Chapter

8 The Structure and Philosophy of the EEG Report

The essential purpose of recording and interpreting an EEG is to communicate information to the clinicians that will help guide the patient's care. When patients are referred for EEG testing, the referring physician often does not have the opportunity to review the EEG personally but usually relies completely on the report of the EEG to learn the findings and clinical implications of the test. Physical and time barriers and lack of EEG expertise may limit direct review of the record. Often, the EEG report becomes the *de facto* permanent record of the results of the study. For these reasons and others, considerable thought should be put into the content and wording of the EEG report, which is typically divided into a number of sections as described in this chapter.

IDENTIFYING INFORMATION

The EEG report generally starts with clinical identifiers, including the patient's name and date of birth, the name and location of the laboratory performing the study, the date of the study, and the name of the referring physician. Next, a brief clinical history is given that includes the general indications for which the study was ordered. This brief summary may reflect a combination of the clinical information that has been provided by the referring physician and additional history that has been obtained from the patient or family by the EEG technologist. The medications taken by the patient and the date of the most recent seizure may also be given, if applicable. This history is usually recounted in a concise fashion:

> This 60-year-old woman is referred because of episodes of confusion lasting 1 to 2 minutes that started approximately 1 month ago. There is a history of a left-sided stroke 3 years previously. The EEG is requested to rule out seizures.

This clinical description serves multiple purposes. First, it may alert the EEG technologist to the necessity of using specific recording techniques. For instance, absence seizures are suspected, the technologist may concentrate particularly on hyperventilation, perhaps even performing it twice. If temporal lobe epilepsy is suspected, the technologist may place extra electrodes over the temporal areas. Second, when the EEG report is completed, issues surrounding the clinical indications for the study are often addressed in the final "Clinical Correlation" paragraph at the end of the report. For example, if the referring physician suspected temporal lobe epilepsy, the EEG report may include additional pertinent negatives that directly address the clinical question posed, such as a comment that no epileptiform or slow-wave activity was noted in the temporal areas. Finally, the clinical history may also alert the technologist and the reader to special situations such as skull defects from previous surgeries, areas of the scalp that are inaccessible because of a bandage or other instrumentation on the head, or perhaps the fact that this is the fourth EEG in a sequence obtained on a patient in a coma.

TECHNICAL SUMMARY

Next, a technical description of the procedure used for the recording is provided. Because in any given laboratory most EEGs are recorded by a standard technique, this descriptive paragraph is usually standardized and only requires revisions when there are deviations from the laboratory's routine procedure. Because the technologist is responsible for the recording procedure, this paragraph is typically produced by the technologist. An example of a procedure description for a routine EEG is as follows:

> A 21-channel digital electroencephalogram was performed in the Clinical Neurophysiology Laboratory of *The Particular Hospital* at a sampling rate of 256 samples per second. The 10-20 international system of electrode placement was used and both bipolar, and referential electrode montages were monitored. Additional electrodes were placed at FT9 and FT10. The patient was sleep-deprived. No sedation was administered. The patient was recorded during the waking, drowsy, and sleep states. The total recording time was 41 minutes.

The next three sections represent the core of the EEG report and are produced by the interpreting electroencephalographer. These include a *description* of the

appearance and findings of the EEG, a summary of the findings or *interpretation* of the EEG (which may include an "abnormality list"), and a *clinical correlation* paragraph discussing the clinical implications of the findings. Each of these sections is now discussed in more detail.

DESCRIPTION

Here the electroencephalographer provides a concise description of the appearance of the EEG. Precise technical terms are used in this part of the report, including electrode names from the international 10-20 system and a variety of other EEG terminology. The goal of this portion of the report is to allow another electroencephalographer to visualize the appearance of the recording without actually having seen the original tracing. Provided with a well-written description, an experienced electroencephalographer should ideally be able to draw up the same abnormality list and clinical conclusions that would have been made had he or she personally reviewed the tracing. To provide this level of detail, the technical description paragraph may include EEG terminology that is not necessarily completely understandable by an internist or other general physician, or even in some cases by a neurologist who does not specialize in electroencephalography.

