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Laser ablative treatment of musicogenic epilepsy arising from dominant mesial temporal lobe: illustrative case

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BACKGROUND Musicogenic epilepsy (ME) is a rare reflex epilepsy in which seizures are triggered by musical stimuli. Prior descriptions of ME have suggested localization to the nondominant temporal lobe, primarily in neocortex. Although resection has been described as a treatment for ME, other surgical modalities, such as laser ablation, may effectively disrupt seizure networks in ME while incurring comparatively lower risks of morbidity. The authors described the use of laser ablation to treat ME arising from the dominant mesial temporal structures.

OBSERVATIONS A 37-year-old woman with a 15-year history of drug-resistant ME was referred for surgical evaluation. Her seizures were triggered by specific musical content and involved behavioral arrest, repetitive swallowing motions, and word incomprehension. Diagnostic studies, including magnetic resonance imaging, single-photon emission computed tomography, magnetoencephalography, Wada testing, and stereoelectroencephalography, indicated seizure onset in the left (dominant) mesial temporal lobe. Laser interstitial thermal therapy was used to ablate the left mesial seizure onset zone. The patient was discharged on postoperative day two. At 18-month follow-up, she was seizure-free with no posttreatment neurological deficits.

LESSONS Laser ablation can be an effective treatment option for well-localized forms of ME, particularly when seizures originate from the dominant mesial temporal lobe.

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KEYWORDS musicogenic epilepsy; drug-resistant epilepsy; stereoelectroencephalography; laser ablation

Musicogenic epilepsy (ME) is a rare form of reflex epilepsy in which seizures are triggered by musical stimuli.[1–3] ME has a slight female predominance, with an average age of onset in the late 20s.[4,5] Seizures in ME, which are elicited by hearing, performing, or thinking about music, involve a range of semiologies. Triggers are often patient-specific and may be restricted to a particular musical genre, instrument, performer, or emotional content.[4] There is evidence that seizures in ME arise from pathological activity patterns in limbic areas.[6,7] Most patients with ME do not exhibit structural lesions on magnetic resonance imaging (MRI),[8] and localization depends on multimodal presurgical evaluation with techniques such as scalp and intracranial electroencephalography (EEG), positron emission tomography (PET), magnetoencephalography (MEG), and single-photon emission computed tomography (SPECT).[9,10]

As with other forms of epilepsy, surgical treatments are indicated for patients with drug-resistant ME.[6] Recently, laser-interstitial thermal therapy (LITT) has proven an effective alternative to resection in various forms of well-localized epilepsy, particularly when seizures arise from the mesial temporal lobe.[11,12] In this case report, we discuss the successful LITT treatment of ME in a patient with seizure onset in the dominant mesial temporal lobe.

Illustrative Case

A 37-year-old, right-handed woman with intractable seizures, type 1 diabetes mellitus, Hashimoto disease, and mild depression presented to our clinic for surgical evaluation. Her seizures, which began 14 years earlier, were initially triggered by hearing specific

ABBREVIATIONS EEG = electroencephalography; LITT = laser-interstitial thermal therapy; ME = musicogenic epilepsy; MEG = magnetoencephalography; MRI = magnetic resonance imaging; MTLE = mesial temporal lobe epilepsy; PET = positron emission tomography; sEEG = stereo EEG; SPECT = single-photon emission computed tomography.

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lyrics from the band The Fray. Her seizure episodes lasted about 45 seconds and consisted of behavioral arrest, word incomprehension, and repetitive swallowing movements. Her auras consisted of nausea and a short, ascending paresthesia that extended from her chest to head. Ten years prior to presentation, her seizures became triggered by an increasing range of music and occurred multiple times per day, despite her efforts to avoid musical stimuli. She began to wear noise-blocking devices and reduce potential exposures to music (e.g., watching television, avoiding the use of sidewalks where she may hear music). Her epilepsy was refractory to numerous medications, including phenytoin, gabapentin, lamotrigine, topiramate, tiagabine, levetiracetam, oxcarbazepine, zonisamide, pregabalin, lacosamide, primidone, and clobazam.

Prior to presentation to our clinic, the patient underwent presurgical evaluations, which included EEG, structural MRI, PET, SPECT, MEG, and Wada testing. EEG studies indicated temporal seizure onset but did not clearly lateralize to one side. Structural MRI findings were normal. PET indicated bitemporal hypometabolism (greater on the left side) whereas ictal SPECT indicated increased left perfusion. MEG localized seizures to the lateral and basal aspects of the posterior left temporal lobe. Wada testing indicated left-sided language dominance and poor memory recall with left injection. Based on these findings, invasive EEG was performed at the outside hospital. It involved a limited implantation of three depth electrodes into each temporal lobe, including the mesial structures. Invasive EEG studies indicated left mesial temporal seizure onset. Given somewhat discordant invasive EEG and MEG study results, a left anterior temporal lobectomy was recommended to the patient, which she declined because of concern for potential neurocognitive sequelae.

