Short Communication

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Temporal pole blurring in temporal lobe epilepsy revealed by 3D Edge-Enhancing Gradient Echo MRI

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Abstract

While abnormalities of the hippocampus have been well characterized in temporal lobe epilepsy, various additional temporal lobe abnormalities have also been described. One poorly understood entity, the so-called temporal pole blurring (TPB), is one of the more frequently described neocortical abnormalities in TLE and is thought to represent dysmyelination and axonal loss due to chronic electrical perturbations in early age-onset temporal lobe epilepsy. In this study, we describe the first reported cases of TPB diagnosed by a recently described MRI sequence known as 3D Edge-Enhancing Gradient Echo (3D-EDGE), which has an effective "myelin weighting" making it exquisitely sensitive to this temporal pole dysmyelination. The value of detection of TPB lies in lateralizing seizure onset, as well as predicting a lower baseline neuropsychological performance compared to temporal lobe epilepsy without TPB. Additionally, it is critical to not mistake TPB for alternative diagnoses, such as focal cortical dysplasia or neoplasm.

Keywords

epilepsy, temporal pole blurring, temporal lobe epilepsy, mesial temporal, sclerosis

Introduction

Epilepsy is a common debilitating disease worldwide with temporal lobe epilepsy (TLE) representing the most common form of drug-resistant focal epilepsy in adults. Abnormalities of the hippocampus, in particular mesial temporal sclerosis (MTS), have been well characterized in patients with TLE; however, studies have also frequently described a variety of additional temporal lobe abnormalities affecting the temporal lobe white matter, neocortex, and other regions.[1,2] A somewhat poorly understood entity, the so-called temporal pole blurring (TPB), is one of the more frequently described neocortical abnormalities in TLE and has been attributed to a variety of etiologies.[3–5] The most recent evidence suggests dysmyelination and axonal loss as the most likely underlying etiology.[4]

Continued advances in MR imaging have greatly enhanced the ability to detect and characterize lesions associated with epilepsy. In this retrospective study, we describe the first reported cases of TPB detected on a recently described MRI sequence known as 3D Edge-Enhancing Gradient Echo (3D-EDGE)[6,7]. Using an inversion pulse timed to create an opposing phase, but equal magnitude, of magnetization recovery in myelinated and nonmyelinated brain matter, the sequence effectively produces a "myelin-weighted image" that is exquisitely sensitive in revealing the extensive nature of this temporal pole dysmyelination.

Case presentation

Case 1

A 20-year-old right-handed man without known risk factors for epilepsy presented for evaluation of a long-standing seizure disorder. The patient reported two semiologies. One consisted of generalized tonic-clonic seizures that arose out of sleep with a frequency of a convulsion every three months. The second seizure type manifested as paroxysmal staring episodes with impaired awareness lasting 30–45 s. The frequency was once every two weeks. Prior evaluation suggested right TLE. Prior brain MRI was reported as normal. Despite taking lamotrigine 300 mg twice daily, lacosamide 200 mg twice daily, and clonazepam 0.5 mg at bedtime, he continued to experience breakthrough seizures. A previous trial of brivaracetam was not well tolerated.

There was a childhood history of speech delay with virtually no language development until reaching the first grade. At the time of presentation, neuropsychological exam revealed average language function. There was, however, weakness on perceptual organization tasks, especially those requiring visuospatial construction. There was also mildly slowed bilateral manual dexterity and a relative weakness in processing speed. His neurological examination was normal.

The patient underwent continuous video-EEG in the epilepsy monitoring unit. Interictal EEG revealed occasional right frontotemporal sharp waves (F8-T8). Two electroclinical seizures were captured, one focal to bilateral tonic-clonic seizure and one focal impaired aware seizure arising

