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Automatic sleep stage classification based on subcutaneous EEG in patients with epilepsy.

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Abstract

BACKGROUND: The interplay between sleep structure and seizure probability has previously been studied using electroencephalography (EEG). Combining sleep assessment and detection of epileptic activity in ultralong-term EEG could potentially optimize seizure treatment and sleep quality of patients with epilepsy. However, the current gold standard polysomnography (PSG) limits sleep recording to a few nights. A novel subcutaneous device was developed to record ultralong-term EEG, and has been shown to measure events of clinical relevance for patients with epilepsy. We investigated whether subcutaneous EEG recordings can also be used to automatically assess the sleep architecture of epilepsy patients.

METHOD: Four adult inpatients with probable or definite temporal lobe epilepsy were monitored simultaneously with long-term video scalp EEG (LTV EEG) and subcutaneous EEG. In total, 11 nights with concurrent recordings were obtained. The sleep EEG in the two modalities was scored independently by a trained expert according to the American Academy of Sleep Medicine (AASM) rules. By using the sleep stage labels from the LTV EEG as ground truth, an automatic sleep stage classifier based on 30 descriptive features computed from the subcutaneous EEG was trained and tested.

RESULTS: An average Cohen's kappa of [Formula: see text] was achieved using patient specific leave-one-night-out cross validation. When merging all sleep stages into a single class and thereby evaluating an awake-sleep classifier, we achieved a sensitivity of 94.8% and a specificity of 96.6%. Compared to manually labeled video-EEG, the model underestimated total sleep time and sleep efficiency by 8.6 and 1.8 min, respectively, and overestimated wakefulness after sleep onset by 13.6 min.

CONCLUSION: This proof-of-concept study shows that it is possible to automatically sleep score patients with epilepsy based on two-channel subcutaneous EEG. The results are comparable with the methods currently used in clinical practice. In contrast to comparable studies with wearable EEG devices, several nights were recorded per patient, allowing for the training of patient specific

algorithms that can account for the individual brain dynamics of each patient. Clinical trial registered at ClinicalTrial.gov on 19 October 2016 (ID:NCT02946151).

KEYWORDS: Automatic sleep scoring; Epilepsy; Sleep; Subcutaneous EEG; Wearable EEG