"JUST LIKE EKGS!" SHOULD EEGS UNDERGO A CONFIRMATORY INTERPRETATION BY A CLINICAL NEUROPHYSIOLOGIST?

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"Just like EKGs!" Should EEGs undergo a confirmatory interpretation by a clinical neurophysiologist?

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ABSTRACT

The misdiagnosis of epilepsy is common and has serious consequences. A major contributor to the misdiagnosis of epilepsy is the tendency to overread normal EEGs as abnormal. In fact, the wrong diagnosis of seizures is sometimes based solely on the "abnormal" EEG. Reasons for the common overinterpretation of normal EEGs are mostly related to the lack of standards or mandatory training in EEG, and the erroneous assumption that all neurologists are trained to read EEGs. The most common overread pattern consists of benign, nonspecific, sharply contoured temporal transients. In particular, there is a common misconception that "phase reversals" are indicative of abnormality. Potential solutions include defining and ensuring EEG competency of neurologists who read EEGs, and perhaps providing a confirmatory reading by an electroencephalographer, as is done for EKGs. Neurology® 2013;80 (Suppl 1):S47–S51

GLOSSARY

ACGME = Accreditation Council for Graduate Medical Education.

A WEEKLY CASE AT AN EPILEPSY CENTER A 74-year-old woman presents with an episode in which she lost consciousness in her kitchen after prolonged standing while washing dishes. She reported feeling dizzy, slumped to the ground, and "was out" for some time (unclear how long). She was brought to the emergency department and was admitted for 24 hours. She was seen by a neurology consultant (not sure why) and had an EEG (not sure why). The EEG was read as showing "temporal sharp activity with phase reversals," so she was diagnosed with a seizure and placed on levetiracetam. The EEG in question was reviewed (figure 1) and was completely normal. The diagnosis was changed to syncope, and levetiracetam was gradually withdrawn without further loss of consciousness.

THE PROBLEM This scenario frequently occurs at epilepsy centers. Furthermore, for one patient like this whose diagnosis is eventually rectified, there are likely dozens that never are. Approximately 30% of patients admitted for EEG-video monitoring for refractory seizures do not have seizures and have been misdiagnosed.[1] As illustrated here, many times the history is not particularly suggestive of seizures (the patient clearly had a syncope), and the diagnosis of seizures is predicated solely on the "abnormal" EEG.[2–8] This of course goes against what is taught at every medical school and during neurology training ("we do not treat the EEG"). It is also why many believe that "routine interictal EEG recording is one of the most abused investigations in clinical medicine and is unquestionably responsible for great human suffering."[5] A dangerous formula is:

Vague Nonspecific Symptoms + an Overread EEG = Incorrect Diagnosis of Seizure(s).

There is no doubt that EEG can be bad for you. The consequences of being misdiagnosed with epilepsy are obvious and serious.[9] Once the "abnormal" EEG is a part of the patient's medical record, there is no way for subsequent EEGs to cancel the effect of an abnormal interpretation. An incorrect diagnosis provided by a wrong EEG interpretation is very difficult to undo. Unlike a CT or MRI scan that is misread, repeating the test and obtaining a normal result will not cancel the effects of the "abnormal" one. Only re-review of the same abnormal sample can cancel the misdiagnosis and undo the harmful result. However, this can be time-consuming and fraught with difficulties (e.g., CD and software compatibility).

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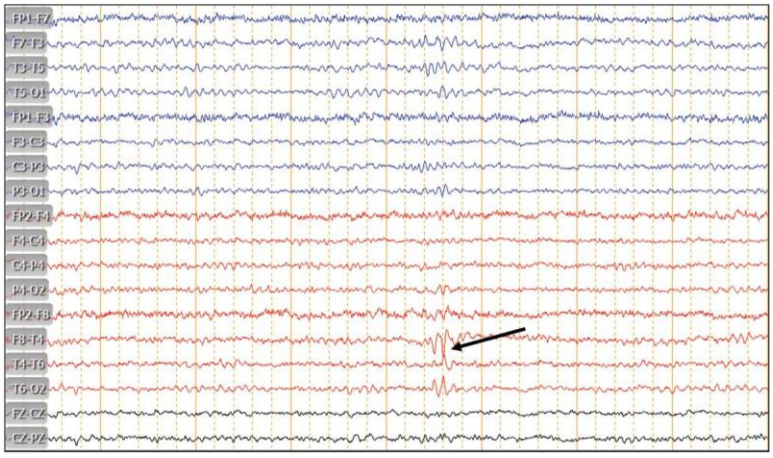
Figure 1 Actual EEG interpreted as "abnormal" after syncope



Note the sharp waveform maximal at T4 (arrow) that reflects a wicket spike in drowsiness.

