Case report

A Report on the Continuous EEG Monitoring in neurocritical care

Introduction

These days, continuous electroencephalogram monitoring (C-EEGM) has been recognized as a crucial tool for patient monitoring, especially in the field of emergency and critical care medicine.

We will introduce reports from doctors representing each field, and in this report, how C-EEGM is actually conducted in the institutions which are practicing neurocritical care, and discuss what is still to be solved to make it an established part of clinical practice.

Experiences of using CV-HS-EEGM in neurocritical care

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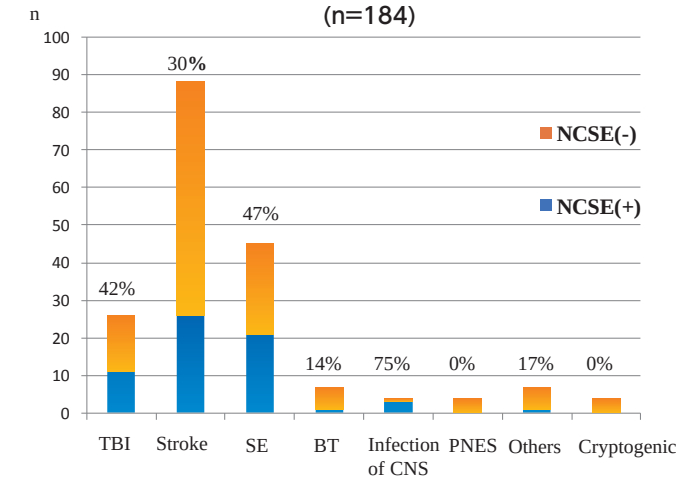
The Aim of EEG Monitoring and Indications in Neurocritical care

Continuous electroencephalogram monitoring (C-EEGM) is indispensable in the field of neurocritical care. It is considered to be helpful in detecting nonconvulsive status epilepticus (NCSE) of a patient who has consciousness disturbance or altered mental status (AMS) with unknown causes, in assessing the degree of disturbed consciousness, in detecting delayed cerebral ischemia (DCI) at an early stage caused by a subarachnoid hemorrhage, and in forecasting the prognosis of brain damage, including post cardiac arrest syndrome (PCAS)[1)]. In particular, there are many reports about the detection of NCSE.

Our hospital conducts continuous video-EEG monitoring (CV-EEGM) using the international 10-20 system of almost every patient who has consciousness disturbance or AMS with unknown causes. We conduct CV-EEGM very carefully on patients who have symptoms such as AMS after convulsive status epilepticus, subtle eye movements, facial myoclonus or myoclonus of limbs, oral automatism, conjugate deviation, aphasia, and delirium.

Figure 1 indicates the number of NCSE cases detected in our neurointensive care unit (Neuro ICU).

Figure 1 Number and proportion of NCSE



NCSE : non-convulsive status epilepticus, TBI : traumatic brain injury, SE : status epilepticus, BT : brain tumour, CNS : central nervous system, PNES : psychogenic non-epileptic seizure

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Using EEG Monitoring in Neurocritical care

Figure 2 shows the flowchart of CV-EEGM in our Neuro ICU.

Ideally, CV-EEGM should be conducted twenty-four hours a day, but in Japan this is impossible due to the lack of suitable manpower. In our actual practice, we have established a system as follows: every day in our morning round, we have a discussion about the patients who have been found to have symptoms listed above and decide whether to conduct CV-EEGM on them or not. If our decision is positive, we immediately ask an EEG technician to conduct a CV-EEGM examination to the patient using the international 10-20 system in the afternoon.

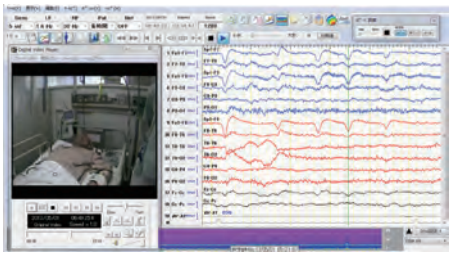
This system has been as much as our capacity in the Neuro ICU can do. But NCSE is a kind of emergency, which means that its examination should be conducted immediately if there are even the slightest signs of the condition. Therefore our hospital has introduced the system of continuous video - headset - EEG monitoring (CV-HS-EEGM). This is a newly developed easy-to-use technology for this purpose. It features eight electrodes (F, C, T, O), and is capable of transmitting EEG data simultaneously by bluetooth. It is a very easy and convenient system which can be put on a patient who has any subtle signs of NCSE.