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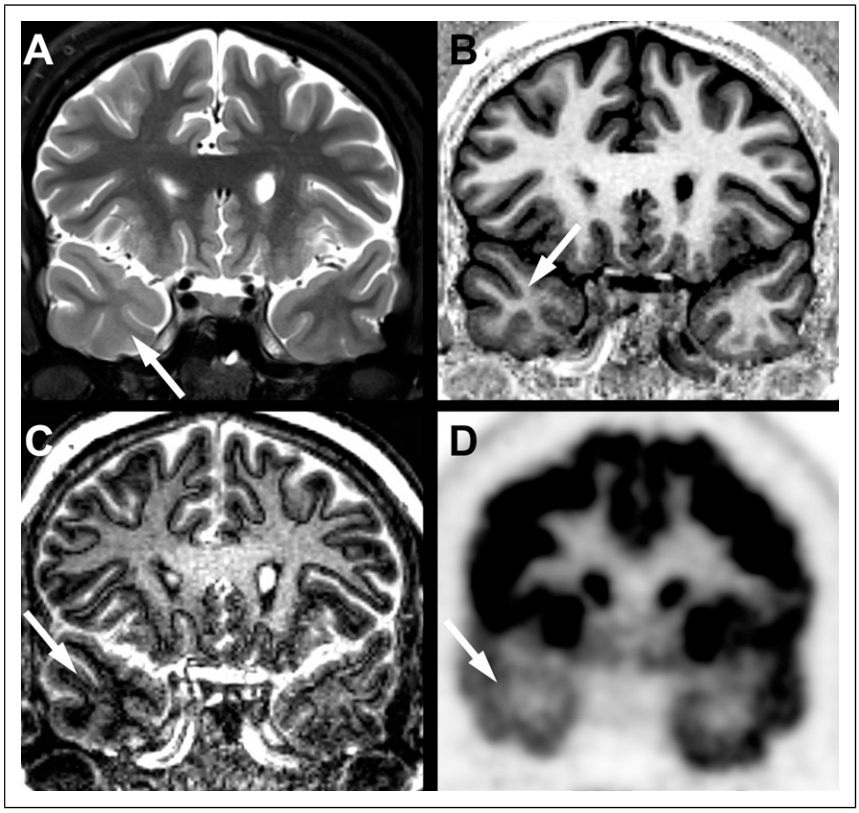

Figure 1. In Patient 1, coronal (a) T2-weighted and (b) SPACE inversion recovery sequences show subtle blurring of the gray-white junction with slight increase in T2 signal in the subcortical white matter of the right temporal pole (arrow). (c) Coronal 3D-EDGE shows unequivocal diffuse hypointensity of the subcortical white matter of the right temporal pole (arrow). (d) Coronal FDG-PET reveals diffuse hypometabolism of the right temporal pole (arrow).

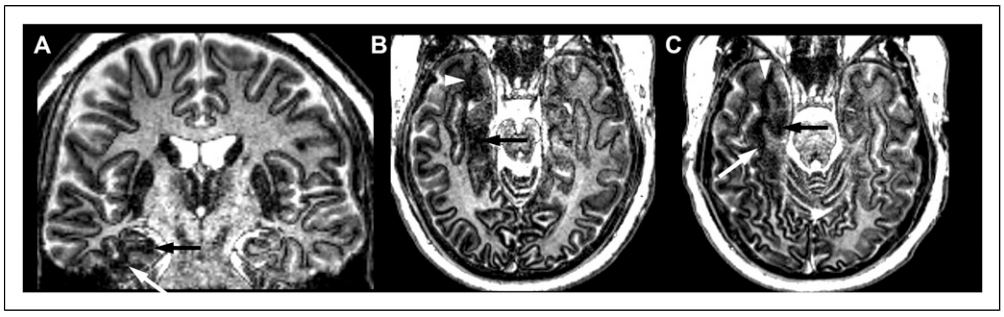

Figure 2. (a) Coronal and (b, c) axial 3D-EDGE images in Patient 1 show a more extensive abnormal white matter hypointensity involving the fusiform (white arrow) and parahippocampal (black arrow) gyri of the left temporal lobe. These white matter regions were entirely unremarkable on other MR sequences (not shown).

from the right anterior temporal region. Furthermore, the patient was felt to be at high risk for sudden unexpected death in epilepsy (SUDEP) due to a prolonged postictal EEG suppression following the focal to bilateral tonic-clonic seizure.