REASONS FOR THE OVERINTERPRETATION OF EEGs The EEG patterns that may be overread can include several well-known normal variants, but these patterns are relatively infrequent.[6] The vast majority of overread patterns are artifact, wicket rhythms, or "nameless variants,"[6,8] which are variations of normal rhythms that produce simple fluctuations of sharply contoured background or fragmented alpha activity that does not fit into a well-described EEG waveform. These nameless fluctuations of normal backgrounds have been described under different names and are found on most EEGs.[10–15] Differentiating normal variants from meaningful spikes and sharp waves can at times be challenging, but helpful rules have been described.[6–8,16–23] Unfortunately, this is often evident to EEG/epilepsy specialists, and most EEGs are read by general neurologists (just like most EKGs are initially read by noncardiologists). In addition, as illustrated in the case above, there is a widespread overemphasis on "phase reversals" (figure 2). The common and unfortunate misconception is that phase reversals are somehow indicative of abnormalities (see survey results in the introductory comments in this issue of Neurology). Phase reversals do not indicate epileptogenicity or even abnormality. They only indicate location.[6–8]

- The importance of the EEG is overemphasized, and it is especially detrimental when it is interpreted out of clinical context. The diagnosis of seizures relies mainly on a good history, which requires skills and time. Unfortunately, doctors

Figure 2 Report examples of the term "phase reversal" as if it meant something abnormal or epileptiform

a.m.). Frontal eye movement artifact was minimal. Muscle artifact was minimal. The background activity was dominated by 8 cycles per second normal alpha rhythm. Frequent phase reversal form sharps with secondary bursts of high amplitude sharp monomorphic discharges were seen.

IMPRESSION:
1. Abnormal EEG in view of FIRDA. This was previ
has also been seen in underlying vascular disease a
2. Sharp waves and occasional sharp-and-slow wa
temporal head region and at times phase reverse n
of cortical irritation raising the possibility of seizure.

IMPRESSION:
Abnormal EEG due to the p
phase reversal complexes
T3-T5. Even though they v

ent did reach a sleep stage during this EEG, and therefo
vertex waves were seen intermittently throughout the gra
2 or 3 episodes of phase reversing sharp waves seen pri
oral lobe at T3 and T5. There was also 1 episode at C3.

Intermittent sharp waves arise from the left temporal head region best
posterior temporal head region. Phase reversal at T3. T5 electrodes i
discharge was seen.

Hyperventilation was not technically feasible. Photic stimulation produc

IMPRESSION: Abnormal EEG. In view of intermittent sharp waves a

4 Hz. Also, seen are epileptic spike waves seen with phase reversal maximally seen over bifrontal central electrodes with a clear epileptic appearance.

and patients (and lawyers) tend to have more faith in "tests." It is often easier (and more lucrative) to order an EEG than to elicit a good history. Whatever the reason, the combination of vague, nonspecific symptoms with an equivocal (weak) EEG abnormality is a very common cause of wrong diagnoses of seizures.[4–8,24] Our patient had an obvious syncope and did not need an EEG, and probably not even a neurology consultation.

- One important human factor is that the reader is "trying too hard" to find abnormalities because the patient had a "seizure" (history bias). The frustration of having yet another normal EEG in a patient who had a seizure leads to the "looking too hard" syndrome.

EEG TRAINING DURING NEUROLOGY RESIDENCY

- The fundamental reasons (for the overreading) are lack of training and inexperience (i.e., not seeing enough normal tracings and the range of normal variations) and not applying strict criteria to make sharply contoured waveforms epileptiform. The less experience, the lower the threshold for "abnormality." For the same reason, a neuroradiologist will have a higher threshold than general radiologists for calling an MRI abnormal, and a cardiologist will have a higher EKG abnormality threshold than an internist. Unfortunately, there is currently no Accreditation Council for Graduate Medical Education (ACGME) requirement for EEG, and one can become a full-fledged and certified neurologist with very little or no experience in EEG. This results in a low and "nervous" threshold for abnormality, which leads to overreading of normal patterns.
- Most neurology training programs include a neuropathology rotation, but we would never assume that neurologists should interpret pathology slides and make tissue diagnoses that determine prognosis and management. Should we assume that any trained neurologist is competent to read EEGs?
- Many neurologists who read EEGs are not adequately trained to do so. The author's observation is that most EEGs ordered in routine clinical practice (typically for encephalopathy) have little or no impact on diagnosis, management, and outcome. For the diagnosis of seizures and epilepsy, however, the consequences of misreading are enormous.

