleep System Specifications **333**

Kelly A. Carden

The goal of this article is to review the current standards for monitoring and evaluating sleep and wake in clinical laboratory and research settings. The standard parameters used to record sleep and wake are electroencephalography, electrooculography, electromyography, airflow measurement, respiratory effort measurement, electrocardiography, oxygen saturation, snoring monitor, and sleep position evaluation. Each of these parameters is addressed in this article, including the application of the monitoring equipment, the derivations used, and the recommended specifications of the equipment.

Staging Sleep **343**

Michael H. Silber

Since the 1930s, various schemas have been suggested to describe the different electrophysiologic patterns of human sleep. This article reviews the historical

development of sleep staging. The development of the new American Academy of Sleep Medicine manual is reviewed, together with the scientific background underlying the choice of staging criteria. The rules for the different stages of wakefulness, non–rapid eye movement sleep, and rapid eye movement sleep are described, and variations recommended for scoring sleep in children.

Respiratory Monitoring Equipment and Detection of Respiratory Events **353**

Jahan Naghshin and Patrick J. Strollo, Jr.

This article examines the current sleep laboratory tools available for diagnosing sleep disordered breathing. The authors discuss the advantages and disadvantages of each modality and the current state of monitoring in adults. It is important to consider that the use of more than one device may be required in identifying an sleep disordered breathing event. The precision of classifying a given event is dependent on the accuracy of the data generated by a given monitor and how those data are integrated by the scoring algorithm that is employed. The authors also provide a brief discussion of advanced signal processing in existing and emerging technology.

Differentiating Nocturnal Movements: Leg Movements, Parasomnias, and Seizures **361**

Anil Natesan Rama, Rajive Zachariah, and Clete A. Kushida

The need to evaluate nocturnal movements is a common clinical problem in the practice of sleep medicine. Because reports of the movements occurring during sleep typically cannot be relayed by the patients themselves, the event descriptions often become second hand during evaluation by a sleep medicine clinician. Use of polysomnography, at times with use of specialized techniques, becomes an integral part of the diagnosis of these movements. This article describes the clinical steps involved in the diagnostic plan and reviews the most common sleep-related movements and their polysomnographic findings.

Cardiac Monitoring During Sleep **373**

Conrad Iber and Kyuhyun Wang

Normal sleep is associated with slowing of the heart rate and occasional asymptomatic selflimited rhythm disturbances. Obstructive sleep apnea produces cyclical changes in heart rate and an increase in the occurrence of cardiac dysrhythmias. Sleep medicine practitioners should be familiar with routine methods, limitations, and scoring of cardiac events, including sinus tachycardia, sinus bradycardia, narrow and wide complex tachycardias, atrial fibrillation, and cardiac asystole. Other cardiac rhythms that are recognizable within the context of the sleep study should be reported. Changes in cardiac rhythm during polysomnography seldom result in adverse outcomes. Decisions regarding interventions for identified cardiac rhythms should be influenced by the nature of the dysrhythmia, risks identified by patient characteristics and comorbidities, and prevailing patient care strategies in managing heart disease.

Multiple Sleep Latency Test and Maintenance of Wakefulness Test **385**

Douglas Kirsch and Josna Adusumilli

Degrees of excessive daytime sleepiness can be quantified by obtaining a comprehensive history in conjunction with various diagnostic studies, such as an overnight polysomnography, the multiple sleep latency test, and the maintenance of

wakefulness test. Although the multiple sleep latency test and maintenance of wakefulness test are laboratory-based assessments of sleepiness and wakefulness, respectively, these findings on these tests may not always correlate with patient safety in the workplace or while driving. Further research is needed to improve the diagnostic accuracy of our assessments of excessive daytime sleepiness.

Pediatric Polysomnography **393**

Suzanne E. Beck and Carole L. Marcus

Pediatric polysomnography is the diagnostic study of choice to evaluate for obstructive sleep apnea in children, and to evaluate cardiorespiratory function in infants and children with chronic lung disease, or neuromuscular disease when indicated. It is helpful to investigate atypical cases of parasomnias. It is important to understand that children are not just small adults when being studied in a sleep laboratory; they require a child friendly atmosphere and approach, need smaller and specialized equipment, and because of developmental and physiologic differences from adults, have age-adjusted rules for the scoring and interpretation of polysomnograms.

Polysomnographic Features of Medical and Psychiatric Disorders and Their Treatments **407**

David T. Plante and John W. Winkelman

Psychiatric, neurologic, and medical illnesses, and their pharmacologic treatments affect the polysomnographic manifestations of sleep. Many patients undergoing sleep studies have multiple medical problems and often are taking many medications. Therefore, it is crucial that those interpreting sleep studies have an understanding of these effects. In this way, all the potential contributors to the polysomnographic findings can be addressed adequately. This article serves as a primer on changes in polysomnography (PSG) caused by commonly encountered disease states and their pharmacologic treatments.

Artifacts and Troubleshooting **421**

Elise Maher and Lawrence J. Epstein

Recordings are made of the physiologic events during sleep to understand the mechanisms of sleep and wakefulness, identify sleep disorders, determine appropriate therapies, and monitor response to treatment. Correct interpretation depends on producing high-quality, artifact-free recordings. The objectives of this article are to illustrate common artifacts in polysomnographic recordings, to show how to differentiate between physiologic and nonphysiologic artifacts, to describe the known causes of artifacts, to learn to identify the source of artifacts, and to explain how to optimize the postrecording signals.

Portable Monitoring **435**

Nancy A. Collop

The diagnosis of obstructive sleep apnea has been confirmed by polysomnography (PSG) for many years. PSG, however, often is considered inconvenient, expensive, and inefficient. The use of monitoring equipment that can be more portable and used in the home has been developed and frequently is used in countries outside the United States and by some federal agencies such as Veterans Administration hospitals in the United States. These portable monitors (PMs) often record fewer physiologic variables, are unattended, and can be performed in the

home. It is anticipated that there will be more widespread use of portable monitors for diagnosing sleep apnea as sleep centers and insurance companies embrace this technology.

Manual Titration of Positive Airway Pressure in Patients with Obstructive Sleep Apnea **443**

Alejandro D. Chediak

Positive airway pressure (PAP) devices are used to treat patients who have sleep-related breathing disorders including obstructive sleep apnea. After a patient is diagnosed with obstructive sleep apnea, the current standard of practice involves performing attended polysomnography, during which positive airway pressure is adjusted throughout the recording period to determine the optimal pressure for maintaining upper airway patency. Continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BPAP) represent the two most common forms of PAP that are titrated manually during polysomnography to determine the single fixed pressure of CPAP, or the fixed inspiratory and expiratory PAPs of BPAP for subsequent nightly usage in the home. I recently cochaired the PAP Titration Task Force of the American Academy of Sleep Medicine, which reviewed the available literature on PAP titration protocols and strategies and, based on this analysis and expert consensus, developed recommendations for conducting CPAP and BPAP titrations. This article serves to review the task force recommendations and to provide a practical approach to using selected recommendations in the course of laboratory titration of PAP.

The Future of Sleep and Circadian Testing **455**

David P. White

When one writes about the future, there is inherent and obvious speculation, as no one can predict with certainty what will come. That being said, this article reflects a combination of what would seem logical based on the evolving science and what, in the opinion of the author, is needed for the sleep field to grow and prosper. Whether any of this will turn out to be accurate, time will tell.

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