

American Clinical Neurophysiology Society

Guideline 8: Guidelines for Recording Clinical EEG on Digital Media¹

INTRODUCTION

With digital systems becoming widely available and relatively inexpensive, it has become practical to record EEG onto magnetic or optical long-term storage media. Such recording has several advantages. It can help reduce the space problem of storing original paper records over many years. It also allows review of selected portions of an EEG record using montages, filters, vertical scaling (gain or sensitivity), and horizontal scaling (e.g., paper speed) selected after the original recording. Finally, digital recording allows the possibility of further digital processing after the fact.

These recommendations describe only minimal technical standards for recording clinical EEG on digital media. Standardization of the structure and format of the data recorded, for free exchange of compatible recordings among EEG laboratories, is addressed separately by the American Clinical Neurophysiology Society (ACNS) document, “Standard Specification for Transferring Digital Neurophysiological Data Between Independent Computer Systems.”

PATIENT INFORMATION

The electronically recorded information should include the patient’s name and date of birth, date on which the test was run, and relevant patient and laboratory identification numbers. In addition, all the routine information that would normally be written onto the facesheet of the EEG should be recorded electronically along with the EEG signals. Preferably, the EEG report will also be stored and merged with the EEG signal after review of the record by a physician. Correction of errors or omissions in the patient-identifying information should be possible after the recording.

IDENTIFYING INFORMATION DURING THE RECORDING

Calibration signals should be recorded at the beginning and end of each recording, in the manner already conventional for EEG. Biocalibration signals should also be run at the beginning of the record. The time of day should be recorded along with the EEG data, as well as any other information that could be used for finding events in the stored record. The recording should contain all of the technologist’s comments since they would ordinarily be written onto a conventional EEG paper record. The technologist should be able to enter event codes and comments even after the EEG is recorded. Codes recorded with the data can represent common events such as eyes closed or eyes open, beginning and end of hyperventilation, details of photic stimulation, or notation of the patient’s alert, drowsy, or asleep state. Free text comments should

¹ This topic was previously published as Guideline 14.

be able to be entered by keyboard as well, and stored along with the EEG data on the recording medium. In addition, there should be provisions for automatically recording information, such as filter settings, gain, montage selections, and other technical amplifier control settings at the start of the recording, and any changes made during the recording should be immediately recorded with the data.

RECORDING

Acquisition of EEG data onto a digital storage medium should occur at a minimum sampling rate three times the high-frequency filter setting, e.g., 100 samples/s for 35-Hz high filter and 200 samples/s for 70-Hz high filter. Higher rates are preferable. The sample rate needs to be sufficient to prevent aliasing. Digitization should use a resolution of at least 11 bits per sample including any sign bit. A resolution of 12 or more bits is preferable, since the recording should be able to resolve EEG down to 0.5 uV and record potentials up to plus or minus several millivolts without clipping. For example, with a 0.5-uV resolution and a 12-bit analog-to-digital conversion, the maximum allowed excursion would be ± 1.023 mV. This is the dynamic range of the system. Interchannel crosstalk should be less than 1%, i.e., 40 dB down or better. Common mode rejection ratio should be at least 80 dB, preferably better, for each of the channels. Additional noise in the recording should be less than 2 uV peak-to-peak, at any frequency 0.5-100 Hz, including 60 Hz.

RECORDING MEDIA

At the present time, several magnetic and nonerasable and erasable optical storage devices seem adequate for routine long-term recording and storage of EEG records. We recognize the uncertainty about durability, especially regarding magnetic recording media. We also recognize uncertainty regarding the availability of commercial transcription devices to replay the stored EEG years into the future. The present lack of standards for commercial nonerasable optical disk storage results in incompatibility between various commercially available devices and may lead to the impossibility of reading, repair, or replacement of some optical disk recordings and drives within a few years. Newly emerging standards for erasable optical media may make this type of storage less prone to this problem. At present, magnetic tapes can replay EEG adequately after 5 years of storage. However, degradation of the magnetic tape may become a serious problem by 10 years.

Digital EEG systems should employ widely supported storage media (currently CD-ROM or DVD-ROM). They should also use nonproprietary or at least publicly available data formats for storage of EEG data, so that other manufacturers or third party software vendors can read the EEG record or translate it into a format readable by another manufacturer's equipment. Manufacturers should also guarantee that newer reader systems could still read older data that may no longer be compatible with current reading systems. This could be accomplished if a manufacturer provides a service to its customers to convert all of their older media and files to the current format, and if EEG laboratories remain aware of deteriorating legibility or technical obsolescence of older recordings and ensure that these are converted when necessary. Manufacturers should also inform customers in a timely fashion of a need to convert their data

files to maintain legibility.

Note is made of the existence of statutes governing medical records in each of the individual states, as well as existence of local or hospital statutes regarding EEG record storage. These govern the duration of storage, and in some instances they may also dictate whether magnetic or optical storage is to be allowed.

DISPLAY

A recording system for clinical use should have the capability to review recorded EEG data on a video display or on paper, preferably with both types of displays available. Overall, review on paper or on a screen should approximate the temporal and spatial resolution of traditional analog paper recordings. Montages available for review should be consistent with those in standard use in the laboratory and with previous ACNS recommendations, preferably allowing additional user flexibility. This should be done using bipolar or referential reconstruction techniques. Post hoc digital filtering should also be available. Playback systems should be able to display channel (montage) designations, gain or filter settings where appropriate, technologist comments, and event markers along with the raw or transformed EEG data. A time stamp on each screen or page of EEG data is essential.

A standard horizontal scaling should be available in which 1 s occupies between 25 and 35 mm with a minimum resolution of 100 data points/s on screen and 200 data points/s on paper. Other more compressed and more expanded horizontal scales should also be available, including scaling differing from standard by a factor of 2, e.g., 7.5, 15, 30, or 60 mm/s. Vertically, appropriate channel spacing between the baseline of each channel depends on the number of channels displayed. A standard vertical scaling with a minimum spacing of 10 mm per channel should be used for a display of up to 21 channels. Other choices for vertical scaling may be provided too. Larger gaps can be introduced where necessary to separate blocks of channels and increase readability. Occasional overlap of data between channels is acceptable. An adequate screen and paper display should have a minimum of 4 pixels resolution per vertical millimeter. The horizontal and vertical scales on screen and paper should be indicated on the display. For purposes of comparison between different devices, important considerations are the maximum number of channels and the maximum number of seconds that could be displayed on a single screen or on a piece of paper, using the standard scaling as defined above.

The system should allow simultaneous display of multiple segments of EEG, allowing side-by-side visual comparison of different segments within one recording as well as different segments from different recordings obtained on different days. If the playback system has hard-copy capabilities, however, one could also compare different EEG segments by printing them individually. Continuous, fan-folded paper is generally preferable for most EEG applications displaying long segments or the entire record.