Seizure onset zone effective connectome as revealed by single pulse electrical stimulation in stereoelectrographic studies

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Background

Focal epilepsy is regarded increasingly as a network disease. In this conceptual frame, standardized tools that define the effective connectivity of the seizure onset zone (SOZ) are needed. Frith et al. (2016) introduced the term “connectome” to describe the entire functional network of neuronal connections. The authors defined a network’s connectivity by its structural elements (eg, the number of connections present in the network) and functional elements (eg, how strongly a connection is present). Our study aimed to identify the most influential aspects of the network connectivity defined on the basis of appropriate methods, in order to offer a better understanding of the network’s functional properties.

Methods

We selected 36 consecutive patients with pharmaco-resistant epilepsy who were explored in the SEEG method during their pre-surgical evaluation. No constraints were put on their SOZ’s location or extent, to best mimic the clinical reality. Single pulse electrical stimulations (SPEs) (threshold, 2ms, 0.25 mA) were applied to adjacent contacts while recording responses from the rest. (Valentin et al. 2012). We calculated the early responses in the 10-12Hz interval and considered only connections between contacts having a RMS value within the 3rd quartile (Q3) of all the responses in an individual patient, correlated with the stimulation current (Spearmann’s rho=0.23, p<0.05). (Brianz et al. 2015)

Table 1

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<tr>
<th>Structure’s Name</th>
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<th>INBOUND</th>
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<td>Parietal Lobe</td>
<td>0.70%</td>
<td>15%</td>
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Fig. 1. Patel 12. Frontal Lobe, Epilepsy, Large FCD 1B, Engel I

Fig. 2. Patel 8. Intra-Operational Epilepsy, FCD 1B, Engel I

Fig. 3. Patel 11. Temporal Lobe, Epilepsy, SMRT, Engel II

Fig. 4. Patel 7. Bilateral Temporal Epilepsy, FCD 0, Engel I

Fig. 5. Patel 54. Occipital Epilepsy, Large FCD 1, Engel II

Results

A large range of structures (8–100%) (mean 55%, SD=25%), sampled for the SEEG exploration, were part of each patient’s SOZ. SOZ’s outflow projections were on average more numerous than the inbound ones (10.7 ± 5.4 vs. 8.2 ± 4.9, average ratio 0.76). Figures 2–7 demonstrate that the number of inbound or outbound connections per se are not of prognostic value (for example both Pat 3 with a small epileptome and Pat 5 with a large one experienced a relapse post-operatively).

However, postsurgical outcome was highly correlated with the proportion of pathological structures in the inbound connections, both pre and postsurgery (62% in seizure free lot vs. 85% in not seizure free lot, MannWhitney U=0.02. Spearman’s for Engel score=0.054, p<0.05), on the same order of magnitude as was the ratio of unreacted to total SOZ contacts (p=0.01).

The initial extent of the SOZ, or its outbound connections were not associated with seizure relapse, neither were the implantation’s extent, the total number or the ratio of pathological structures from those sampled. (please see Table 2.)

Table 2

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Conclusions

Grouping the subjects based on their SOZ anatomical location, significant differences appear between the 3 types of lobar epilepsies. The frontal group had received inbound connections from the most of co-implanted lobes while the temporal one from the least (95% vs. 60%). The posterior epilepsies had the highest ratio of pathological structures in the outbound connections. No significant associations were demonstrated between the duration of the disease and the properties of the epilepsies.

Acknowledgements

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References