Magnetoencephalography for focal cortical dysplasia diagnosis

If the MRI is normal, other tests such as PET, SISCOM or MEG can help pinpoint the location of the brain where seizures arise. While these tests can help show the region where seizures arise, they are not able to distinguish focal cortical dysplasia (FCD) from other focal causes of epilepsy.

The use of source analysis based on electroencephalography (EEG) and magnetoencephalography (MEG) has gained considerable attention in presurgical epilepsy diagnosis. However, in many cases the source analysis alone is not used to tailor surgery unless the findings are confirmed by lesions, such as, e.g., cortical malformations in MRI. For many patients, the histology of tissue resected from MRI negative epilepsy shows small lesions, which indicates the need for more sensitive MR sequences.

A study of Gautham et al. from Bengaluru included a cohort of 231 children (1-18 years) with focal drug-resistant epilepsy who underwent MEG as a part of their presurgical workup. Characteristics of MEG observations were described in all children. The concordance and agreement of Magnetic Source Imaging (MSI) of interictal discharges (IED) was estimated with either of the 3 subgroups - MRI lesion; presumed epileptogenic zone (EZ); or resection cavity. In operated children group, MEG dipole characteristics between good and poor outcome groups were assessed.

A total of 153 cases (66.2%) showed frequent IEDs (60 spikes/60 min). Of the 173 cases where MSI showed clusters (74.9%), 151 had lesions and 22 were non-lesional. amongst patients with lesional epilepsy and MEG clusters, class I concordance (MEG localization either completely included or overlapped at least 60% with the MRI lesion) was seen in 60.92% with a Cohen's kappa of 0.608. In non-lesional epilepsy, class I concordance of MEG with presumed EZ was found in (81.81%) with an agreement of 0.317. Fifty-three children underwent surgery of whom 39 (73.58%) showed a good outcome (Engel I). In operated children, concordance between MEG focus and resection cavity was observed in 23 (58.97%) with good outcome and in 12 (86.72%) with poor outcome with no significant difference ($p>0.05$). However, MEG cluster regular organization and clusterectomy are associated with good seizure outcome postoperatively ($p< 0.05$). Presence of scatters were associated with poor outcome ($p<0.05$) in children with focal cortical dysplasia.

MEG provides useful information that can serve as a biomarker for prognosticating the surgical outcome in pediatric epilepsy. Cluster removal and regular cluster organization shows predictive power in post-surgical prognostication in children and the presence of scatters predicts poor outcome in children with focal cortical dysplasia [1)].

Aydin et al. describe a technique to maximize the synergy between combined EEG/MEG (EMEG) source analysis and high resolution MRI. The procedure has three main steps: (1) construction of a detailed and calibrated finite element head model that considers the variation of individual skull conductivities and white matter anisotropy, (2) EMEG source analysis performed on averaged

interictal epileptic discharges (IED), (3) high resolution (0.5 mm) zoomed MR imaging, limited to small areas centered at the EMEG source locations. The proposed new diagnosis procedure was then applied in a particularly challenging case of an epilepsy patient: EMEG analysis at the peak of the IED coincided with a right frontal focal cortical dysplasia (FCD), which had been detected at standard 1 mm resolution MRI. Of higher interest, zoomed MR imaging (applying parallel transmission, 'ZOOMit') guided by EMEG at the spike onset revealed a second, fairly subtle, FCD in the left fronto-central region. The evaluation revealed that this second FCD, which had not been detectable with standard 1 mm resolution, was the trigger of the seizures [2)].

1)

Gautham B, Ahmed A, Mundlamuri RC, Narayanan M, Jayabal V, Kenchaiah R, Asranna A, Dawn BR, Jitender S, Nagaraj C, Mangalore S, Karthik K, Sadashiva N, Mahadevan A, Rajeswaran J, Kumar K, Arivazhagan A, Rao MB, Sinha S. Magnetic source imaging in presurgical evaluation of paediatric focal drug-resistant epilepsy and its predictive value of surgical outcome in lesional cases: A single-centre experience from South India. Seizure. 2021 May 24;91:22-28. doi: 10.1016/j.seizure.2021.05.015. Epub ahead of print. PMID: 34058605.

2)

Aydin Ü, Rampp S, Wollbrink A, Kugel H, Cho J-, Knösche TR, Grova C, Wellmer J, Wolters CH. Zoomed MRI Guided by Combined EEG/MEG Source Analysis: A Multimodal Approach for Optimizing Presurgical Epilepsy Work-up and its Application in a Multi-focal Epilepsy Patient Case Study. Brain Topogr. 2017 May 16. doi: 10.1007/s10548-017-0568-9. [Epub ahead of print] PubMed PMID: 28510905.