Should I Order an EEG? An Overview of Electroencephalography in the Hospital Setting at Gundersen Lutheran Medical Center

**ABSTRACT**

Nonneurologists have become less familiar with the electroencephalogram (EEG) and with the questions it can help answer. The EEG can (1) help identify the etiology of mental status changes; (2) help determine the presence, persistence, and type of seizure activity; and (3) assist with the prognosis of patients in coma and assessing their outlook for meaningful recovery. This paper clarifies for clinicians the use of the EEG in a hospital setting.

**HISTORY**

Hans Berger first recorded the electroencephalogram (EEG) in humans in Germany in 1929. By 1935, the technology was available to begin describing the EEG correlates of various pathological states. The 1940s saw EEG laboratories springing up all over the United States and the world, and the EEG quickly became the standard for investigating brain physiology in health and disease. The routine EEG records brain cortical electrical activity for about 30 minutes, using 21 electrodes applied to the scalp and ears; the activity is measured in microvolts. These tiny voltages require special amplifiers to minimize environmental electrical noise and other artifacts. Compared with the older paper-and-pen–writing EEG, modern EEG instruments using digital technology allow more information to be extracted from the available data. Just as with the older systems, interpretation of the routine EEG relies upon visual analysis.

At Gundersen Lutheran, the number of EEGs performed has declined from over 2000 per year in the 1970s to approximately 600 per year in the last decade. Much of this decline is due to advances in brain imaging, but it should be pointed out that the cost of a routine EEG in our institution is approximately 600 per year in the last decade. Much of this decline is due to advances in brain imaging, but it should be pointed out that the cost of a routine EEG in our institution is approximately 600 per year in the last decade.
SHOULD I ORDER AN EEG?

But spikes and sharp waves (epileptiform abnormalities) may be less frequent in the immediate postictal period than they are interictally. In patients with definite epilepsy, a single interictal EEG has a sensitivity of about 50% to 75% in demonstrating an epileptiform abnormality. Thus, a single normal EEG does not rule out epilepsy. If the initial EEG is normal, sleep deprivation improves the sensitivity, as does repeating the study. After 3 EEGs, the sensitivity approaches 90%. Fortunately, the test is relatively inexpensive. In patients with frequent spells, an all-day video EEG may be needed in an attempt to capture and define the episodes. A common type of seizure disorder in adolescents and young adults is juvenile myoclonic epilepsy (JME). JME constitutes 5% to 10% of epilepsy in most series and often presents with convulsions. While appropriate medications are very effective in JME, many of the traditional anticonvulsants are ineffective in controlling this epilepsy syndrome—or may actually worsen seizures. The EEG is key to making the diagnosis.

WHAT IS THE PROGNOSIS?

This question is often asked in the setting of coma secondary to anoxic/ischemic encephalopathy after cardiopulmonary arrest or after head injury. Some EEG patterns suggest a favorable outcome. For example, a background reactive to environmental stimuli—or an EEG with normal sleep features such as sleep spindles—are patterns that suggest a favorable prognosis. Other patterns carry a poor prognosis, such as diffuse monotonous unreactive 8 Hz to 13 Hz activity (the alpha-coma pattern), or bursts of electrical activity mixed with periods of background flattening (the burst-suppression pattern). In the absence of hypothermia or barbiturate overdose, a completely flat EEG, which indicates electrocerebral inactivity, is incompatible with recovery of brain function. Since the EEG is completely silent during arrest and may take several hours to recover, it is usually best to wait a day before performing an EEG for prognosis. If symptoms are suggestive of seizures, however, the EEG may be done earlier. Median nerve (upper extremity) somatosensory evoked potentials (SSEP), a test using EEG technology, is 100% specific for predicting poor outcome (death or vegetative state) in anoxic-ischemic coma, when the early potentials are bilaterally absent within the first week of coma. The SSEP has the advantage of being relatively resistant to drugs and metabolic changes.

CASE EXAMPLES

Case 1

A 76-year-old man was found in the hall of his apartment building, confused. His neighbor called an ambulance, and in the emergency department the man was noted to be mute, he followed commands only sporadically, and he had a blood pressure of 220/100. The emergency physician observed tremors of the left arm and leg associated with tonic eye deviation to the left, with nystagmus. After receiving intravenous lorazepam and fosphenytoin, the patient was somnolent, moved the right side only to noxious stimuli, and had conjugate gaze to the right. An unenhanced head CT scan showed some old microvascular ischemia changes, but nothing acute. The patient remained obtunded the following day, and a magnetic resonance imaging (MRI) scan of the brain showed no acute abnormalities. A bedside EEG (Figure 1, Figure 2) revealed almost continuous right temporoparietal seizure activity. He received intravenous valproate, promptly awakened, and was discharged. In the months following discharge, he had several partial (focal) seizures and is now participating in an experimental anticonvulsant medication protocol at Gundersen Lutheran.

