

Detection of interictal epileptiform discharges in an extended scalp EEG array and high-density EEG

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Background & Rationale

LTM with 40 scalp electrodes

hdEEG

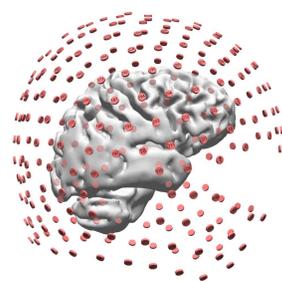
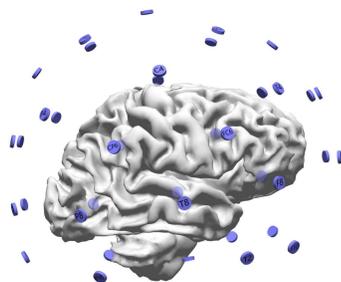


Fig 1: Left panel: setup of 40 electrodes glued to the patients' scalp during long-term Video-EEG-Monitoring (LTM), right panel: setup of high-density-EEG with 256 electrodes (hdEEG).

High counts of averaged interictal epileptiform discharges (IED) are key elements of accurate interictal electric source imaging (ESI) in patients with focal epilepsy. Automated detections may be time-efficient, but they need to identify the correct IED-types. Thus, we compared automated and semi-automated detection of IED in long-term Video-EEG-Monitoring (LTM) using an extended 40 electrode scalp EEG array and short-term high-density-EEG with 256 electrodes (hdEEG) against visual detection of IED-types and the seizure onset zone (SOZ).

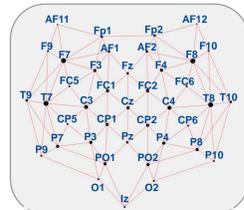


Fig 2: Plot of electrodes considered as neighbours for overlap comparison between methods with one neighbourhood-level tolerance.

We prospectively recruited all patients who underwent both, LTM with a scalp EEG with 40 electrodes and short-term hdEEG with 256 electrodes from four European epilepsy centers, which participate in the ongoing PROMAESIS trial². Only patients with a single circumscribed SOZ in LTM were included. In LTM and hdEEG IED-types were identified visually, automatically (Persyst P13, Persyst Solana Beach, USA) and semi-automatically with expert review. Concordances of (semi-)automated detections in LTM and hdEEG as well as visual detections in hdEEG were compared against visually detected IED-types (LTM-Vis) and the SOZ in LTM. For statistical comparisons of concordances with LTM-vis and the SOZ two-tailed sign-tests with Bonferroni correction were used. In addition, rates of amplitude maxima of most the frequent IED-types per patient in inferior temporal electrodes according to the 2017 IFCN electrode setup³ and AF11/AF12 was evaluated.

Results

Concordance of most frequent IED-type with visual detection LTM, N=48

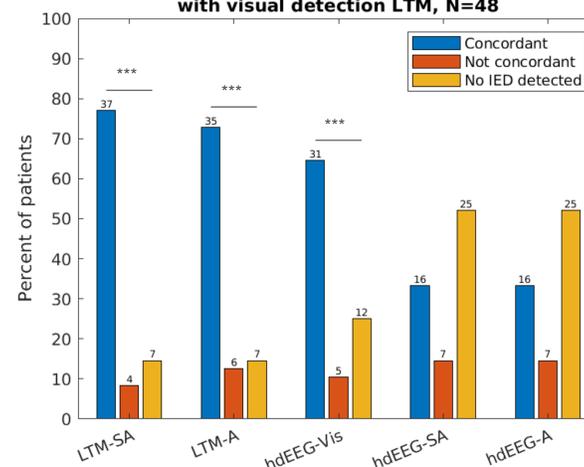


Fig 3: Concordances of the most-frequently detected IED-types with the most frequently visually detected IED-types in LTM. hdEEG: high-density-EEG, SA: semi-automated, A: automated, Vis: visual. Please note high rates of not-detected IED in (semi-)automatic detections in LTM. ****: $p < 0.0001$, sign-test