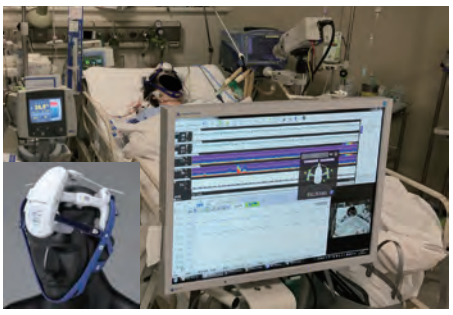
It always helps us to make a quick diagnosis as it is possible to use this technology on patients with suspected NCSE just when we see them in our morning round. Moreover, it is also helpful because it is so easy to use that any doctors on duty at night can use it on the patients.

As is shown in Figure 3, CV-HS-EEGM has an easy and clear protocol with animated manuals, so that even nurses can easily conduct CV-HS-EEGM on patients.

Our experience with CV-HS-EEGM suggests that this system is very easy to use and it is a very useful tool in judging how urgently we should treat the patient.

Figure 2 Protocol of continuous EEG monitoring in Neuro ICU





CV-HS-EEGM

Morning round

NCSE associated symptoms (+)

p.m

CV-EEGM
(International 10-20 system)

NCSE(+)
fPHT 22.5 mg/kg
and/or
LEV 60 mg/kg*, others

CV-HS-EEGM

Next morning round

Assess the effects of AEDs

Determine whether to continue CV-EEGM or not

NCSE: non-convulsive status epilepticus, CV-EEGM: continuous video-EEG monitoring,
CV-HS-EEGM: continuous video-headset-EEG monitoring,
fPHT: fosphenytoin, LEV: levetiracetam, AED: antiepileptic drug
* Approved by the ethics committee of our hospital.

If we need to unexpectedly conduct CV-EEGM, we perform CV-HS-EEGM with eight electrodes.

Figure 3 Preparation of patient for CV-HS-EEGM by nurse

CV-HS-EEGM: continuous video-headset-EEG monitoring

Now we will explain how we evaluate the EEG morphologies of C-EEGM to make a diagnosis in our Neuro ICU. We always make a diagnosis based on two sources: “American Clinical Neurophysiology Society’s Standardized Critical Care EEG Terminology: 2012 version” [2] and “modified Salzburg consensus criteria” [3].In addition, the final diagnosis of EEG morphologies is made by two or more neurophysiologists.

On the other hand, it is necessary for EEG morphologies to be evaluated correctly by any doctor or even nurses, because EEG morphologies are a critical warning of NCSE.

To achieve this, we have devised easy flags to recognize NCSE. As is shown in Figure 4, at our Neuro ICU, we have divided the EEG morphologies into three categories and indicate each division as green, yellow and red respectively, like a traffic signal.

