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ORIGINAL ARTICLE/ARTICLE ORIGINAL

Automatic detection of rhythmic and periodic patterns in critical care EEG based on American Clinical Neurophysiology Society (ACNS) standardized terminology

Détection automatique de patterns rythmiques et périodiques dans l'EEG de soins intensifs basée sur la terminologie standardisée de l'American Clinical Neurophysiology Society (ACNS)

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Automatic detection;
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Summary
Aims of the study. — Continuous EEG from critical care patients needs to be evaluated time efficiently to maximize the treatment effect. A computational method will be presented that detects rhythmic and periodic patterns according to the critical care EEG terminology (CCET) of the American Clinical Neurophysiology Society (ACNS). The aim is to show that these detected patterns support EEG experts in writing neurophysiological reports.
Materials and methods. — First of all, three case reports exemplify the evaluation procedure using graphically presented detections. Second, 187 hours of EEG from 10 critical care patients were used in a comparative trial study. For each patient the result of a review session using the EEG and the visualized pattern detections was compared to the original neurophysiology report.

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Results. — In three out of five patients with reported seizures, all seizures were reported correctly. In two patients, several subtle clinical seizures with unclear EEG correlation were missed. Lateralized periodic patterns (LPD) were correctly found in 2/2 patients and EEG slowing was correctly found in 7/9 patients. In 8/10 patients, additional EEG features were found including LPDs, EEG slowing, and seizures.
Conclusion. — The use of automatic pattern detection will assist in review of EEG and increase efficiency. The implementation of bedside surveillance devices using our detection algorithm appears to be feasible and remains to be confirmed in further multicenter studies.

MOTS CLÉS
Terminologie ACNS
USI ;
EEG ;
Détection automatique ;
Motifs rythmiques et périodiques ;
Soins intensifs

Résumé
Buts de l'étude. — L'EEG continu (cEEG) des patients en unité de soins intensifs doit être évalué plus efficacement pour optimiser le traitement. Nous présentons une méthode informatique de détection de patterns rythmiques et périodiques. Celle-ci est basée sur la terminologie de soins intensifs (CCET) de l'American Clinical Neurophysiology Society (ACNS). Le but est de montrer que la détection de ces patterns permet aux experts d'écrire plus facilement des rapports neurophysiologiques.
Méthodes et matériaux. — Dans un premier temps, trois études de cas illustrent la procédure d'évaluation en utilisant des détections présentées graphiquement. Ensuite, 187 heures d'EEG venant de dix patients d'unités de soins intensifs ont été introduites dans une étude comparative. Pour chaque patient, le résultat d'une session de révision utilisant l'EEG et la détection des patterns a été comparé avec le rapport neurophysiologique original.
Résultats. — Parmi les cinq patients ayant eu des crises épileptiques, les crises de trois patients ont été reconnues correctement. Les deux autres patients avaient des crises cliniques très subtiles et sans corrélation claire dans l'EEG. Les patterns périodiques latéralisés (LPD) ont été correctement reconnus chez les 2 patients concernés et un ralentissement du EEG a été correctement reconnu dans 7/9 cas. Pour 8/10 patients des caractéristiques additionnelles ont été identifiées, incluant des patterns périodiques latéralisés, un ralentissement de l'EEG et des crises.
Conclusion. — L'utilisation d'algorithmes de détection automatique basés sur la CCET assisteront dans la révision de l'EEG et augmenteront son efficacité. L'implémentation de dispositifs de surveillance utilisant notre algorithme sera possible et sera montré dans de futures études multicentriques.

Introduction

Over the past decade, a considerable amount of research effort has been expended to study the prevalence in EEG of nonconvulsive seizures (NCS) or nonconvulsive status epilepticus (NCSE) in acutely ill patients. In 1999, a publication by Kaplan [14,15] showed that the extended use of continuous EEG (cEEG) revealed many patients with NCS/NCSE that would have been undiagnosed without cEEG. Several years later, Claassen et al. reported that the percentage of patients in the intensive care unit (ICU) undergoing cEEG monitoring who were found to have seizures was 19% [4] with a very high percentage (92%) of these seizures being nonconvulsive. A recent cohort study at 11 North American sites showed that 30% of pediatric ICU patients had seizures and 11% of the patients had NCSE [1]. Continuous EEG remains the gold standard for diagnosis of NCS/NCSE. CEEG is beginning to be used in ICU seizure treatment studies [12] and has been shown to be favorably associated with good outcome [18]. Recently, it has also been reported that not only patients with primary neurological diseases but also medical/surgical ICU patients with secondary neurological complications benefit from cEEG monitoring [3,13].

There is significant cost associated with cEEG monitoring. EEG recording equipment, network connections, MRI and CT compatible electrodes [5], and 24-hour EEG technologist support for connecting and maintaining electrodes are needed. However, another significant source of cost is the physician effort needed to review the cEEG signal, which is recorded by approximately 20 sensors over a time period of hours to days. Optimal diagnosis would involve continuous analysis of this signal to detect seizures, but this is unfeasible for conventional ICU staffing models. In clinical practice, manual analysis of cEEG recordings is done by reviewing pages showing 10 to 20 seconds of EEG. In order to review this much data, the physician reviewer often has to view the cEEG recording very rapidly, which makes it easy to miss brief seizures. An automated detection system could evaluate the cEEG continuously and present results in real-time. Detailed analysis of EEG segments labeled by an automated detection system could replace continuous evaluation of the full EEG and avoid an error-prone accelerated review of long-term EEGs.

Quantitative EEG (QEEG) was a first step towards an automatic and objective interpretation of the EEG signal to assist in evaluation and decision-making. QEEG allows