A good description allows a second electroencephalographer either to confirm the identifications of waveforms given in the interpretation paragraph or perhaps to disagree with them. For instance, if low-voltage sharps waves in sleep in the occipital areas with positive polarity were described as epileptiform activity, such a description may lead a second (more experienced) electroencephalographer to reject this interpretation and reidentify them as POSTS (positive occipital sharp transients of sleep), a normal variant (see Chapter 11, "Normal Variants in the EEG," for further discussion of POSTS). Formally, the description paragraph should consist of pure description of the visual appearance of the EEG; conclusions as to whether a described wave is normal or abnormal are not absolutely required in this paragraph and would usually appear in the interpretation section. In practice, for clarity's sake, some readers will flag findings as normal or abnormal in the description, especially if there are multiple findings, so that the message of the report is as clear as possible.

If appropriate to the EEG, the description is organized according to sleep state. Separate paragraph descriptions may be written for wakefulness, drowsiness, and sleep as needed. In the paragraph describing wakefulness, it is customary to quote the frequency and reactivity of the posterior rhythm, assuming it is identifiable. The amount of fast activity present during wakefulness is also commented on. A sleep paragraph would generally describe the presence of vertex waves and spindles if these are present. Any additional findings in each state would also be included in these sections. A typical description of normal wakefulness and sharp waves in sleep might include the following:

> AWAKE
> A moderate amount of 11- to 12-Hz medium-voltage rhythmic waves are seen posteriorly that suppress with eye opening. A small amount of symmetric 18–30 Hz low-voltage fast activity is seen anteriorly bilaterally.
>
> ASLEEP
> Stage II sleep is seen with vertex waves and a moderate amount of 14-Hz bicentral sleep spindles. Low- to medium-voltage sharp waves are seen occasionally in T8.

These two paragraphs describe the background activity during wakefulness and the presence of normal sleep elements. It is also clear that the right anterior temporal sharp waves were seen in sleep but not during wakefulness.

INTERPRETATION

This paragraph generally starts by clearly stating whether the EEG is considered normal or abnormal, assuming that this determination can be made. Terms such as "probably normal" or "probably abnormal" should be avoided whenever possible as they limit the usefulness of the report and are often found frustrating by the clinician who receives the report. Such noncommittal terms should only be used in the small minority of cases in which a determination of normality is not possible.

At this point in the report, it is also useful to give an abnormality list, an example of which follows:

> This EEG is abnormal due to the presence of
>
> 1. low- to medium-voltage spikes maximum in the right anterior temporal electrode during drowsiness and light sleep and
> 2. increased slow-wave activity over the right hemisphere during drowsiness, maximum in the right mid- and anterior temporal areas.
>
> No other asymmetries or epileptiform activity was noted.

Note that this portion of the report could have described "a discharge maximum in F8, with slow-wave activity maximum in F8 and T8." Because some future readers of the report may not be familiar with the official names of electrode positions and other technical EEG terminology, in this section of the report, it is preferable to use plain English terminology such as "right anterior temporal" rather than "F8." An abnormality list gives the report reader an opportunity to get a quick picture of the EEG findings by scanning the list. In reality, many report recipients may lack the time, patience, or expertise to go back and read the technical description

portion of the report. The goal is to write an interpretation paragraph that can stand alone and communicate the main findings of the EEG.

In both the description and interpretation paragraphs, the location and field of EEG events should be given with as much specificity as the tracing allows. For instance, if a spike has been found in the F8 electrode, it is insufficient to describe it simply as a "right temporal spike"; after all, there are *at least* three right temporal electrodes (anterior, mid-, and posterior temporal). In fact, a spike in the right anterior temporal area and a spike in the right midtemporal area may have significantly different clinical implications.

