SLEEP SPINDLE ANALYSIS

1 Supervising staff

Antoine Nonclercq (professor) – antoine.nonclercq@ulb.be
Alec Aeby - Directeur de service de Neurologie Pédiatrique - Faculté de Médecine Hôpital Universitaire des Enfants (HUDE)

2 Context

Epilepsy is the second most common chronic neurological disease, associated with stigma and high economic costs. Worldwide, 50 million people are affected by epilepsy, and one-third do not respond to antiepileptic drugs [1]. These patients should be referred for a presurgical evaluation to identify and subsequently remove the epileptogenic focus surgically. If surgery is impossible, neuromodulation can be offered as an adjunctive treatment [2]. In particular, Vagus Nerve Stimulation (VNS) is an attractive neuromodulation technique, as it is less invasive and/or more convenient than other alternatives, i.e., responsive neurostimulation (stimulation is applied directly to the seizure focus), deep brain stimulation of the anterior nucleus of the thalamus, and transcranial direct current stimulation. VNS consists of an implanted pulse generator that delivers trains of electrical pulses to the left vagus nerve, which induces antiepileptic effects for both focal and generalized seizures [3]. Up to 6-9% of patients are rendered seizure-free [4], [5], and approximately half of the treated patients achieve a good clinical response (>50% seizure frequency reduction) [5]. However, despite 30 years of experience in using VNS for epilepsy, the mechanisms of action of VNS remain to be fully elucidated [6]. Nearly one-third of patients do not respond to VNS, and very little is known about why this occurs [4]. Moreover, until now, the titration of VNS parameters is performed empirically, with current intensities raised until the patient's tolerance or a clinical effect is reached. It may lead to administering unnecessarily high currents, resulting in avoidable side effects and a waste of battery energy [4].

The abortive effect of VNS is confirmed by several human and animal studies [7]–[9]. These publications strengthen the expectation that an automated seizure detection controlling on-demand VNS would significantly increase the treatment's efficiency and provide a warning possibility. Within this context, the vagus nerve is a key bidirectional information pathway between the brain and different visceral organs. For this reason, exploiting the vagus nerve traffic related to seizures might offer a novel method for the early detection of seizures as needed to control an on-demand therapeutic stimulation of the same nerve.

The circadian rhythm strongly impacts different types of pathology, such as epilepsy, a common neural disease. The rhythmicity of seizures has been known for years and recent advances in EEG monitoring have shown circadian seizure patterns in some patients. Diurnal seizures cluster during certain times of the day, such as on awakening and late in the afternoon, whereas nocturnal seizures occur primarily at bedtime and in the hours before awakening. Seizures occur in patterns dependent on the pathophysiology of the epileptic condition and one hypothesis is that the circadian clock plays a crucial role in these.

We want to study the impact of epilepsy on the night through EEG analysis and, more specifically, through the occurrence of sleep spindles in the EEG. A spindle is commonly defined as a group of rhythmic waves characterized by progressively increasing, then gradually decreasing amplitude that may be present in low voltage background EEG, superimposed to delta activity, or temporally locked to a vertex sharp wave and to a K complex. Spindles are one of the hallmarks of Non-Rapid Eye Movement (NREM) stage 2 sleep, both in adults and children.

Manual scoring of spindles is time-consuming for recordings that typically show 1,000 spindles. Achieving accurate manual scoring on long-term recordings requires a high level of vigilance, resulting in a highly demanding task that augments the risk of decreased accuracy in the diagnosis, especially for sleep-related studies, for which precise information (such as spindle's amplitude, frequency, and length) is often required. In that regard, we developed a sleep spindle detection algorithm[1].

3 Work

The main goal of this project is to analyze EEG sleep spindles in epileptic patients through automated EEG analysis. The sleep spindle analysis software will be used and adapted according to the needs of this analysis.

Major steps will include:

- Get familiar with the existing software and the requirements of the neurological team.
- Analyze the EEG sleep spindles in epileptic patients.
- Propose an adapted version of the EEG sleep spindles analysis software.
- Analyze the impact of epilepsy on the night through EEG analysis and, more specifically, through the occurrence of sleep spindles in the EEG.

4 References

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