EEG and cardiac arrest
Divining prognosis at the bedside

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Out-of-hospital cardiac arrest affects 326,200 persons in the United States each year.1 Mortality remains high despite advances in critical care and emergency response, with only 31.4% of patients surviving to hospital discharge.1 Survivors also face the prospect of disability due to hypoxic-ischemic brain injury. Prognostication is an important aspect of care in these patients, so that decisions about end of life and intensity of support can be made. Neurologists are commonly consulted to assist in this assessment. Bedside examination is an essential element in this process; however, ancillary testing is often desired to provide further clarity and support when rendering opinions. EEG is the most widely used modality for this purpose. However, EEG recordings in this setting are complex, and variability in interpretation occurs, even among experts.2 Studies analyzing the reliability of EEG in this setting are needed, in order to provide clarity as to the limitations and appropriate interpretation of results for clinicians who use it for this purpose.

In this issue of Neurology®, Westhall et al.3 present the results of a study evaluating the reliability of EEG in prognostication following cardiac arrest using a relatively straightforward categorical system. In their study, 4 reviewers evaluated EEGs obtained in the course of care of cardiac arrest patients enrolled in an 8-center clinical trial investigating the efficacy of therapeutic hypothermia who were still comatose 48–72 hours after resuscitation. EEG reviewers were blinded to clinical outcome, and categorized the EEG as highly malignant, malignant, or benign as defined in the study protocol. In this cohort, the EEG was classified as highly malignant in 37% and benign in 14%. The EEG provided relatively clear prognostic information at both extremes: poor outcome was seen in all patients graded as having a highly malignant EEG, and in only 1% of patients with a benign recording. This indicates that the EEG provides useful prognostic information in up to half of patients who remain comatose 2–3 days following resuscitation after cardiac arrest when showing either the most severe abnormalities or in the absence of any malignant abnormalities.

The study also highlights some of the limitations of EEG. In half of the cases, the EEG did not provide clear prognostic information. Also, findings classified as malignant yet not highly malignant had specificity for poor prognosis of only 48%, with 14 false-positives. While there was evidence that a greater number of malignant findings correlated with increasing specificity (the presence of 2 or more malignant findings increased the specificity for poor outcome to 96% with 1 false-positive), it is clear that certain malignant abnormalities do not have inherent prognostic value. Another limitation in EEG in this setting is interrater variability, which reflects the complexity and heterogeneity of these recordings, and the level of uncertainty sometimes present in the interpretation of these studies.2 The authors utilized the American Clinical Neurophysiology Society critical care EEG nomenclature to try to limit variability. Despite that, differences in specificity and sensitivity remained for abnormalities categorized as malignant. The greatest variability involved malignant findings attributable to changes in the background. On review of the supplementary data, periodic and rhythmic malignant abnormalities retained high specificity with reasonable interrater agreement among the EEG reviewers, an observation made by previous investigators.2 However, other abnormalities, such as background discontinuity, reduction in amplitude to a value greater than 10 μV, and lack of reactivity, showed interrater variability and reduced specificity.

Several EEG abnormalities have been associated with poor prognosis following cardiac arrest.4,5 Based on these observations, EEG scoring systems have been developed to aid in prognosis.6–8 Abnormalities that have been noted to be associated with poor prognosis include severe suppression of background amplitude, the presence of generalized periodic discharges, recorded seizures, burst-suppression patterns, and nonreactivity, including coma patterns such as alpha coma. The study by Westhall et al. clarifies that the degree of background suppression needed to have prognostic import is an amplitude less than 10 μV, and that generalized periodic discharges...
and burst-suppression patterns in which suppression comprises >50% of the recording are meaningful. In contrast to the relatively large number of retrospective series on this subject in the literature, there is a paucity of prospective studies evaluating the use of EEG and application of scales after cardiac arrest in a manner that more closely matches clinical practice. The authors appropriately caution against using individual EEG findings in prognosis based on their results.

The phenomenon of self-fulfilling prophecy confounds many studies evaluating the roles of tests and clinical findings in cardiac arrest prognosis. As the authors attest, this study is not free from the potential for bias, as care providers were aware of the EEG results during the patients’ care, which could have influenced decisions on continuing or withdrawing life-sustaining therapy. Nonetheless, this study helps clarify certain EEG findings that have clear prognostic value and should help inform clinical decisions for a large proportion of cardiac arrest patients. However, it also remains clear that there are a substantial number of patients in whom the EEG does not provide prognostic clarity, and there is a need for the development of other technologies to assist in determining prognosis so that appropriate levels of care can be determined for these patients.

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**REFERENCES**