POSSIBLE SOLUTIONS AND RECOMMENDATIONS

1. Use a backup or confirmatory interpretation. Cardiologists have utilized this system for years. A general practitioner (emergency physician, pediatrician, or internist) needs to be able to read EKGs or chest radiographs to make immediate clinical decisions, but as a safeguard against serious errors, a confirmatory and "official" reading by a cardiologist or radiologist almost always follows. Even for neuroimaging studies (e.g., MRI), an official and confirmatory interpretation eventually comes from a (neuro) radiologist. A good argument can be made that we should have the same for EEGs. The general population and medical community assume that all neurologists are competent to interpret an EEG with similar reliability. Competencies are currently being defined for newer procedures (e.g., transcranial Doppler) to ensure that neurologists who interpret them are qualified, but EEG is assumed to be an easy and standard test, perhaps because it is not a new test. It is not easy. If all neurologists can read EEGs to manage their patients, there should be some safeguard with a confirmatory reading by an electroencephalographer or epileptologist.
2. If we are to assume that all neurologists who want to read EEGs are qualified to do so, there should be better, more, and mandatory EEG training during neurology residency. It would be inconceivable to become an internist without demonstrating some proficiency in EKG interpretation, and in fact, this is specifically addressed in the cardiology and internal medicine fields.[25–32] Not so for EEGs. As is done for electrocardiography, ACGME should require minimum EEG training in neurology residency, in terms of quantity (so many months, so many studies) and quality (under the supervision of electroencephalographers/epileptologists). ACGME currently has very few specific requirements, and "clinical neurophysiology" is mentioned together with neuropathology and neuroimaging. However, there is an enormous difference because pathology specimens and neuroimaging studies are not read only by the neurologist. (We are, of course, welcome to look, but an official report comes from a trained pathologist or radiologist.) Clinical neurophysiology studies (EEGs, EMGs) are interpreted only by neurologists. We are it and have the final say.
3. Define special competency for neurologists who choose to interpret EEGs. Our colleagues in cardiology have paved the way for us in this regard. Such training requirements for noncardiologists who read EKGs in their practice are put forth and subjected to ongoing discussions.[25–32]

More immediate and less politically charged measures include the following:

- "Conservative" reading should be strongly emphasized during EEG training. All epileptologists

agree that overreading is more harmful than underreading; in fact, this may be the only thing on which all epileptologists agree! "Hardly anyone with epilepsy will come to any harm from a delay in diagnosis, whereas a false-positive diagnosis is gravely damaging."[5] "Much more damage is done by overdiagnosis than by underdiagnosis of epilepsy."[20]

- To avoid the "looking too hard" syndrome, EEGs should be classified blindly to (unbiased by) the history: this is in fact practiced and recommended by many EEG and epilepsy authorities, and should be incorporated into EEG guidelines. (The clinical interpretation should, of course, incorporate the history and the clinical setting, but the EEG itself should be classified without the history.)
- There is a need for authoritative guidelines on EEG interpretation. Unfortunately, the only existing American Academy of Neurology guidelines related to EEG are on esoteric or clinically irrelevant topics, such as quantitative EEG (1997 and 2003) and the EEG in the evaluation of headaches (1995). The American College of Cardiology works together with the American Society of Internal Medicine, the American College of Physicians, and the American Academy of Emergency Medicine[25–32] to raise standards for EKG. Our professional organizations (American Academy of Neurology, American Epilepsy Society, American Clinical Neurophysiology Society) are working to address this politically difficult situation and working together to raise standards in EEG, in the interest of our patients.

It should be pointed out that this is hardly a new problem, having been addressed somewhat by classic EEG pioneers.[33] This makes it even more disheartening that 25 years later it is not addressed or even discussed by our professional organizations.

AUTHOR CONTRIBUTIONS

S.R. Benbadis: drafting/revising the manuscript, analysis or interpretation of data.

DISCLOSURE

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