After relocating and establishing care at our center, the patient sought additional evaluation for her seizures. Noninvasive studies were performed at our center, including scalp EEG, structural MRI, functional MRI, and neuropsychological testing. Scalp EEG suggested seizure onset in the posterior left temporal lobe, largely consistent with her previous MEG results. Structural MRI was unremarkable (Fig. 1A). Functional MRI suggested left-sided language dominance, consistent with prior Wada testing. Neuropsychological testing suggested mild deficiencies in word retrieval but strong memory retention without other significant weaknesses.

Based on these findings, stereo EEG (sEEG) was recommended to further localize the patient's seizure onset zone. At the time of surgery, her antiseizure medication regimen included levetiracetam (1,500 mg in morning and 2,000 mg in evening) and zonisamide (400 mg in evening). A total of 12 intracranial electrodes were placed in the left hemisphere, including nine electrodes that provided coverage of the left temporal lobe (temporal tip, basal temporal lobe, lateral neocortex [including extensive coverage of the superior temporal gyrus], hippocampus, and amygdala), two electrodes oriented in the anterior parietal lobe, and one electrode in the anterior occipital lobe (Fig. 1B). Five clinical seizures were recorded during inpatient monitoring; in the setting of medication weaning, three of the seizures were induced by music and two occurred spontaneously. In all seizure events, ictal activity localized to sEEG contacts in the mesial left temporal lobe without clear initial involvement or early spread to neocortical sites (Fig. 1C).

Given evidence for (1) focal onset seizures arising from the left mesial temporal lobe and (2) left-dominant language and memory function, responsive neurostimulation and focal laser ablative treatment were presented to the patient as treatment options. Laser ablation was considered a minimally invasive option that, compared to resective treatment, would limit violation of uninvolved left temporal structures while offering the possibility of seizure freedom. Responsive neurostimulation was considered an option that would provide significant seizure reduction but less likely seizure freedom and would avoid the potential neurocognitive impacts associated with laser ablation. After weighing these options, the patient elected to undergo laser ablation, which involved robotic assisted stereotactic placement of a diffuse tip laser probe with subsequent laser application under MR thermometry (ROSA, Zimmer Biomet Robotics; Neuroblate, Monteris Medical). An occipitotemporal trajectory was used to ablate the left inferomedial amygdala, hippocampal head, and anterior hippocampal body. Six ablation zones were made at sites spaced 6 mm apart along the distal catheter trajectory. Upon completion of the laser application, fluid-attenuated inversion recovery MRI and postcontrast T1 sequences were performed, which depicted successful ablation of the intended target (Fig. 2A and B).

