

Different patterns of electroencephalography during hypoglycemia in type 1 diabetes mellitus

A case report

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Abstract

Rationale: Electroencephalographic (EEG) changes are frequently observed not only by epileptic seizures but also by metabolic encephalopathies. The EEG changes during hypoglycemia are known as mixed frequency theta to delta activity with higher amplitude than the initial background rhythm. Although there are many reports about hypoglycemia induced EEG changes, few studies of hypoglycemic EEG patterns have been evaluated between arousal and sleep stage.

Patient concerns: A 45-year-old man who had been diagnosed as type 1 diabetes mellitus for 15 years admitted to the emergency room due to seizure attack. The EEG findings of the patient showed increased amplitude of theta slowing on both hemispheres. The abnormal EEG finding had recovered and the background frequency remarkably increased as the patient fell asleep, but reappeared when he woke up.

Diagnosis: The patient was diagnosed as hypoglycemia with altered mentality.

Interventions: Fifty percent dextrose fluid 50mL was loaded and maintained with 10% dextrose water afterwards.

Outcomes: The patient improved after medical treatment.

Lessons: The EEG presentation of hypoglycemia involves low frequency and increased amplitude of delta-theta activity. As the previous studies, we observed medium amplitude semi-rhythmic theta slowing EEG findings on both hemispheres during arousal, indicating hypoglycemia. However, it was stabilized during sleep as background frequency increased and medium amplitude of slowing disappeared. Although there are many reports about hypoglycemia induced EEG changes, few studies of hypoglycemic EEG patterns have been evaluated between arousal and sleep stage. We report a case of different EEG patterns between arousal and sleep stage during hypoglycemia.

Abbreviation: EEG = electroencephalographic.

Keywords: arousal, diabetes mellitus, electroencephalography, hypoglycemia, sleep

Editor: N/A.

The patients have given their consents for this case report.

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

All data and material supporting our findings are contained within the manuscript.

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1. Introduction

Hypoglycemia may cause generalized tonic-clonic seizures when the blood glucose level drops below 36 mg/dL (2.0 mmol/L).^[1] Electroencephalographic (EEG) changes due to hypoglycemia occur more rapidly than seizures. When blood glucose decreases below 41.4 mg/dL (2.3 mmol/L), EEG changes appear on the mixed frequency of theta activity in temporal, parietal, and occipital areas.^[2] However, EEG differences between sleep and arousal have not been evaluated in patients with hypoglycemia. We recorded EEG differences between sleep and arousal under hypoglycemia in a patient with type 1 diabetes mellitus, who visited the hospital with an acute symptomatic seizure. We report the present case with a literature review.

2. Case report

A 45-year-old man visited the hospital due to a first-time generalized seizure. The patient reported drowsiness before breakfast repeatedly during the week before his hospital visit. He was diagnosed with type 1 diabetes for 15 years and was on insulin management. According to a witness, he had a generalized tonic-clonic seizure lasting 1 minute. Serum blood glucose was not recorded before and after the seizure and the patient had taken light refreshments before visiting the emergency room. The



Figure 1. Different EEG patterns for arousal and sleep during hypoglycemia. The EEG demonstrated medium amplitude, mixed frequency theta activity on both hemispheres during arousal (Average montage, A; Bipolar montage, B) and small amplitude, increased background theta to alpha activity during sleep (Average montage, C; Bipolar montage, D). EEG = electroencephalography.

blood test was conducted 4 hours after a meal on the day of the hospital visit. The blood glucose level was 157 mg/dL and HbA1c was 8.3%. On his hospital visit, the vital signs, and physical and neurological examination appeared normal and no abnormality was found in the brain magnetic resonance imaging scan. Eight hours after the patient experienced the seizure, he gradually lost

consciousness and confusion was observed (Fig. 2). The EEG examination was conducted 10 hours after symptom onset and medium amplitude semi-rhythmic theta activity was observed during arousal (Fig. 1A and B). During sleep, an increased background rhythm activity and decreased amplitude with loss of theta slowing were observed on EEG (Fig. 1C and D). The EEG