Lessons from this case: (1) Some cases of apparent stroke represent seizure activity; and (2) A patient with unexplained or prolonged decrease in level of consciousness may be experiencing subtle status epilepticus, and ordering an EEG is the only way to investigate this possibility.

Figure 1. Subtle subclinical focal seizure activity in a confused elderly patient.

Figure 2. Voltage map of focal seizure activity in the patient whose EEG tracing is shown in Figure 1.
**Case 2**

A 17-year-old high school senior had a witnessed, generalized convulsion at home after taking a nap in the afternoon. She had no aura, but she admitted to several years of occasional “jerkiness” without loss of consciousness in the mornings before school. The initial unenhanced head CT scan was normal, as was an MRI scan of the head the following day. A routine EEG prior to discharge was likewise normal, and she was discharged on phenytoin. A sleep-deprived EEG the following week (Figure 3) revealed frequent generalized polyspike and slow wave bursts associated with myoclonic jerks of both arms. The myoclonus and EEG paroxysms subsided promptly after a single oral dose of valproate, and she was subsequently switched to lamotrigine. She remains seizure-free and has no myoclonic jerks, so long as she avoids alcohol and gets adequate sleep.

Lessons from this case: (1) A single normal EEG does not rule out epilepsy; (2) In some cases, sleep deprivation activates epileptiform abnormalities on the EEG; and (3) The EEG can help the clinician select the appropriate anticonvulsant medication.

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**COMMENT**

For hospitalized patients, EEG is an inexpensive and noninvasive tool for investigating brain function, something not assessed by traditional imaging studies. A routine EEG can help the clinician answer several types of questions posed by the history and bedside physical exam. EEG is quite sensitive in the presence of organic disease, but it is often nonspecific in many of the toxic and metabolic encephalopathies. In cases of confusion or obtundation, however, EEG may suggest a specific anticonvulsant regimen.

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**Figure 3. Generalized polyspike and wave complexes characteristic of juvenile myoclonic epilepsy (JME).**

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**Figure 4. Right temporal periodic lateralized epileptiform discharges (PLEDS) in an obtunded patient with pancreatic encephalopathy. An MRI scan the next day suggested a temporal infarct.**

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**Case 3**

Figures 4 and 5 represent the EEG tracing and voltage map of an obtunded patient with pancreatic encephalopathy. The images illustrate periodic lateralized epileptiform discharges (PLEDS). The focal EEG led the clinical team to order an imaging study.

**Case 4**

Figure 6 is an example of a normal EEG. The test was conducted in order to explore the possibility of an organic cause for the auditory hallucinations and hyperreligiosity experience by a 75-year-old woman.

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**Figure 5. Voltage map of periodic lateralized epileptiform discharges (PLEDS) in the patient whose EEG tracing is provided in Figure 4. Maximum voltage negativity is white surrounded by gray.**
SHOULD I ORDER AN EEG?

Diagnosis and help guide treatment. In some cases (subtle subclinical status epilepticus for example), there is no other way to make a correct diagnosis. EEG is fundamental to the differential diagnosis of the epilepsies and helps guide treatment. EEG often provides useful prognostic information in obtunded hospitalized patients. A normal EEG can be reassuring to the physician who believes a patient’s abnormal behavior may have a psychiatric cause.

ACKNOWLEDGMENT

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REFERENCES


APPENDIX

How to Order an EEG in the Hospital at Gundersen Lutheran

Write an order for “Routine EEG.” A neurology consult is not required. During usual weekday hours, the test will be performed promptly by the next available technologist. If the patient cannot easily be transported to the laboratory, indicate “Bedside [or portable] EEG.” If the EEG is urgent, a ward secretary can expedite the request with a call to the EEG lab. EEGs performed in the hospital are read the same day by the neurologist on call, and preliminary results are called to the floor. The final EEG reports are found in Clinical Workstation under “Reports.”

Sleep deprivation prior to an EEG increases the likelihood of finding epileptic abnormalities in patients with symptoms suggestive of epilepsy, but it is often unnecessary in the hospital setting. The neurologist on call can assist with the decision about whether to utilize sleep deprivation.

When ordering an EEG after hours or on weekends, in addition to writing the order, page the neurologist on call. The neurologist will then arrange for a technologist. This requirement is not to discourage off-hour testing but, rather, to ensure that the technologists are utilized appropriately. The neurologist will come in to interpret the EEG immediately after it is performed, so the primary team will have the results promptly.

Figure 6. Normal EEG in a 75-year-old woman with auditory hallucinations and hyperreligiosity.