CLINICAL CORRELATION

The paragraph on clinical correlation is probably the most useful to the referring physician, yet it may be the most difficult to write, partly because many EEG findings are nonspecific (i.e., the patient's EEG findings usually do not establish a specific diagnosis). Therefore writing this paragraph is not as simple as stating "*Finding A* is present, which implies that the patient has *Diagnosis B*." The challenge of writing this paragraph lies in neither understating nor overstating the clinical implications of whatever findings are present. Rather, abnormal EEG findings may increase the chances that a diagnosis is present, yet they will rarely establish a particular diagnosis definitively. Thus, the clinical correlation paragraph must be worded with care. For example, it is well known that the presence of spikes in the EEG is not associated with a diagnosis of epilepsy 100% of the time. Many individuals go through life with spikes in the EEG, possibly never knowing they have them and never experiencing a single seizure. Nevertheless, the presence of spikes in the EEG makes it more likely that that person does have epilepsy compared with another person who does not have such spikes. The report should, therefore, communicate this concept of "increased risk" or "an association" rather than appear to be diagnosing epilepsy:

> Spikes in the right anterior temporal area suggest the possibility of a decreased seizure threshold in that area. Slowing over the right hemisphere suggests the possibility of an anatomical or functional (post-seizure) change in that region.

These sentences make it clear that the epileptiform abnormality seen in the EEG increases the chances that the patient has epilepsy, but does not establish the diagnosis. The slowing over the right hemisphere could have a number of possible causes, such as stroke, tumor, or the recent occurrence of a focal seizure from that hemisphere. The same type of thinking can be used when writing a clinical correlation for a normal EEG. Some electroencephalographers choose to signal to the referring clinician that a normal EEG tracing does not exclude the diagnosis of epilepsy.

The electroencephalographer must resist temptation to suggest further diagnostic studies in the report. For instance, in the earlier example, the combination of spikes in the right anterior temporal area associated with slowing over the hemisphere do suggest the possibility of a fixed right hemispheric lesion. The findings are potentially consistent with the patient having a right temporal lobe glioma (among other diagnoses). Why not suggest the patient undergo magnetic resonance imaging (MRI)? Because the electroencephalographer often does not know the patient firsthand, it may not be known that the patient had neuroimaging 4 months earlier. In such a case, a suggestion that an MRI be obtained may be confusing. Is the electroencephalographer saying that the MRI should be repeated? Decisions about obtaining neuroimaging are best made by the clinician who knows the entirety of the patient's story, including the EEG report.

Similarly, the EEG report should not suggest specific medications. The patient may have already been on a suggested medication in the past or could even be allergic to a suggested medication. Again, medication decisions should only be made by the treating physician who knows the whole story, not just the appearance of the EEG.

WHAT IS AN ABNORMAL EEG FINDING?

This question is not often asked directly, but when making the decision to label an EEG finding as normal or abnormal, the meaning of the word "abnormal" should be considered. As an initial thought, one might feel that a finding that is uncommon or rarely encountered should be considered abnormal. This is a poor definition for many reasons. For instance, in a given town, individuals who have red hair might be quite rare. Nevertheless, having red hair is not abnormal. The rarity of a given finding does necessarily indicate that it is abnormal. Rather, for the purposes of EEG interpretation, a finding should be considered abnormal if it is associated with *pathology* (disease or disability).

Consider the following hypothetical example: you have been reading EEGs for a year and have noticed a small group of patients with an atypical finding, for which you have invented the term "x-wave." Because x-waves look so unusual and so few patients have them, you are inclined to consider them abnormal. What threshold should be used to make a definite assertion of abnormality? You decide to conduct the following study: You collect 100 patients with x-waves and compare them to 100 patients of the same age who do not have x-waves. You then compare the two groups, looking to see whether one group has more epilepsy (or any other pathologic condition) than the other. You find that the rate of epilepsy is 1% in both groups. No other disorder is more common in one group than the other. Therefore, even though at first these x-waves did not "look right" to you, you finally conclude that x-waves represent a normal variant. Even though they are rarely seen, it is incorrect to call them abnormal because they are not associated with pathology or disease.

