The Reemergence of EEG Reactivity After Cardiac Arrest

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Joseph Zachariah, DO¹, and Alejandro A. Rabinstein, MD¹

Abstract

Electroencephalogram (EEG) reactivity has been increasingly utilized in prognostication after cardiac arrest. Recent studies have demonstrated a false-positive rate of 0% in predicting poor outcome with a nonreactive EEG. The reemergence of reactivity after an initial nonreactive EEG has been noted in cases of drug intoxication, rewarming after hypothermia, and after discontinuing sedation. This is the first case describing the reemergence of EEG reactivity without the confounding factors listed above. We describe a case of resuscitated cardiac arrest with initial EEG demonstrating a lack of reactivity. A repeat EEG completed 3 days later revealed a reemergence of reactivity in the setting of normothermia, a negative drug screen, and the absence of sedation. The delayed recovery of EEG reactivity without previously established confounding factors is novel. Serial EEGs may be beneficial as the available literature on reactivity and prognostication is based on an average of 24 to 48 hours of EEG tracing. Prognostication after cardiac arrest continues to require a multimodal approach.

Keywords

central nervous system bacterial infections, meningoencephalitis, central nervous system infections, hypoxia–ischemia, brain, cerebrovascular disorders, neurocritical care, clinical specialty, seizures, epilepsy

Introduction

The utility of electroencephalogram (EEG) in critically ill patients has increased in recent years. This led to a renewed interest in the role of EEG in estimation of neurological prognosis after cardiac arrest. The concept of EEG reactivity being associated with better outcomes was introduced by Dr Fishgold in 1959.¹ Reactivity is defined as a change in EEG activity (amplitude or frequency) with external stimuli,² which can be visual, auditory, tactile, or noxious.³ Epileptiform transients, that is, stimulus-induced rhythmic, periodic, or ictal discharges in response to external stimuli, also classify an EEG as reactive in the formal definition. An EEG that is not reactive indicates considerable injury to the reticular activating system.^{4,5} Reactivity has been noted to reemerge in the setting of drug intoxication,⁶ withdrawal of sedation, and during rewarming after therapeutic hypothermia.^{7,8} We describe a case of reemergence of reactivity without exposure to the aforementioned factors.

Case Presentation

A 56-year-old male with a history of hypertension, type II diabetes mellitus, and hepatitis C had noted several days of back pain and generalized malaise before presenting with a transient syncopal episode. On arrival to the emergency

department, he had returned to his baseline but then had a generalized tonic–clonic seizure. As his seizure subsided with benzodiazepines, he went into pulseless electrical activity arrest and was resuscitated successfully within 4 minutes. The patient was not treated with hypothermia, but temperature was kept at 36°C. Pupillary reflexes were preserved, but all other brain stem reflexes were absent. There was no motor response to pain. Magnetic resonance imaging (MRI) of the brain demonstrated multiple areas of restricted diffusion in bilateral cerebral hemispheres (Figure 1A–C) as well as a high cervical cord serpiginous infarct (Figure 2A and B). Workup revealed methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia as well as a large epidural abscess spanning the entire spine also involving MRSA. In the setting of bacteremia, the MRI findings were suspicious for septic embolism. Neuron-specific enolase was equivocal at 33 pg/mL, and somatosensory-evoked potentials for evaluation of cortical responses was uninterpretable due to the cord infarct. Initial EEG obtained 24 hours after the admission showed a severely

¹ Department of Neurology, Mayo Clinic, Rochester, MN, USA

Corresponding Author:

Joseph Zachariah, Department of Neurology, Mayo Clinic Hospital, St. Mary's Campus, MB 8E, 1216 2nd St SW, Rochester, MN 55902, USA.
Email: joe.zachariah@gmail.com

Figure 1. Diffusion-weighted imaging (DWI) revealing scattered bihemispheric diffusion-restricted areas. Magnetic resonance imaging (MRI) of the brain demonstrated multiple areas of restricted diffusion in bilateral cerebral hemispheres (A-C).

Figure 2. Diffusion-weighted imaging (DWI) of the cervical spinal cord revealing left-sided infarct. Magnetic resonance imaging (MRI) of the brain demonstrated a high cervical cord serpiginous infarct (A and B)

suppressed background and was nonreactive to visual, auditory, and painful stimuli to limbs, nipples, and temples. There were no confounding factors that could have accounted for these EEG findings (ie, drug intoxication was excluded with a comprehensive toxicology screen, the patient had not received sedation, and his body temperature was normal throughout admission). A follow-up EEG 3 days later demonstrated reactivity and spontaneous variability (Figure 3). Subsequently, he started to wake up and follow commands with his right arm. He remained paralyzed in the other 3 limbs likely as a result of his cervical cord infarct. His infection was refractory to antibiotic therapy, and due to the extent of his spinal epidural abscess, it was deemed inoperable. Given the overall prognosis, his family decided to withdraw life-support measures. A waiver of informed consent was granted by the institutional review board.

