HORIZON 2020

Functional brain networks in epilepsy

Berichterstattung

Projektinformationen

EPICONNECT

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Projektwebsite

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Periodic Reporting for period 2 - EPICONNECT (Functional brain networks in epilepsy)

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Zusammenfassung vom Kontext und den Gesamtzielen des Projekts

Approximately 30-40% of patients with epilepsy cannot be adequately treated with anti-epileptic drugs. For these patients, epilepsy surgery is the treatment with highest efficacy to become seizure-free. The goal of the epilepsy surgery is to resect or disconnect the brain region that is causing the patient to have seizures, the so called epileptic focus. The pre-surgical evaluation answers the question whether a patient will benefit from epilepsy surgery or not. Therefore, the patient undergoes a battery of test to localize the epileptic focus and to find overlap with eloquent cortex. The two cornerstone investigations are electroencephalography (EEG) that records the electrical field generated by the brain and Magnetic Resonance Imaging (MRI) that images the anatomy of the brain. EEG is used to reveal electrical epileptic phenomena and MRI to detect structural abnormalities.

During the video-EEG monitoring, the patient is admitted during 5-7 days in the hospital to record EEG and video simultaneously to study the electrical field and the semiology during seizures. The recorded long-term EEG is visually analyzed by the treating physician. Epileptic spikes and seizures are marked in the EEG to get an estimate about the location of the epileptic focus. Because epilepsy is a network disorder seizures and spikes rapidly spread throughout the brain. This makes the localization of the focus from EEG recordings a challenge. In this project we studied how brain regions communicate with each other during baseline and seizures to identify the region that is causing the epilepsy.

The main outcome of the project is that we achieved to localize the region that is generating the epilepsy by studying the functional interactions between the regions with EEG. We optimized the information obtained during the video-EEG monitoring to provide the treating physician with more information about the regions causing the epilepsy in an early phase of the presurgical evaluation. During seizures and interictal epileptiform discharges the epileptic zone could be estimated from the EEG with high localization accuracy. Furthermore, even during resting state the functional brain connectivity obtained by a brief EEG test tells us which regions have been affected mostly in the patient by the epilepsy. This has the potential to ameliorate patient care. Not only could some additional more expensive tests during the presurgical evaluation become redundant, also the patients can be treated more efficiently and earlier in time, allowing faster reintegration into the society and therefore reducing costs for the society.

Arbeit, die ab Beginn des Projekts bis zum Ende des durch den Bericht erfassten Berichtszeitraums geleistet wurde, und die wichtigsten bis dahin erzielten Ergebnisse

In this project we studied how the functional connectome derived from EEG recordings can be used to localize the epileptic focus in patients. The functional connectome indicates how brain regions communicate with each other. For example in the figure we see a functional connectome during a seizure. The arrows show the connections between the regions during the seizure. Based on these connections we can see that the brain region depicted by the star is sending information to other regions in the brain during the seizure. This indicates that this brain region is leading the seizure and we can consider it as the epileptic focus.

We investigated the functional connectome in 27 patients during 111 seizures. We compared the standard EEG-based localization technique, namely looking which brain region is most active during a seizure, with the localization technique based on functional connectome that depicts the driver of the seizure. All patients had epilepsy surgery after the presurgical evaluation and were seizure-free after surgery. This allowed us to compare the brain region we localized based on the two techniques with the resection in the patients. The brain region with maximal activity was inside the resection in 31% of the seizures and estimated within 10 mm from the border of the resection in 42%. Using the functional connectome, these numbers increased to 72% in the resection and 94% within 10 mm of the resection. Therefore, we showed that looking at the functional connectome during seizures has an added value and should be included in the presurgical evaluation.

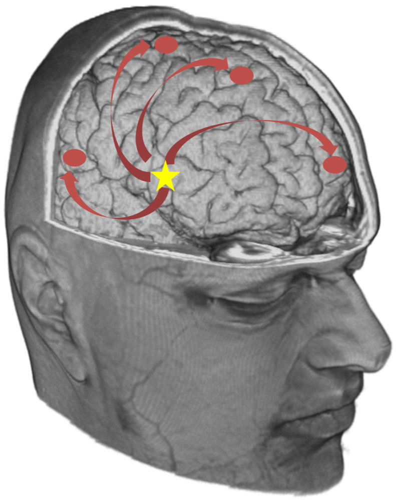
We also investigated the functional connectome during resting state in 20 patients with left temporal lobe epilepsy, 20 patients with right temporal lobe epilepsy and 35 healthy age-matched subjects. We studied how well we can classify a person to have epilepsy or not, and if we can predict the lateralization of the epilepsy (left vs. right). The diagnosis and lateralization classifiers achieved a high accuracy (90.7% and 90.0% respectively). Meaning that based on 15min resting state EEG we can predict if the person has epilepsy or not, and if yes, the side where the epilepsy is originating from with 90% accuracy.

The project resulted in a total of 8 peer-reviewed publications: 2 in NeuroImage Clinical, 2 in Brain Topography, 1 in Epilepsia Open, 1 in Brain Stimulation, and 1 in IEEE Transactions on Biomedical Engineering and over 20 conference contributions. The results of the project have been orally presented at 10 conferences such as the European Congress on Epileptology 2016 & 2018, the International Epilepsy Congress 2017 and the International Congress of Clinical Neurophysiology 2018. The first prize of oral presentation was won at the Alpine Brain Imaging Meeting 2016.

Fortschritte, die über den aktuellen Stand der Technik hinausgehen und voraussichtliche potenzielle Auswirkungen (einschließlich der bis dato erzielten sozioökonomischen Auswirkungen und weiter gefassten gesellschaftlichen Auswirkungen des Projekts)

In current clinical practice the long-term EEG is visually analyzed by the treating neurologist. Localizing the seizure onset zone from these EEG recordings is currently not used in clinical practice. This is mainly because the EEG signals are polluted with muscle and movement artefacts during a seizure and the seizure rapidly propagates to other regions. This makes the localization of the SOZ visually from EEG recording an impossible task. We showed that by looking at the functional connectome during seizures we are able to localize the region that is causing the seizures. This leads to new valuable information that will be available during the presurgical evaluation. Patients will again benefit from this by getting an improved treatment earlier in time. Furthermore, in some cases this extra information will mean that the patient can immediately undergo epilepsy surgery without the need for expensive invasive EEG monitoring that is accompanied with several side effects.

In a last study we showed the feasibility to diagnose and lateralize epilepsy from 15 minutes of resting state EEG with accuracy around 90%. Although more research is needed to confirm these findings in a larger patient cohort, it opens the way to improved epilepsy diagnosis with an inexpensive noninvasive test. In the long run this could mean that anti-epileptic drugs are started sooner in some patients, when the epilepsy has not manifested itself completely. The sooner a patient is treated, to more chance the patient has to become seizure-free and to contribute to the society.



Functional brain network during a seizure. The region depicted by the star is causing the seizure.

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