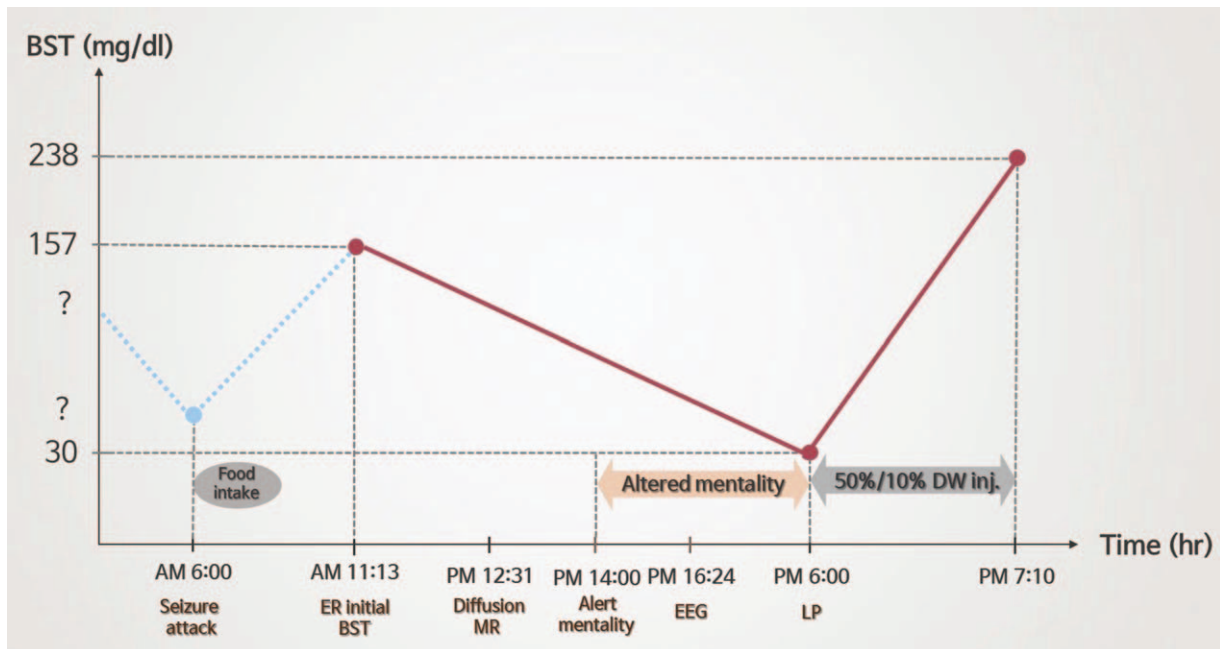


Figure 2. Timetable from hypoglycemia symptom onset to condition of recovery. The EEG was performed during the altered mental status of hypoglycemia. EEG = electroencephalography.

findings of mixed frequency rhythmic theta activity reoccurred during activating procedures as the patient awoke (Fig. 1A and B). Serum blood glucose was tested again immediately after the EEG examination and was found to be 30 mg/dL, a steep drop from the initial 157 mg/dL value (Fig. 2). Therefore, 50% dextrose fluid 50 mL was loaded and maintained with 10% dextrose water afterwards. Intra-cranial pressure (92 mmH₂O), white blood cells (0/mm³), and protein (25 mg/dL) were within normal ranges but glucose level was low (30 mg/dL) in the cerebrospinal fluid test. The patient was treated using a reduced insulin dose and oral valproic acid (1200 mg/d) for the hypoglycemia and acute symptomatic seizure, respectively. The patient improved and no further seizures occurred.

3. Discussion

The patient visited the hospital due to a generalized seizure. As he ate a small amount of food after the seizure, his blood glucose was 157 mg/dL on admission. However, it decreased greatly to 30 mg/dL immediately after the EEG examination. EEG was conducted in the hypoglycemic state, unintentionally, including the physiologic conditions of arousal and sleep. We consider this case meaningful as it is almost impossible to check EEG activity during hypoglycemia; it is against clinical ethical standards to artificially induce hypoglycemia and conduct an EEG examination. The semi-rhythmic theta activity observed in the EEG of the patient may be observed during a specific physiological state such as the transition to sleep, hyperventilation, or as a form of epileptiform discharge in addition to hypoglycemia.^[3] In the presented case, semi-rhythmic theta activity was observed during arousal and the patient did not hyperventilate. As there was no spike-and-wave complex or typical evolving patterns in the EEG with background suppression and slowing, epileptiform discharge was also excluded. Therefore, the semi-rhythmic theta activity during arousal was attributed to EEG changes due to hypoglycemia.

The EEG presentation of hypoglycemia involves low frequency and increased amplitude of delta to theta activity.^[4] It is known that these EEG patterns are not correlated with altered consciousness or sleep in patients with hypoglycemia.^[4] We observed medium amplitude semi-rhythmic theta slowing on both hemispheres during arousal, indicating hypoglycemia. However, it stabilized during sleep as background frequency increased and medium amplitude of slowing disappeared. Theta waves appeared when the patient was again in the arousal stage. Snogdal et al reported a method of alarming patients of hypoglycemia by detecting changes in continuous EEG monitoring.^[5] This study presented the blood glucose levels of 10 patients with changes in EEG. The mean blood glucose level was 48.6 and 45 mg/dL in the arousal and sleep stages, respectively, indicating abnormal EEG at a lower blood glucose level during sleep as opposed to arousal.^[5] No statistically significant differences were observed due to the small sample size, but the pattern was similar to that of this case report. The EEG against hypoglycemia was more stable during sleep than at arousal. EEG findings during sleep are related to the thalamocortical system and result from

oscillations in membrane potentials.^[6] At sleep onset, the firing rate of the midbrain reticular formation and mesopontine cholinergic nuclei diminishes, thus, suppressing an excitatory drive from the thalamocortical system and allowing the membrane potential to reach hyperpolarization.^[7] It was suspected that the sleep stage EEG was more stable in hypoglycemia in this case report, as the thalamocortical projection was more inhibited during the sleep than the arousal stage; thus, the glucose demand in the brain decreased.^[8]

Patients with diabetes mellitus may experience changes in consciousness, acute symptomatic seizures, and cerebral damage, due to hypoglycemia. Therefore, they are required to have suitable monitoring and follow appropriate preventative measures. Some recent studies have reported that it is possible to detect the occurrence of hypoglycemia by continuous EEG monitoring in patients with uncontrolled diabetes during sleep.^[5] According to this case report; however, EEG patterns differed between arousal and sleep in hypoglycemia. Our results suggest that it may be necessary to conduct appropriate interpretation of continuous EEG monitoring in patients with hypoglycemia, especially during sleep.

Author contributions

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