MRI was repeated on a 3T Siemens Skyra (Siemens Healthineers AG, Erlangen, Germany) with a 32-channel head coil using an epilepsy protocol. The 3D-EDGE sequence was generated as part of an MP2RAGE scan, as previously described.[6] On T1-weighted images and FLAIR, there was subtle blurring of the gray-white junction with slightly increased FLAIR signal in the white matter of the temporal pole (Figure 1(a) and (b)). On 3D-EDGE, a diffuse hypointensity of the temporal pole white matter was evident (Figure 1(c)). However, this abnormality was more widespread and involving the white matter extending into the parahippocampal and fusiform gyri (Figure 2) compared to the T1 and FLAIR images. Brain FDG-PET scan showed diffuse hypometabolism of the right temporal pole and mesial right temporal lobe (Figure 1(d)).

Based on the concordance of clinical, EEG, and neuroimaging findings, the group consensus recommendation was a right anterior temporal lobectomy. The patient underwent surgery without complication. On pathology, there was reactive gliosis most prominent at the subpial areas (Chaslin-type gliosis) with no evidence of neoplasm or cortical dysplasia. The patient had Engel class III outcome at one year after surgery and underwent an extended lobectomy due to persistent right temporal seizures. The patient was seizure free at one year after the second surgery.

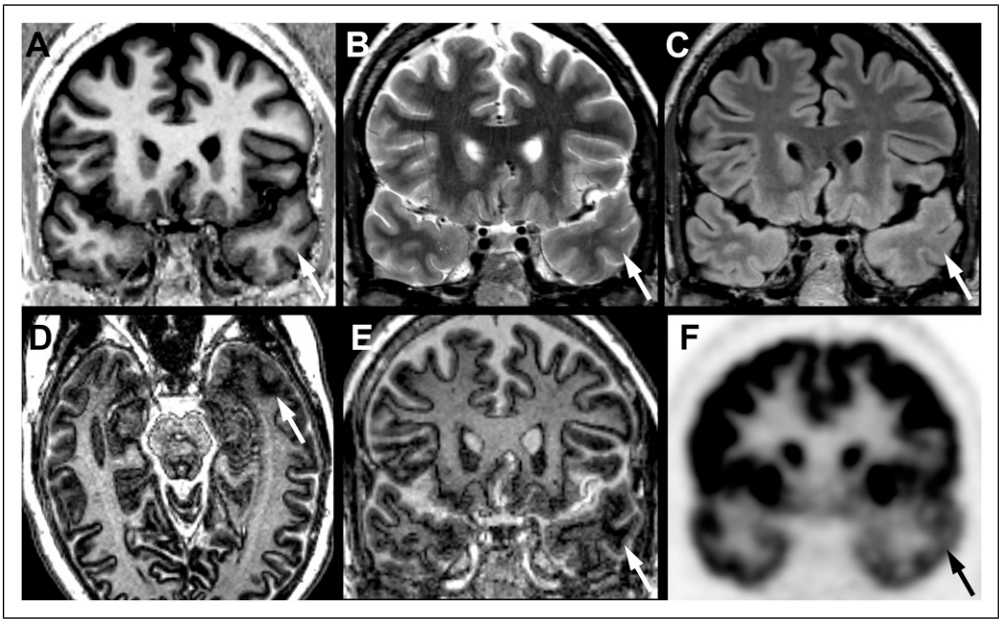

Figure 3. In Patient 2, coronal (a) SPACE inversion recovery, (b) T2-weighted, and (c) FLAIR MRI show no definite asymmetry of the gray-white boundary in the left temporal pole (arrow) and was interpreted as normal. (c) Axial and (d) coronal 3D-EDGE clearly reveal abnormal white matter hypointensity (arrow) in the subcortical white matter of the left temporal pole. (e) Coronal FDG-PET also shows hypometabolism of the left temporal pole (arrow).

