The Evolution of Polysomnographic Technology

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LEARNING OBJECTIVES

On completion of this chapter, the reader should be able to:

1. Discuss some of the key people involved in the development of sleep medicine and technology
2. List some of the hallmark publications related to sleep medicine and technology
3. Provide an overview of the technological advances in sleep medicine and technology
4. Describe a brief history of the Association of Polysomnographic Technologists/American Association of Sleep Technologists

KEY TERMS

Analog (paper) polysomnography
Association of Polysomnographic Technologists
American Association of Sleep Technologists (AAST)
Continuous positive airway pressure (CPAP)
Digital polysomnography
Hallmark publications
Technologic advances

CHAPTER OUTLINE

HISTORY

The seed of polysomnographic technology was sown during the late 1920s and 1930s in research studies in physiology and psychology/psychiatry. Dement’s chronicle of the history of sleep physiology and medicine provides an insight from the perspective of one of the pioneers of sleep medicine (1). Since the first recording of the EEG in humans by Berger (2) in the late 1920s, the following five decades provided the substrate upon which the current level of sleep medicine and polysomnographic technology was built. Much of the information came out of efforts to determine in which state of sleep dreaming was most likely to occur (3–6). It was not until the 1950s when papers by Aserinsky and Kleitman (7,8) describing the electrographic characteristics of REM sleep and the association of REM sleep and dream reports, as well as the work by Dement and Kleitman (9) describing the cyclical variation of sleep depth in normal subjects, that the root system really began to be established.

One of the next events that shaped the evolution of sleep medicine and technology was the development of a standardized manual for terminology and scoring by Rechtschaffen and Kales in 1968 (10). This hallmark publication, likely the most quoted and referenced source in sleep medicine, provided a nomenclature, technical methodology recommendations and sleep scoring method needed to provide a common reference point for future development of the science.

At this point, sleep medicine and polysomnography were yet obscure. In the early to mid-1960s, the electrographic description of sleep onset REM periods was established (11–13), interest in sleep problems from a clinical perspective developed in Europe (14), and the discovery of sleep apnea (15,16) entrenched sleep as a clinical, medical entity. In 1974, the term polysomnography was coined by Jerome Holland at Stanford University following the routine employment of multiple physiologic parameters, adding respiratory and cardiac sensors to the routine EEG, EOG, and chin EMG sensors of sleep studies. The addition of these derivations was instigated following the arrival of Christian Guilleminault, M.D., at Stanford, based on his experience with sleep apnea in Europe (1,17).
The body of knowledge of sleep disorders and sleep medicine advanced and several key resources were published, including the Peter Hauri and William C. Orr classic monograph, *The Sleep Disorders* (18), the Guilleminault-edited *Sleeping and Waking Disorders: Indications and Techniques* (19), the first edition of *Principles and Practice of Sleep Medicine*, edited by Meir Kryger, M.D., Thomas Roth, and William Dement, M.D. (20), and the *Atlas of Clinical Polysomnography* (21) by Nic Butkov, RPSGT.

**TECHNOLOGICAL ADVANCES**

The development of sleep science, sleep medicine, and polysomnography has been codependent on advances in both recording and treatment technology.

It is fascinating to read some of the early information on methodology for recording sleep studies. These recordings were performed on analog equipment, using paper and ink EEG machines with DC capabilities and limited channel availability. Because of the limitations in the number of recording channels, montages had to be well devised to provide adequate information for proper diagnosis, often sacrificing a recording derivation for one that may be more important, based on the presentation of a particular patient. Recording devices with eight, ten, or twelve channels were commonplace; sixteen, eighteen or twenty-one channels were a luxury. Sleep technologists had to possess a good understanding of amplifiers and filters, as well as expected frequency ranges of the physiologic parameters recorded. This was WYSIWYG (what you see is what you get) technology. Improper utilization of filters or sensitivity controls could make stage 4 sleep look like wakefulness or make normal breathing appear to be apnea... and there was no return. Once on paper, it was there for good. Ink-stained clothing from unclogging polygraph pens, changing broken galvanometers, or ink splatter caused by abrupt patient movement, as well as paper cuts from incessant attempts to keep the fifteen to twenty pounds of paper generated folded and aligned from a single overnight recording were common battle scars. Scoring was performed manually and data tabulation was done with pencil and paper, sometimes with the assistance of a calculator. It often took longer to generate the requisite sleep report statistics than to identify sleep stages and abnormal events. The recording technologist could hear the sound of sleep spindles, REM sleep, slow wave sleep, arousals, cardiac dysrhythmias and periodic limb movements. Each had a distinctly different sound generated by the scratching of the pens on the moving paper chart. This was actually quite helpful, as it drew the attention of the attending technologist to a particular patient, when concentration may have been focused elsewhere.

The polygraphs were massive, veritable monoliths, with approximate dimensions of 3’ to 6’ h, 4’ w and 2.5’ to 3’ d, each weighing several hundred pounds (see Figure 1-1). Storage and archival of recorded data was an enormous and expensive problem. The cost of the paper alone for four recordings was over $200 and required about 2.3 cubic feet of storage space for a minimum of seven years (see Figure 1-2). This is not to say that these behemoths were not wonderful, highly reliable workhorses. They seldom failed in such a way that a recording needed to be rescheduled. Fairly simple pen or galvanometer replacement, or occasional swapping of an amplifier board ‘on the fly’ put you back in business. There are times when many of “the old guard” may long for the days of analog recorders with stable amplifiers and filters, in place of nebulous software glitches and corruptions, or the whims and fancies of computer hardware, networks, and interfaces that can put one out of commission for days. Days when adding a couple more beds didn’t mean several months of troubleshooting, as often seen today, even when using the same brand of equipment and software.

