Clinical Neurophysiology 130 (2019) 793–794

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Editorial

EEG and MEG source imaging for epilepsy surgery – A sobering 22-year interim report

See Article, pages 845–855

Source localization (or source imaging) – the temporo-spatial modelling of epileptic discharges from MEG and scalp EEG – has gained momentum over the last 10–20 years as a valuable clinical tool in the pre-surgical work-up of patients with medically refractory focal epilepsy. But Mouthaan et al. (2019) in this issue of *Clinical Neurophysiology* deliver a word of caution in their sobering report on the "Diagnostic accuracy of interictal source imaging in presurgical epilepsy evaluation: A systematic review from the E-PILEPSY consortium" (Mouthaan et al., 2019). From a catchment of 3177 papers spanning 22 years (1995–2/2017), only 11 source imaging studies (0.3%) met their inclusion criteria for clinical validity – 8 studies used magnetoencephalographic source imaging (MSI) and 3 studies used high 'resolution' (64+ electrodes) electroencephalographic source imaging (HR-ESI).

From these studies (267 MSI patients, 127 HR-ESI patients), the authors found no significant difference between respective MSI and HR-ESI sensitivity and specificity measures referenced by resection volume linked to post-operative outcome. Diagnostic sensitivity (source imaging concordance with resection volume linked to Engel 1 or ILAE 1–2 outcome) was 79% (95% CI 69–87%) for MSI and 87% (95% CI 77–93%) for HR-ESI. Diagnostic specificity (source imaging non-concordance with resection volume linked to any other outcome) was 46% (95% CI 25–70%) for MSI and 61% (95% CI 45–74%) for HR-ESI.

With so few papers making the grade, this source imaging meta-analysis cannot be regarded as definitive, but there is much food for thought. For a start, the authors argue that their overall MSI and ESI diagnostic accuracy results are probably over-estimates from what appeared to be systematic bias across source imaging studies. Sources of bias included dismissal of indeterminate source imaging results, exclusion of non-operated patients, and unblinded inclusion of source imaging results in the surgical decision-making process. The authors raise the possibility that their inclusion criteria were too strict – but they actually seem quite reasonable. Studies had to feature at least 10 patients, had to use resection volume linked to surgical outcome as the reference, and had to present 2×2 contingency results for sensitivity and specificity (or provide data from which such results could be obtained). Studies did not have to be prospective in design – only 5/11 studies were prospective (all HR-ESI studies and two MSI studies) – nor did they have to reach a minimum one year post-operative follow up (4/11 studies had a minimum six month follow-up).

The authors point to the lack of standardization in the use of inverse models (HR-ESI studies featured distributed models, while all MSI studies applied dipole models) and forward models (HR-ESI studies featured either realistic or spherical head models). They also flag an apparent lack of consensus on how to interpret source solutions that only partly overlap with the resection volume. A valid call is made for a normalization algorithm that factors in resection size against source estimate size to allow a more equitable comparison between modelling approaches and between study centres.

And despite the quality of the 11 surviving papers, Mouthaan et al. (2019) still uncover a lack of transparency on the reporting of fundamental technical details including the type of resective surgery performed (only specified in 5/11 studies), how post-operative resection volumes were calculated (only specified in 7/11 studies), and exactly which phase of the spike was modelled (half the MSI studies modelled a 200 ms epoch "across the peak" while the other half gave no detail; all the HR-ESI studies modelled at the spike 50% mid-upswing point). Because EEG potential and MEG field patterns can change dramatically from spike onset to spike peak (largely due to the effects of cortical propagation) such detail ought to be given as standard practice in source imaging studies.

In an effort to minimize bias across studies, the authors rightly point to the need for long term prospective studies and to the application of minimum standards for reporting results (such as STARD and STROBE checklists) for cross-checking by reviewers. Bias is also inherently minimized by multi-national or multi-centre trials when blinding is arguably more secure.

Mouthaan and colleagues are to be congratulated for the sheer volume of this work. Their recommendations are timely and justified. It is well known that surgery is underused in the treatment of intractable focal epilepsy and that there is a pressing need for better non-invasive surgical localization methods in the work up of these challenging patients. Let's hope the next 22-year interim report card on EEG and MEG source imaging will be cause for celebration.

https://doi.org/10.1016/j.clinph.2019.02.001

Conflict of interest

No conflicts of interest.

References

Mouthaan BE, Rados M, Boon P, Carrette E, Diehl B, Jung J, et al. Diagnostic accuracy of interictal source imaging in presurgical epilepsy evaluation: a systematic review from the E-PILEPSY consortium. Clin. Neurophysiol 2019;130:845–55.

Chris Plummer
Centre for Neurosciences and Neurological Research, St Vincent's Hospital, Melbourne, Australia
E-mail address: Chris.PLUMMER@svha.org.au

Available online 10 February 2019