Case 2

A 43-year-old woman presented initially with seizures at 10 years of age. There were no known risk factors for epilepsy. The most common seizure type consisted of staring episodes associated with impaired awareness, occasionally with oral automatisms. These occurred 1–2 times per month despite antiseizure medication. In addition, she experienced 5–6 focal to bilateral tonic-clonic seizures that occurred during sleep, which were controlled by lamotrigine. Past medications included carbamazepine, lamotrigine, and levetiracetam. At the time of evaluation, she was taking levetiracetam 1500 mg twice daily and lamotrigine 250 mg twice daily. Neurological examination was normal.

A prior EEG reported demonstrated left temporal spikes and left temporal interictal rhythmic delta activity (TIRDA). One of her typical focal impaired awareness seizures was captured during video-EEG, which showed a left temporal onset.

MRIs had been repeatedly performed over 15 years. None of them revealed a structural source as a cause for seizures. A high-resolution brain MRI was performed on a 3T Siemens Prisma (Siemens Healthineers AG, Erlangen, Germany) with a 32-channel phased-array head coil using an epilepsy protocol, which included the 3D-EDGE sequence. Standard MRI sequences (Figure 3(a–c)) failed to reveal an abnormality. However, a diffuse hypointensity of the subcortical white matter and gray-white junction was identified in the left temporal pole on 3D-EDGE (Figure 3(d) and (e)). An FDG-PET scan showed left temporal pole and mesial temporal lobe hypometabolism (Figure 3(f)).

Based on the consensus obtained from the clinical, EEG, and neuroimaging findings, surgical intervention involving left anterior temporal lobectomy was recommended. Surgery is pending at the time of this report.

Discussion

Extrahippocampal abnormalities have frequently been reported in TLE, but the prevalence is likely underestimated due to variability in the sensitivity of imaging techniques. TPB has been previously described in TLE and is believed to represent chronic dysmyelination and axonal loss.[4] We report the first cases of this entity shown with a recently described MRI technique, 3D-EDGE, in two patients without MTS. Due to the effective "myelin weighting" of this sequence, it is exquisitely sensitive to subtle alterations in myelin and reveals a much greater extent of the abnormality compared to the current clinical state-of-the-art MR sequences employed in epilepsy imaging.

TPB has been previously reported in TLE patients[3–5,8–12] and occurs exclusively ipsilateral to the TLE onset. There is a frequent association with temporal pole atrophy.[3] TPB in the setting of TLE has also been shown to be highly correlated with hippocampal sclerosis.[5] Patients with TPB typically were younger at the age of seizure onset.[3–5] In addition, patients with TPB generally performed worse on neuropsychological testing, including deficits in attention, executive function, and memory.[3,4] Data are currently limited on postoperative neuropsychological decline. With respect to seizure outcomes, most studies show comparable seizure freedom after surgery in TLE with TPB compared to TLE without TPB.[3,4,10,13,14]

The etiology of TPB has been debated, including various congenital and acquired causes, such as FCD. Histopathological analysis had previously shown a paucity of white matter staining in the temporal pole white matter suggesting abnormalities in myelination.[9] Decrease in myelination was subsequently confirmed by Garbelli et al.,[4] who also found associated severe axonal loss. The etiology of this dysmyelination and axonal loss has been hypothesized to be the result of subclinical temporal lobe electrical perturbations in

young patients that disrupt normal myelination with resulting axonal degeneration.[4,14] As a result, patients with TPB may have more extensive temporal hypometabolism on FDG-PET and more diffuse MRI abnormalities.[15]

Recognition of TPB in the diagnosis of epilepsy has important implications. First, this sign, when present, has been shown to be a reliable lateralizing feature for the side of seizure onset. While MTS is a common co-occurrence, TPB may be the only MRI abnormality in some cases, as in ours, providing additional confidence in the side of seizure onset. Second, TPB should not be mistaken for other entities, such as FCD or neoplasm, as this may erroneously influence surgical decision making. Last, while rates of seizure freedom after surgery have not been shown to be significantly different between TLE with or without TPB, studies suggest poorer neuropsychological function in patients with TPB.

Declaration of conflicting interests

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Informed consent

Requirement for informed consent was waived for this retrospective case study approved by the Mayo Clinic Institutional Review Board.

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