Semi-automatic interictal electric source localization based on LTM EEG: a prospective study

L Spinelli[1] , AG Baroumand[2,3] , S Vulliemoz[1] , S Momjian[4] , G Strobbe[3] , P van Mierlo[2,3] , M Seeck[1]

[1]University Hospital of Geneva, Neurology, Geneva, Switzerland, [2]Ghent University, Medical Image and Signal Processing, Ghent, Belgium, [3]EPILOG, Clouds of Care NV, Ghent, Belgium, [4]University Hospital of Geneva, Neurosurgery, Geneva, Switzerland

Introduction

Electric source imaging (ESI) of interictal epileptiform discharges (IEDs) has shown a significant yield in numerous studies. Nevertheless, its implementation is labor- and cost-intensive for most clinical units. Semi-automatic ESI analysis (SAEA) comprising automated spike detection and source localization has been proposed as an alternative. Here we examine the yield of SAEA in a prospective study.

Materials & Methods

Between 2017 and 2022, 122 patients underwent SAEA. Inclusion criteria for the current study were: unifocal epilepsy disorder, epilepsy surgery with curative purpose, and postoperative follow-up for at least 2 years. In total, **40 patients** matched the inclusion criteria and had continuous video-EEG long-term monitoring (LTM) with 37 scalp electrodes.

	TLE	Functional hemispherotomy	MRI-negative	Subsequent intracranial EEG
Patients (N=40)	15 (37%)	3 (7%)	12 (30%)	20 (50%)
15 female, 9 pediatric, seizure-free 35. Mean age 30.3 y (±16.7). Age at onset 13.3y (± 11.3) and duration of epilepsy 17.0y (± 13.3)				

Epilog PreOp reports (now available as Persyst ESI powered by Epilog) were made based on the LTM EEG recordings and the patient-specific MRI (Epilog, Clouds of Care NV, Ghent, Belgium) (fig.1). This included IED detection in the entire LTM recording, clustering of the detected events and source localization using an individualized head model. We considered "correct localization" if the patient was Engel class I since the surgical intervention and ESI localized within the resection volume.

