Defining an electrical biomarker of the epileptogenic zone

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Video Abstract

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Abstract

Much research on epilepsy treatment has focused on properly identifying the epileptogenic zone, the area of the brain where a seizure initiates. This zone, previous studies have found, can potentially be recognized by high-frequency activity, or "fast activity," that occurs in a brain area right after seizure onset. However, this method does not accurately delineate the epileptogenic zone from other normal brain tissues. A new paper published in Human Brain Mapping examines how a different marker, or "fingerprint," can be used to accurately identify the epileptogenic zone, whether this fingerprint can be seen in different types of brainwaves, and, finally, how the method compares to using fast activity. The study builds on a previous paper published by the authors, in which the fingerprint itself was identified as a specific pattern of brain activity observed in seizure patients. This pattern had three features: spikes before seizure onset, narrow-band fast activity, and suppression, or an apparent lack of lower frequencies. The study retrospectively looked at seizure patients whose brain activity had been evaluated using stereo-electroencephalography, or SEEG, a pre-surgical procedure that involves inserting electrodes into a patient's brain to identify where the seizure originated. First, the authors trained a machine learning program to predict how likely a certain brain area would be part of the EZ, using SEEG data from their previous study. Then, this model was applied to the SEEG data of a new batch of 24 patients, where surgery had been performed and part of their brain was removed. Of the 24 patients, 11 had become seizure-free after surgery, and the remaining 13 were non-seizure-free or experiencing seizures after surgery. Finally, the results from the model, which predicted the likelihood that an area was within the EZ, were mapped onto MRI scans of the patients' brains. The authors found that their method was indeed successful at identifying seizure onset areas. For most of the patients who became seizure-free after surgery, the predicted seizure area was found entirely within their surgically removed brain region, while for many of the non-seizure-free patients, at least part of the predicted area was found outside of the resected region. This, the authors postulate, may explain why surgery did not completely prevent future seizures, since not all of the pertinent brain area was removed. Moreover, they found that using only "fast activity" can vastly over-estimate the actual epileptogenic zone, which could result in unnecessary removal. Thus, the combination of all three features is necessary to properly identify the epileptogenic zone.