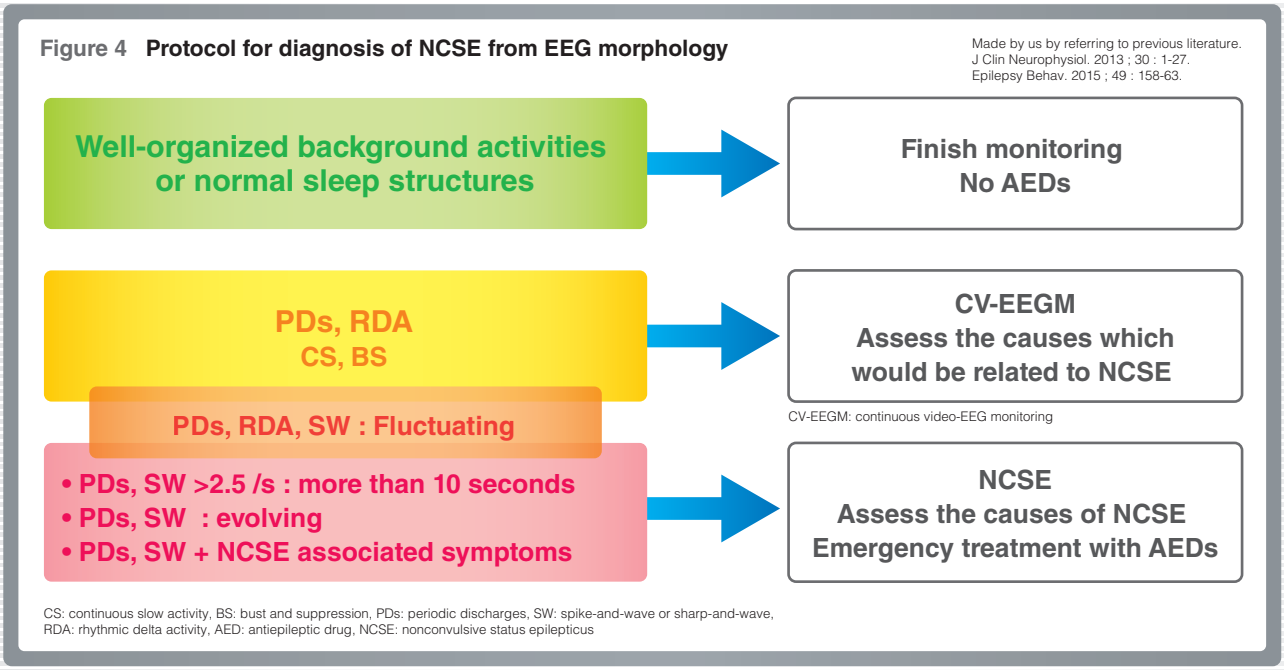
Green means there is no problem because the background activities are well organized and sleep structure is stable, so that it is safe to stop CV-EEGM.

Yellow comes when Periodic Discharges (PDs) or Rhythmic Delta Activity (RDA) has been found and it suggests that we should observe the patient very carefully checking whether the PDs or RDA is accompanied by some emergent alteration of the EEG morphologies which we will mention below. In addition, it suggests we should never fail to investigate and treat the original disease of the patient.

The red signal indicates the most emergent situation. This signal comes when PDs or Spike-and-wave / Sharp-and-wave (SW) is 2.5/s and lasts more than 10 seconds, or when it is estimated as evolving. Red requires us to make an urgent consultation with neurophysiologists and provide treatment using antiepileptic drugs (AEDs) immediately, in addition to continuing to treat the original disease. Besides this, we usually choose to provide treatment if PDs or SW is combined with other NCSE associated symptoms.

On the other hand, if PDs or RDA is fluctuating, we talk with neurophysiologists and make our decision very carefully because we believe that it is necessary to make a diagnosis from a wider point of view, taking into account other symptoms of the patient.

To diagnose NCSE, we used these methods in both CV-EEGM with the international 10-20 system and CV-HS-EEGM.



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Case presentation

As the last part of this report we will present two actual cases.

<Case 1>

A male patient in his seventies was taken to our Neuro ICU due to disturbed consciousness after generalized convulsive status epilepticus (GCSE). He had CV-HS-EEGM put on his head. His acute physiology and chronic health evaluation II score (APACHI II score) on arrival was 16. When we began CV-HS-EEGM, on the first day in Neuro ICU, his sequential organ failure assessment score (SOFA score) was 4, Glasgow Coma Scale (GCS) was 6 (E1VtM4), and Full Outline of UnResponsiveness (FOUR) Score was 6 (E0M2B4R0). CV-HS-EEGM showed right LPDs, as well as a little of SW. The fact that LPDs faster than 2.5 /s lasted more than 10 seconds and that LPDs were evolving led us to conclude that this patient was in the 'red' status, and we began to treat him immediately with AEDs [fosphenytoin (fPHT) 22.5 mg/kg/day, levetiracetam (LEV) 60 mg/kg/day].