If, however, individuals with "x-waves" have more seizures, or mental retardation, or brain tumors than the 100 patients who lack them, then the fact of this association can be included in the reports of patients who have x-waves. In the real world, it is surprising how difficult it can be to perform this seemingly simple hypothetical study. Although it may not be particularly difficult to amass a large number of patients with one EEG finding or another in a busy EEG laboratory, the real challenge lies in assembling a "normal" comparison group. In reality, it is logistically difficult to obtain the recordings of 100 "normal" 50-year-olds or 100 "normal" schoolchildren. How does one choose 100 normal patients and then induce them to come to the EEG laboratory for a study? If 100 patients are invited and 50 refuse, are the remaining 50 still a "random" group, or may there be a difference between refusers and nonrefusers? How does one ethically handle the eventual occurrence of EEG abnormalities discovered in the so-called normal group?

The example of the hypothetical "x-wave" serves as a cautionary tale. It reminds us that even if an EEG tracing does not "look right" to us, we should not jump to the conclusion that it is abnormal. Properly, if abnormal, whatever does not "look right" should be categorizable as a known abnormality type. After it is categorized, the type of pathology that has been associated with that abnormality type can be cited in the Clinical Correlation section. If something does not "look right" in the EEG but it is not possible to categorize it as a known abnormality type, one must hesitate before calling it abnormal. The finding should still be described in the report, noting that it is of "uncertain clinical significance."

The histories of several of the known "normal variants" (see Chapter 11) have followed this course. Initially, because they "looked abnormal" and were recorded in individuals with epilepsy (because most EEGs are obtained in persons with epilepsy), they were presumed to be abnormal. Only later was it recognized that certain of these findings were present with significant frequency in the normal population, leading them to be reclassified as normal variants.

THE THRESHOLD FOR "ABNORMAL"

In the course of interpreting EEGs, from time to time the question arises as to whether a wave is sharp enough or an asymmetry asymmetrical enough to label abnormal. For instance, several waves are seen in the EEG, but it is not clear that they are sharp enough to be labeled as spikes. After a lot of thought, you estimate that the chances are fifty-fifty that the discharges represent an epileptiform abnormality. Is it best to err on the side of calling the discharge normal or abnormal? What is the potential impact of each type of judgment, which might represent a different type of error?

Imagine the following hypothetical story behind the patient described earlier with the "fifty-fifty spike." Although the EEG reader may not know it, the EEG was obtained because the patient had an episode of loss of consciousness. The referring physician is completely undecided as to whether the patient has had a syncopal event (a simple fainting spell) or an epileptic seizure. What would the consequences be of either type of reading error in this patient's EEG: calling a normal wave a spike or missing a true spike and calling the EEG normal?

First, consider the scenario in which the patient does not have epilepsy and the discharge is not really an epileptic spike, but you make the error of reporting that an epileptic spike is present. The referring physician reads your report and comes to the (erroneous) conclusion that the patient has epilepsy and considers starting an antiepileptic medication. The patient is labeled as having epilepsy and cannot drive for a period of time according to local law. In this case, the patient is now considered to have a potentially chronic disease where none exists and may be unnecessarily receiving antiepileptic medications. Perhaps the referring physician should realize that the finding of a spike in the EEG does not necessarily compel the diagnosis of epilepsy. Unfortunately, epileptiform findings in the EEG tend to carry more weight than they should among nonspecialists.

In the second scenario, the patient does have epilepsy but you make the "error" of calling the EEG normal. In this situation, however, the "opposite" sequence of the events does not necessarily occur. This is partly because it is known that individuals with epilepsy may still, from time to time (and sometimes repeatedly), have a normal EEG. The referring physician cannot exclude the diagnosis of seizure simply because of your report of a normal EEG. In reality, this patient does have a seizure disorder and your reading "error" may, at the very least, delay the diagnosis and incur any of the disadvantages to the patient consequent to that delay. If the patient does, in fact, have epilepsy, additional spells will probably occur, providing additional descriptions of the event that may be more clearly suggestive of seizure. There will also be additional opportunities to check the EEG. One may argue that this type of error could delay the ordering of neuroimaging that could reveal an important finding, such as a tumor, leaving the patient inappropriately untreated. In fact, if a tumor is present, additional symptoms or spells will probably occur, eventually prompting the ordering of neuroimaging studies.