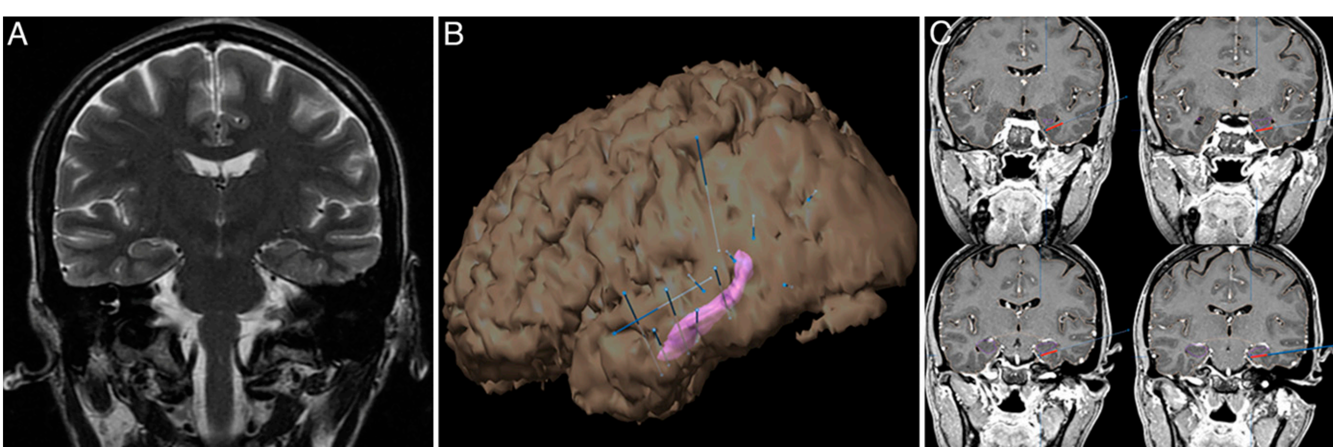

FIG. 1. A: Pretreatment coronal T2-weighted MRI sequence depicting the absence of hippocampal changes. **B:** Lateral reconstruction of left-sided sEEG implantation depicting trajectories of 12 electrodes. The amygdala and hippocampus are highlighted in purple. **C:** Coronal reconstructions of sEEG electrodes that captured ictal activity during seizure onset, located in the amygdala, hippocampus, and parahippocampal gyrus. All four electrodes were involved in each captured seizure event. Red indicates positions of ictal contacts.

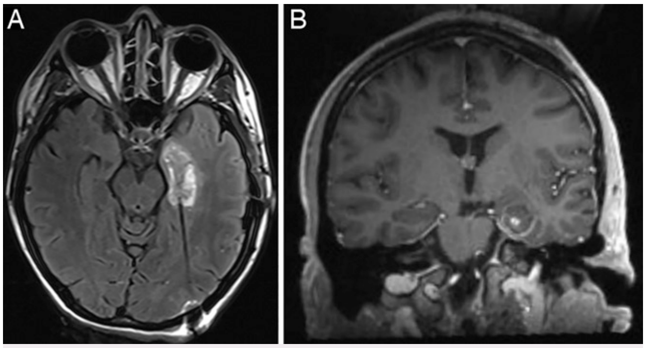

FIG. 2. Posttreatment MRI sequences depicting laser ablation of mesial temporal seizure-onset zone. **A:** Axial fluid-attenuated inversion recovery sequence depicting laser probe trajectory and ablation volume. **B:** Coronal T1-weighted postcontrast image depicting left hippocampal ablation.

Postoperatively, the patient exhibited no neurological deficits. She was discharged home on postoperative day 2. Eight months after LITT, neuropsychological testing indicated minimal posttreatment changes, with slight worsening of baseline word retrieval and semantic fluency, and improved performance on measures of visual construction, speeded sequencing, and divided attention. With slight reduction in her levetiracetam dosing and maintenance of pretreatment zonisamide dosing level, she has been seizure-free for 24 months posttreatment. She no longer avoids musical stimuli.

Discussion

Observations

Although prior reports of ME have described seizure onsets more commonly in the nondominant hemisphere,[5] including mesial structures[13,14] and neocortex,[15] our patient presented with seizure onset in the mesial structures of the dominant temporal lobe. Given this localization and her increased risk of neurocognitive impacts (e.g., language and verbal memory dysfunction) with resective treatments, such as anterior temporal lobectomy, the patient elected to undergo mesial temporal LITT. Responsive neurostimulation, an option that would further minimize neurocognitive sequelae, was also considered; however, this option would be unlikely to provide our patient significant likelihood of seizure freedom.[16] To our knowledge, this is the first reported case of ME treated with LITT. In other forms of mesial temporal lobe epilepsy (MTLE), numerous single-institutional studies have reported nearly comparable seizure outcomes between LITT and resection after 1 to 2 years.[17–20] Multicenter retrospective studies of LITT for MTLE have reported Engel I seizure outcomes of 71% and 58% at 1 and 2 years, respectively.[21,22] Long-term outcomes following LITT of MTLE are limited; however, a recent report suggests that seizure freedom rates may be decreased at intervals of 5 years or more following LITT.[23] In addition to MTLE, LITT has proven a reasonable treatment option for various forms of lesional epilepsy, including those arising from hypothalamic hamartomas, cavernomas, focal dysplasias, and other developmental malformations.[24] Furthermore, LITT is also a technique for callosotomy in cases of primary or secondarily generalized epilepsy.[25] As a treatment option that offered good probability of seizure freedom with potentially lower functional morbidity than resection, LITT was an appropriate treatment for this rare presentation of ME. As a case report, the treatment approach and results described here do not necessarily generalize to the surgical treatment of ME or other presentations of MTLE. Our findings are also limited by the relatively short duration of follow-up (2 years) described here.

Lessons

This case report highlights the use of LITT to treat a form of well-localized ME arising from the dominant mesial temporal lobe.

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Author Contributions

Conception and design: Southwell. Acquisition of data: all authors. Analysis and interpretation of data: Southwell, Sinha. Drafting the article: Southwell, Park. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Southwell. Study supervision: Southwell.

Supplemental Information

Previous Presentations

Portions of this work were presented as a poster at the 90th American Association of Neurological Surgeons Annual Scientific Meeting, April 2021, virtual meeting.

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