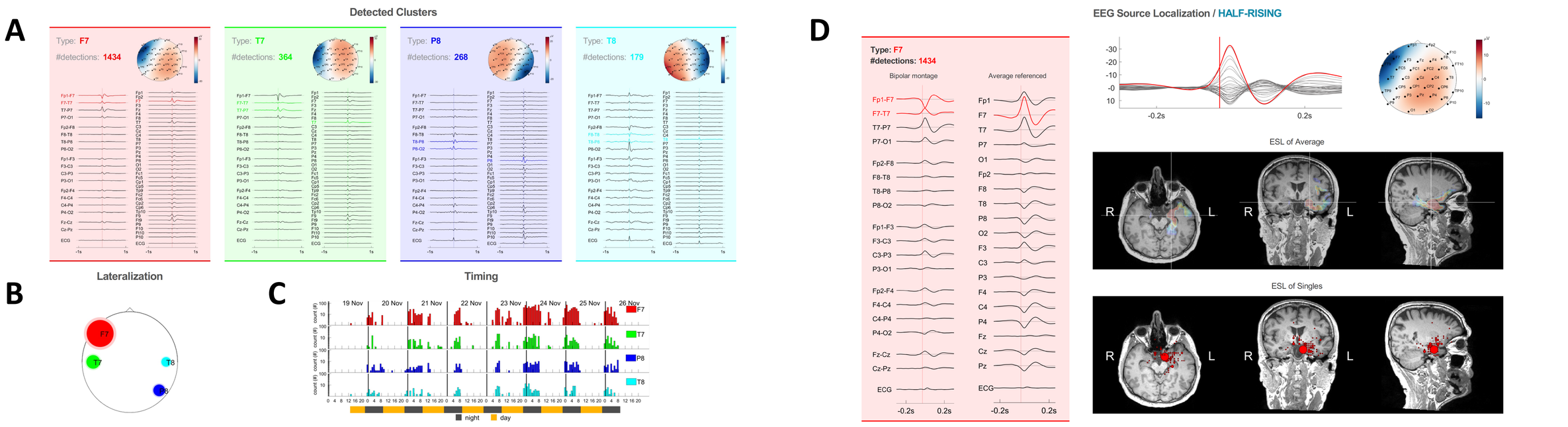

Figure 1: *Epilog report summary for one of the patients.* ***A****: four clusters have been detected as F7, T7, P8, T8 in order of number of detected spikes.* ***B****: Spike Lateralization, the bigger circle shows a higher number of detected spikes.* ***C****: Spike Timing. A higher number of spikes are observed during sleep.* ***D****: Spike Source Localization, the average spike is localized using patient-specific MRI at the half-rising time and peak (not shown) of the spike and the localization of 100 single spikes most representing the average spike is also shown, the bigger the dots the more the single spike localize to the same region.*

Results

In total 4094.8 hours (171 days) of recordings were analyzed leading to a total of 509'949 detected spikes. Mean EEG recording time was 4.3 days (+/-3.1 d) and we obtained a mean of 12'749 IEDs (+/- 22'324) per recording.

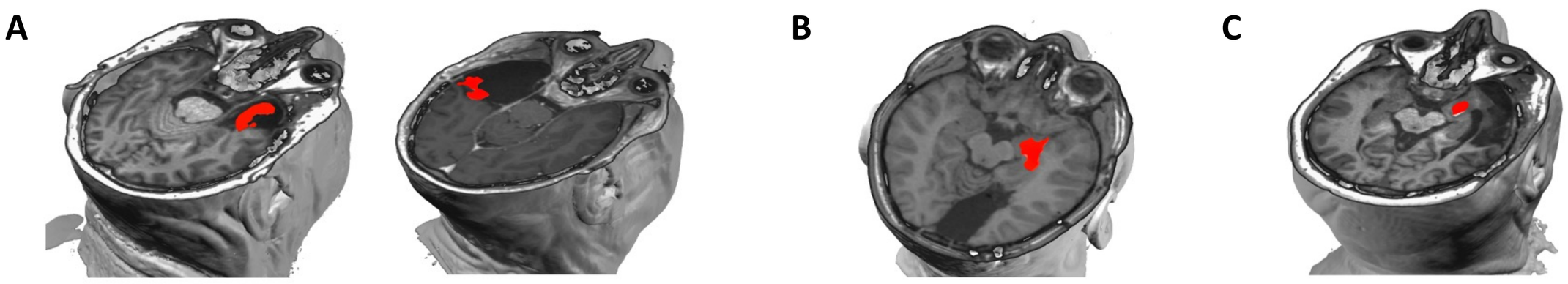

Figure 2: *Example of Semi-automatic ESI with postoperative MRI.* ***A****: Engel class 1 and ESI concordant patients. The first images shows the same patient as in figure 1.* ***B****: Engel Class1 and ESI non-concordant patient.* ***C****: Engel class 2 and ESI non concordant patient.*

	Sensitivity	Specificity	PPV	NPV	Accuracy	OR
All (40)	**74.3% (56.7-87.5)**	**80% (28.4 – 99.5)**	**96.3% (81.7-99.3)**	**30.8% (17.9-47.6)**	**75% (58.8-87.3)**	**11.5 (1.14-117.4)**
TLE (15) / ETLE(22)	84.6% / 63.2%	50% / 100%	91.7% / 100%	33.3% / 30%	80% / 68.2%	5.5 / 11.7
MRI-neg (12)	81.8%	100%	100%	50%	84.6%	19
IEEG (20)	70.6%	100%	100%	37.5	75%	15.9

Semi-automated ESI has a high accuracy (75%) and odd's ratio (11.5) to localize the epileptogenic focus. The accuracy remains in the same range for difficult patient groups such as ETLE, MRI-negative patients and patient with subsequent invasive EEG monitoring.

Conclusions

In this prospective study, using SAEA of long-term video-EEG, spanning several days, we found excellent localizing information and a high yield, even in difficult patient groups. EMU presurgical evaluation could benefit from SAEA in many patients.