Population Data Can Be Applied to Diagnostic Images to Reveal New Information

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Success in the surgical treatment of epilepsy relies on accurately locating the focus of seizures, identifying abnormal structures and defining the borders of the area to be treated. To make the most accurate analyses possible, radiologists and other treatment team members employ multiple diagnostic modalities — including MRI, FDG-PET, diffusion tensor imaging and electrophysiology — to inform treatment decisions. Yet in many cases, even multiple layers of diagnostic information fail to identify with a high degree of certainty the patient's seizure focus.

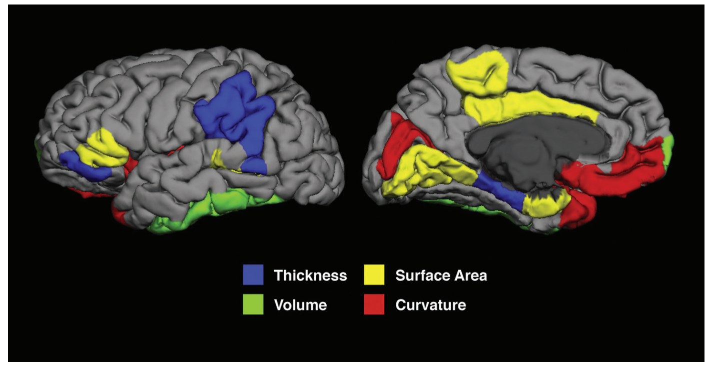
"Technologies that provide precise information to guide treatment have been the great development of the last 25 years in the neuroradiological assessment of epilepsy. But there are still many things that we cannot see," states Noriko Salamon, MD, PhD, professor of radiology and chief of neuroradiology at the David Geffen School of Medicine at UCLA. "We're now starting to use artificial intelligence to reveal subtle information in these images that we cannot detect with the naked eye."

Artificial intelligence used to predict abnormalities not yet visible

Epilepsy surgery aims to eliminate the focus, or origin, of seizures in the brain, which is different from the lesion. While epileptogenic foci are sometimes associated with well-defined lesions — including vascular malformations, traumatic brain damage, tumors and perinatal injuries — foci are often normal-appearing tissue adjacent to the lesion. FDG-PET (fluorodeoxyglucose positron emission tomography) can add a layer of information to MR imaging by showing areas of glucose hypometabolism, revealing epileptogenic foci adjacent to the lesion. Combining imaging information and electrophysiology can help define the boundaries of brain abnormalities to help guide surgery.

But in many cases of congenital focal cortical dysplasia, the lesion is very difficult to detect, as when an area of tissue disorganization is not obvious enough to detect with current diagnostic imaging techniques. Artificial intelligence offers radiologists a powerful tool that can use data from a large group of similar patients to determine the potential for normal-appearing structures to be abnormalities not yet distinguishable using visual inspection. "AI can take information on the volume of each brain structure and perform a population-based computational analysis that can reveal potential abnormalities among structures that are still within normal range for that patient," says Dr. Salamon.

An example of AI's usefulness in identifying abnormal brain structures is in distinguishing a unilateral abnormality from an asymmetrical bilateral abnormally. Temporal lobe epilepsy is the most common form of adult epilepsy, with hippocampal sclerosis often being the cause of seizures. "Usually, hippocampal sclerosis is unilateral, and removing the abnormal side — which shows



Surface rendering machine analysis shows top twenty morphological measures that distinguish epilepsy patients with hippocampal sclerosis and epilepsy patients without hippocampal sclerosis.
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atrophy and is smaller in volume than the contralateral side — successfully treats the seizures," explains Dr. Salamon. "But about 30 percent of these patients don't improve in their seizure symptoms following surgical treatment." In these cases, the untreated side may also be affected, but still within normal range. UCLA neuroradiologists are using machine learning to perform volumetric analyses based on data from a large population of patients. The machine algorithm assigns a percentile score that allows the team to identify subtle disease in the contralateral side. This enables them to make treatment decisions with greater confidence. "Machine learning is providing information that goes beyond what the human eye can detect," says Dr. Salamon.

Algorithms able to contribute broadly to treatment decisions

Beyond AI's usefulness in identifying seizure foci, artificial intelligence can be applied more broadly to help determine when patients can benefit from treatments aimed at mitigating or reversing damage done by epileptic seizures and to prepare patients for the likely outcomes of their epilepsy treatment.

Each seizure can cause global brain atrophy, but the effects can be too subtle to detect using diagnostic imaging. Sophisticated AI analysis using cortical thickness maps can yield information on probable treatment outcomes and suggest when other therapeutic options — such as cognitive training — may be effective in helping to protect the brain.