Which type of error is worse, "overcalling" or "undercalling" the spike? In the scenario just described, the "overcalling reader" encountering 100 patients with a "50-50 spike" could be responsible for giving 50 patients an erroneous diagnosis of epilepsy. The "undercalling reader" will be responsible for delaying a true diagnosis of epilepsy in 50 people. Although neither is desirable, most would say that the first scenario in which fifty patients are given a diagnosis that they do not have is the less desirable outcome. Physicians are generally charged with alleviating disease, but in this scenario, the physician has effectively attributed to these patients a disease they do not have, possibly relegating them to unnecessary long-term therapy and other possible negative consequences. In the second scenario, the diagnosis of a seizure disorder, and its etiology may be missed or delayed.

Although this is not desirable, if disease is present, it will likely declare itself at some time in the future. If it does not, then no harm has been done. In summary, the type of error in which abnormalities are "undercalled" is usually the lesser of two evils: it is generally worse to *erroneously label* a patient with a disease he or she does not have than to *delay the diagnosis* of epilepsy in another patient, keeping in mind that a good physician knows that a normal EEG does not exclude the diagnosis of epilepsy. For this reason, it is recommended that readers lean to the conservative side in making judgments about findings that are not entirely clear. While giving an EEG tracing a normal interpretation, the electroencephalographer also has the option of including a comment in the EEG that reflects the difficulty of the decision:

Several waveforms seen in the O2 electrode attain sharp contours at times, but probably fall within the range of normal. Although these do not clearly represent an example of sharp waves, the question could be further investigated by obtaining a repeat study, if clinically indicated.

Although the reader should be able to categorize the large majority of EEG tracings as normal or abnormal, in the case of unclear findings the reader may wish to communicate to the referring physician that "a repeat study may provide additional useful information." This kind of wording and phrases such as "if clinically indicated" are chosen so as not to appear to compel the referring clinician to obtain a repeat study if one is not necessary when the patient's overall picture is considered.

THE CONCEPT OF INDEPENDENT OBSERVATIONS

Imagine that you are reading an EEG and you have a brief suspicion that there is slowing over the right hemisphere. By the time you get to the end of the EEG, however, you have convinced yourself that the asymmetry was not persistent enough and you have decided to make an overall interpretation of the EEG as normal. Before preparing the final report, however, by chance you come across the patient's MRI report, which describes a stroke in the right hemisphere. Should you reverse your decision and write your report so that it describes slowing in the right hemisphere? After all, the patient does have a stroke there! The answer is that you should not change your opinion of what the tracing shows based on the patient's clinical history. Often, clinicians refer patients for additional studies to confirm the importance of other findings and to see whether they "line up" with one another. In this case, it is possible that the referring physician has reviewed the MRI scan but doubts the presence of the stroke, thinking that the MRI was interpreted incorrectly. By ordering the EEG, the referring clinician was seeking an independent corroboration of the MRI finding. The purpose of the current EEG interpretation is not simply to echo the finding of what was found on a previous study. The ordering physician certainly has not referred the patient for EEG just to hear a repetition of the findings in the MRI report. Instead, to be useful, the results of your EEG interpretation should represent an independent observation.

To avoid the temptation of this type of error, many electroencephalographers do not read the patient's history before looking at the tracing. This is good practice. It also increases the sense of satisfaction the reader gets in picking up subtle right hemispheric slowing and learning that the patient has had a stroke on that side only after a conclusion about the EEG slowing has been reached. If the reader is already aware that the patient has a stroke on the right side before looking at the first page of the EEG, it may be psychologically difficult not to see slowing over the right hemisphere. The search for slowing over the hemisphere "where it's supposed to be" may absorb so much mental energy that other abnormalities may be missed because of the distraction. The best time to review the patient's history is after the EEG has been read, at least for the first time, and a preliminary conclusion has been reached. After the initial reading, it is not "dishonest" to review the record again in light of the patient's history to make sure that something has not been missed. If the interpretation is changed at this point in the process, the reader fully realizes that the finding was not evident to him or her without the additional clue of knowing the patient's history.