Concordance of most frequent IED-type with SOZ, N=48

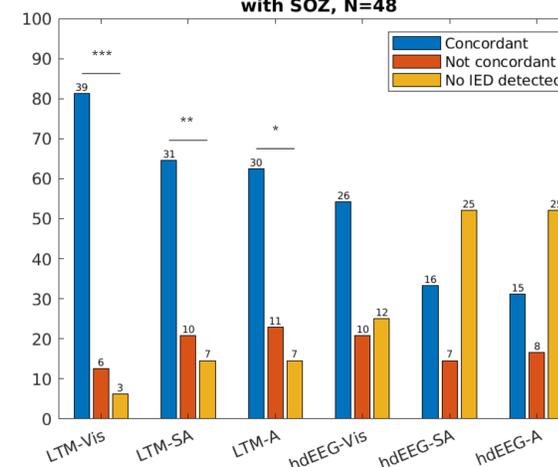


Fig 4: Concordances of the most-frequently detected IED-types per patient with the seizure onset zone (SOZ). hdEEG: high-density-EEG, SA: semi-automated, A: automated, Vis: visual. Please again note high rates of not-detected IED in (semi-)automatic detections in LTM. ****: $p < 0.0001$, **: $p < 0.01$, *: $p < 0.05$, sign-test

- Forty-eight out of 58 patients with LTM and hdEEG met the inclusion criteria.
- Concordance rates of the most frequent IED-type with visual detections in LTM: semi-automated (77%), automated (73%) detections in LTM, visual detections in hdEEG (67%), semi-automated (33%) and automated (35%) detections in hdEEG ($P < 0.001$ for all comparisons).
- Concordance rates most frequent IED-type with SOZ electrodes: visual (83%), semi-automated (65%) and automated (63%) detections in LTM and visual detections in hdEEG (54%), automated (31%) and semi-automated (33%) detections in hdEEG.
- For all IED-types of the irritative zone per patient, agreement between visual and semi-automated detections in LTM was high.
- Amplitude maxima of the most frequent IED-type per patient were found in inferior temporal electrodes or AF11/12 for 53 % (23/41 patients) of semi-automated detection in LTM and in 39% (9/23 patients) of semi-automated detection in hdEEG.

Discussion

Automated and semi-automated detection of IED-types in LTM show significant agreement with visually detected IED-types. In short-term hdEEG, the most frequent IED-types from LTM can be typically detected visually. The most frequently semi-automatically and automatically detected IED-type in LTM and the visually detected IED-types in hdEEG are significantly concordant with the SOZ, so that they are good candidates for ESI. Inferior temporal electrodes should be included in presurgical EEG setups, especially in temporal lobe epilepsy patients, as they often record negative amplitude maxima of IED.

References

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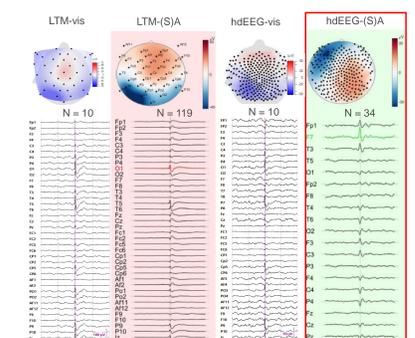


Fig 5: Most frequent IED-type in a patient with left occipital lobe epilepsy. Concordant amplitude maxima were found at electrode O1 in visual detection (LTM-vis), semi-automated and automated detection (LTM-(S)A) in LTM and visual detection in hdEEG (hdEEG-vis). Please note that the field topography and the IED morphology of the O1-IED-type in LTM-vis, LTM-(S)A and hdEEG-vis are very similar. The event count was very high for the IED-type LTM-(S)A, which results in a high contrast field topography. The most frequent IED-type in hdEEG-(S)A was a sharp transient that could not be verified as IED during expert review (panel right side, red frame).

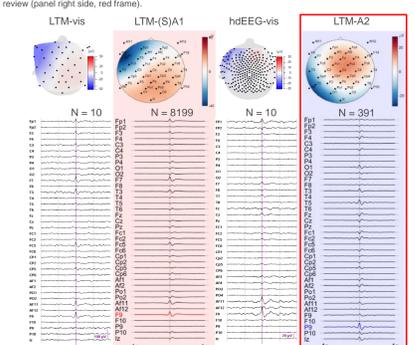


Fig 6: Most frequent IED-type in a patient with left temporal lobe epilepsy due to hippocampal sclerosis. Concordant amplitude maxima at contact P9 in visual (LTM-vis) detection, semi-automated and automated detection (LTM-(S)A1) in LTM and visual detection in hdEEG (hdEEG-vis). In this patient no IED were detected automatically in hdEEG. Compared to IED-type P9 less often IED-type P9 was detected automatically in LTM (LTM-A2). Expert review discarded this candidate IED-type and classified it as wicket spikes (panel right side, red frame).