Discussion

Electroencephalogram reactivity, introduced in 1959 by Dr Fishgold,¹ has increasingly gained favor as an ancillary for prognostication after cardiac arrest. Reactivity is defined as a change in EEG activity (amplitude or frequency) with external stimuli.² Stimuli can be visual, auditory, tactile, and noxious.³ A nonreactive EEG therefore is thought to indicate considerable injury to the reticular activating system.^{4,5}

Multiple studies point toward a poor prognosis based purely on a nonreactive EEG with false-positive rate (FPR) ranging from 0% to 9%.^{2,7-11} However, EEG in the first few hours after cardiac arrest has very limited prognostic value.¹² Electroencephalogram patterns can fluctuate¹³ and reactivity can be absent during therapeutic hypothermia but then be elicitable after rewarming.^{7,8} Reemergence of reactivity after rewarming was noted in 4 of 13 patients and 2 of 23 patients in

Figure 3. Electroencephalogram (EEG) demonstrating reactivity after an observer claps. A follow-up EEG 3 days later demonstrated reactivity and spontaneous variability.

2 studies.^{7,8} The prognostic value of EEG is higher 1 to 2 days after cardiac arrest.¹⁴

Much of the work on postanoxic reactivity has been done by Rossetti et al.^{7,11} In 2 separate studies of 61 and 111 patients, all of the patients with nonreactive EEG achieved a poor outcome Cerebral Performance Category (CPC 3-5). The FPR for the prediction of mortality based only on nonreactivity was 7% in the 2010 series and 0% in the 2012 study. The increased accuracy in prediction between the 2 studies likely lies in the study's definition of reactivity. In the earlier study, reactivity was defined as a change in frequency or amplitude to stimuli which included epileptiform transients, that is, stimulus-induced rhythmic, periodic, or ictal discharges. In the latter study, epileptiform transients were excluded from being labeled as a reactive EEG. Separation of epileptiform transients from the definition of reactivity does deviate from the accepted definition,³ but the exclusion did improve the FPR of mortality prediction from 7% to 0%.

Reactivity is known to reemerge after weaning of sedation and drug intoxication.⁶ In the setting of therapeutic hypothermia, reactivity can emerge in 10% to 20% of cases after rewarming.^{7,8} This article describes a case of reemergence without contamination by any of these factors. The studies discussing EEG reactivity with cardiac arrest are in the setting of therapeutic hypothermia and have an average EEG monitoring period of 24 to 48 hours. In our case, the repeat EEG demonstrating reactivity and spontaneous variability was recorded 3 days after cardiac arrest. The delayed recovery

of EEG reactivity in patients with cardiac arrest who are not treated with hypothermia is novel and deserves attention. Therefore, it is important to bear in mind that EEG findings, including the presence or absence of reactivity, need to be put in the context of a multimodal approach to the prognostication after cardiac arrest. Serial EEGs may be useful in patients with nonreactivity on an early tracing.

Authors' Note

A waiver of informed consent was granted by the IRB.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

1. Fishgold H, Mathis P. Obnubilations comas et stupeurs: études électroencéphalographiques. *Electroencephalogr Clin Neurophysiol*. 1959;11(suppl 11):27-68.
2. Rossetti AO, Oddo M, Logroscino G, Kaplan PW. Prognostication after cardiac arrest and hypothermia: a prospective study. *Ann Neurol*. 2010;67(3):301-307.

3. Hirsch LJ, LaRoche SM, Gaspard N, et al. American Clinical Neurophysiology Society's standardized critical care EEG terminology: 2012 version. *J Clin Neurophysiol*. 2013;30(1):1-27.
4. Gutling E, Gonser A, Imhof HG, Landis T. EEG reactivity in the prognosis of severe head injury. *Neurology*. 1995;45(5):915-918.
5. Vincent SR. The ascending reticular activating system—from aminergic neurons to nitric oxide. *J Chem Neuroanat*. 2000;18(1-2):23-30.
6. Ramachandranair R, Sharma R, Weiss SK, Cortez MA. Reactive EEG patterns in pediatric coma. *Pediatr Neurol*. 2005;33(5):345-349.
7. Rossetti AO, Carrera E, Oddo M. Early EEG correlates of neuronal injury after brain anoxia. *Neurology*. 2012;78(11):796-802.
8. Crepeau AZ, Rabinstein AA, Fugate JE, et al. Continuous EEG in therapeutic hypothermia after cardiac arrest: prognostic and clinical value. *Neurology*. 2013;80(4):339-344.
9. Söholm H, Kjær TW, Kjaergaard J, et al. Prognostic value of electroencephalography (EEG) after out-of-hospital cardiac arrest in successfully resuscitated patients used in daily clinical practice. *Resuscitation*. 2014;85(11):1580-1585. doi:10.1016/j.resuscitation.2014.08.031.
10. Thenayan EA, Savard M, Sharpe MD, Norton L, Young B. Electroencephalogram for prognosis after cardiac arrest. *J Crit Care*. 2010;25(2):300-304.
11. Rossetti AO, Urbano LA, Delodder F, Kaplan PW, Oddo M. Prognostic value of continuous EEG monitoring during therapeutic hypothermia after cardiac arrest. *Crit Care*. 2010;14(5):R173.
12. Bassetti C, Bomio F, Mathis J, Hess CW. Early prognosis in coma after cardiac arrest: a prospective clinical, electrophysiological, and biochemical study of 60 patients. *J Neurol Neurosurg Psychiatry*. 1996;61(6):610-615.
13. Bauer G, Trinka E, Kaplan PW. EEG patterns in hypoxic encephalopathies (post-cardiac arrest syndrome): fluctuations, transitions, and reactions. *J Clin Neurophysiol*. 2013;30(5):477-489.
14. Walker AE. *Cerebral Death*. 3rd ed. Baltimore, MD: Urban & Schwarzenberg; 1985.