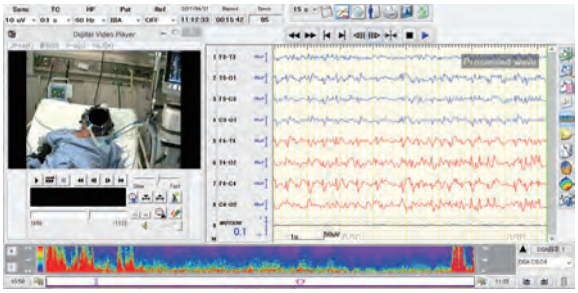
<Case 2>

A female in her eighties was found unconscious at home. She was found to have such symptoms as: the complete right hemiparesis and aphasia. Her APACHI II score on arrival was 27. When we started CV-HS-EEGM, on the first day in Neuro ICU, her SOFA score was 8, GCS was 8 (E2V2M4), and FOUR score was 14 (E4M2B4R4). A head computed tomography (CT) scan revealed a light degree of left chronic subdural hematoma. In addition, according to MRI (fluid attenuated inversion recovery: FLAIR), a subtle hyperintensity area was found in the left frontal lobe. A diffusion weighted image didn't show any sign of acute cerebral infarction. Using these data, we concluded that she had a disturbed unconsciousness with unknown causes. And it might be caused by NCSE because of complete right hemiparesis. We decided to give her CV-HS-EEGM, which indicated she had some LPDs (bilateral asymmetric, dominant in the left) with evolving. As she also showed acute renal failure, we began to treat her with LEV 1000 mg/day. With this treatment her PDs disappeared, her right hemiparesis was improved, her consciousness recovered so well that the final GCS was E4V5M6, and she was moved to another hospital with a modified Rankin Scale of 1.

Case 1

A male patient in his seventies with disturbed consciousness after GCSE

LPDs (rt)



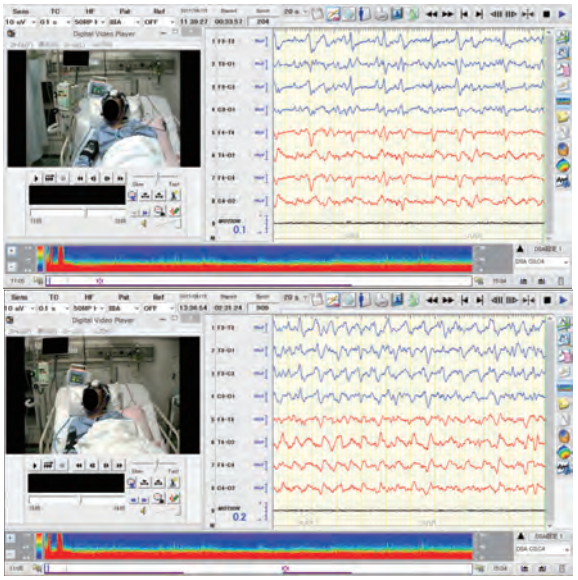
APACHI II score = 16, SOFA score = 4, GCS = 6 (E1VtM4), FOUR score = 6 (E0M2B4R)

GCSE: generalised convulsive status epilepticus, LPDs: ateralized periodic discharges,
APACHI II score: acute physiology and chronic health evaluation II score,
SOFA score: sequential organ failure assessment score,
GCS: Glasgow Coma Scale, FOUR score: Full Outline of UnResponsiveness score.

Case 2

A female patient in her eighties with disturbed consciousness of unknown etiology

LPDs bilateral asymmetric, dominant in the left



APACHI II score = 27, SOFA score = 8, GCS = 8 (E2V2M4), FOUR score = 14 (E4M2B4R4)

GPDs: generalised periodic discharges,
APACH II score: acute physiology and chronic health evaluation II score,
SOFA score: sequential organ failure assessment score
GCS: Glasgow Coma Scale, FOUR score : Full Outline of UnResponsiveness score

References:

1) Friedman D, Claassen J, Hirsch LJ. Continuous electroencephalogram monitoring in the intensive care unit. Anesth Analg. 2009; 109: 506-23.
2) Hirsch LJ, LaRoche SM, Gaspard N, et al. American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2012 version. J Clin Neurophysiol. 2013;30 : 1-27.
3) Leitinger M, Beniczky S, Rohracher A, et al. Salzburg Consensus Criteria for Non-Convulsive Status Epilepticus--approach to clinical application. Epilepsy Behav. 2015; 49: 158-63.

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9206 SP67-0031 '17. 10. SE. a.