Many of the sensors for peripheral devices were constructed in the laboratory. Snore sensors, flow sensors, and mercury strain gauges were often home made and chasing down spilled mercury balls with a syringe or...
pipette was a challenge. Burns and blisters from dropped or mishandled soldering irons were painful.

Ear oximeters were bulky and cumbersome, even painful, and performed poorly or not at all on patients with highly pigmented skin.

Huge technologic strides have been made in the past twenty-five to thirty years. In the late 1980s and early 1990s, computer technology had advanced sufficiently for the introduction of digital polysomnography. As with any new technology, digital recordings were not without problems. Hard drive capacities were insufficient to run the acquisition program and store the raw data. Thirty to fifty Mb hard drives were the standard. Raw data had to be stored on optical media at a cost of about $100 per optical disc. Processor speeds were slow (<100 MHz/sec) and frequent computer crashes due to data overload were a common occurrence. Waveform definition on the computer screen was mediocre at best. Automated sleep staging and scoring algorithms were very inaccurate. However, by the late 1990s, computer technology had advanced far enough to make digital polysomnography the rule rather than the exception. With current technology, massive several hundred Gb hard drives are available, processor speeds have increased to several GHz/sec, archival media storage is very inexpensive (<$1/patient) and several years of recording data can be stored in the space required for one or two nights of paper studies. Resolution of the monitors can produce paper-like, crisp appearing records (see Figure 1-3). Although automated sleep staging is still not sufficient, recognition of abnormal events has improved dramatically, but still requires review and editing.

Despite all these advances, the technologist must still possess a good working understanding of the basics of polysomnographic technology, including amplifiers, filters, sensitivities, expected frequency ranges of physiologic parameters, and troubleshooting. Now, additionally, the technologist must understand the Nyquist theorem, sampling rates, signal resolution, hardware vs. software filters, common referencing, basic networking, and data file management. Indeed, there are more potential recording and troubleshooting issues now than ever before. There are currently over twenty manufacturers and suppliers of digital polysomnography systems.

Today’s recording technologist has high quality snore sensors, thermocouples and thermistors, respiratory effort sensors, etc. available from multiple commercial companies. There are also multiple vendors supplying a variety of preparation materials and supplies needed for polysomnographic recordings. Pulse oximetry devices placed on the finger have replaced the ear oximeter.

Patients with obstructive sleep apnea that could not be ameliorated significantly by weight loss, by maintaining a side sleeping position or by changing bed elevation, were often subjected to a tracheotomy. It was not uncommon, even in a modest sized laboratory, to encounter one or two such cases per week. This provided the impetus for the massive growth in sleep medicine and technology, such as the demonstration of treating obstructive sleep apnea via nasal continuous positive airway pressure (CPAP) by Colin Sullivan and colleagues in 1981 (22).

An effective, nonsurgical treatment for a debilitating, potentially life-threatening disorder had been discovered. In the early years, CPAP masks were individually molded to the patient and adhesive was used to apply the mask. The flow generators were noisy and cumbersome, weighing close to sixteen lbs. Early commercial CPAP devices became available in the mid 1980s (Figure 1-4). Competition among manufacturers continues to lead to increasingly smaller, less noisy flow generators and more comfortable interfaces. Some of the newer flow generators are less than a tenth the size and weight of the early models and very quiet during operation.

Working through the years, the APT leadership has successfully advanced the profession, culminating in April 2003 when the profession of polysomnographic technology was recognized by the Commission on Accreditation of Allied Health Education Programs (CAAHEP) and the Committee on Accreditation of Education for Polysomnographic Technologists (CoAPSG) was formed. The CoAPSG is comprised of three sponsoring organizations: the APT, the American Academy of Sleep Medicine and the Board of Registered Polysomnographic Technologists (BRPT). The CoAPSG established standards and guidelines for the accreditation of educational programs in sleep technology. The CoAPSG recommended the first community college educational programs in polysomnographic technology to CAAHEP for accreditation in 2006.

Within the last few years, the APT has experienced a tremendous growth, leading to development of numerous educational programs and continuing education credits (CECs) for members of the association and those interested in the polysomnographic technology. The APT offers comprehensive review courses to technicians preparing for the BRPT certification exam, scientific sessions, courses and workshops at its annual meetings, position papers, and career opportunities listed on the association’s website, and other valuable resources. The association’s goal is to prepare future RPSGTs for a rewarding career in the field of sleep technology and to enhance their skills and existing knowledge as the profession continues to expand.

The AAST continues to engage new initiatives that promote sleep technology as a separate and distinct profession and that direct the advancement of the profession by increasing recognition in many venues, including the medical community, educational institutions, and the public. New technologies are continually being developed that provide state of the art methods that are used in the evaluation and diagnosis of sleep disorders. The future is certainly difficult to predict, but given the recent developments on multiple fronts, it will provide sleep technologists with opportunities for continued career growth and development for years to come.

REFERENCES