NERVUS MONITOR

Status Epilepticus Tutorial

December 2003

Reykjavík, Iceland

Table of Contents

Status Epilepticus Monitoring

This document is written as a guide for the ICU staff on how to monitor Status Epilepticus (SE) in the patient at risk, using The Nervus Monitor. It is also meant to be a guide for non-medical staff working with the Nervus Monitor and seeking a better understanding of SE. **The information in this document is not medical advice.**

This document is based on several sources which are mentioned in the references section and on The User Manual for Nervus Monitor. It is not meant to replace these sources in any way and we encourage the user to study them further.

Screenshots in the document are from actual recordings of SE, done at The University Hospital in Lund, Sweden.

Introduction to Status Epilepticus

Definition

The term is used to describe any continuing type of seizure activity in the brain. The definition of status epilepticus is evolving, but traditionally the term was defined as 30 minutes of continuous seizure activity or a series of seizures without return to full consciousness. Cerebral metabolic decompensation is believed to occur after approximately 30 minutes of uncontrolled convulsive activity according to this definition.

Later research suggests that shorter periods of seizure cause neuronal injury and that seizure self-termination becomes unlikely after 5 minutes. In addition, it is now considered unacceptable to wait as long as 30 minutes to diagnose a patient in this state without treatment.

Many specialists now use the term Status Epilepticus to describe continuing or recurrent seizure activity in the brain without return to full consciousness with a duration exceeding 5 minutes.

Emergency

SE is a medical emergency that requires rapid and vigorous treatment to prevent neuronal damage and systemic complications.

Recent studies have shown a surprisingly high incidence of non-convulsive seizures (NCS) and non-convulsive status epilepticus (NCSE) among patients in the ICU (Jordan).

Diagnosis

Timely diagnosis of epileptic activity is of major importance. Mortality rises with delay of diagnosis and in specific underlying diseases if accompanied by SE. History plays an important role in the diagnosis process. Causes of SE may be divided into two categories: acute and chronic.

Acute processes: electrolyte imbalance, e.g. Na^{+} and Ca^{++}; cerebrovascular accident; cerebral trauma (including surgery); drug toxicity; cerebral anoxic/hypoxic damage; central nervous system infection, e.g. encephalitis, meningitis; sepsis and renal failure.

Chronic processes: pre-existing epilepsy; poor anticonvulsant drug compliance or change of anticonvulsant therapy; chronic alcoholism; cerebral tumours or other space occupying lesions in the brain.

Differential diagnosis exists, but will not be explained further in this text. Approximately 50% of cases occur in the absence of previous epilepsy.

SE occurs in both sexes and all ages; incidence increases considerably with age. EEG is by far the best method of diagnosing status epilepticus and monitoring efficacy of treatment as it is simple to use and is both sensitive and specific to seizure activity in the brain.

Diagnosis of the initial cause is of course of great importance. Lab studies can reveal toxicological causes and electrolyte abnormalities, arterial blood gas testing reveals a metabolic acidosis and it is also important to monitor oxygenation. A lumbar puncture should be considered if CNS infection is in the differential diagnosis.

Treatment

Once the patient is in hospital, SE treatment should focus on termination of seizures, prevention of recurrence, treatment of potential or underlying causes according to diagnosis and management of complications.

Termination of seizures is done with the help of anti-epileptic drugs. Benzodiazepines given **i.m**. or **i.v.** is the first choice followed by phenytoin and other drugs and even general anaesthesia.

Monitoring Method

In the patient at risk, a full EEG should be performed to confirm the presence of SE and localize it. ICU staff can, however, start monitoring SE and treatment of it in the patient shortly after admittance. Monitoring of SE enables the doctor to monitor efficiency of treatment and recurrence of SE.

Status Epilepticus Protocol

Montage: Should be as simple as possible so that the ICU staff will be comfortable in applying the electrodes and maintaining them. A two-channel (four electrode) montage is recommended. The C3-P3/C4-P4 monitoring montage is recommended, reference (placed in the midline) and neutral (we recommend a hairless spot on the head like the ear lobe). To verify the quality of the signal, start the recording with a referential montage (C3-ref, P3-ref, C4-ref, P4-ref) and then change to the monitoring montage C3-P3/C4-P4. Note that if the seizure activity is very focal according to full EEG, another montage might be preferable.

Trend: For detecting asymmetry in the left and right hemisphere, set the trends for chosen channels (C3-P3 and C4-P4). For detecting seizure activity (high amplitude), choose the Envelope. For detecting changes in frequency, choose the Spectrogram. Further settings of trends are discussed later in this document.

Events: You can create events, duration or non-duration; add them to the Palette and they are ready to use in the recording. Remember to choose the size of events: small-medium-large.

Amplifier setup: Check boxes for input 1(C3), 2(P3), 3(C4) and 4(P4). Reference and neutral have special inputs on the amp. **The reference is essential to the recording; to ensure high quality recordings, the neutral should also be used.**

Connecting the electrodes

In most hospitals, ICU doctors and nurses have not yet developed the necessary skills to apply electrodes to the patient's head and need detailed training to be able to immediately start recording EEG. The training of ICU staff should be left to those who have developed such skills, e.g. EEG technicians or clinical

application specialists. This ensures the safety of the patient and the quality of the recording.

Following is a short description of the procedure. Please note that some EEG technicians and application specialists may have a different way of approaching the task of applying electrodes.

Needle electrodes: Wipe the skin at the insertion spot with antiseptic wipe. The needle is inserted under the skin at an angle of 30°, subdermally. Secure the needle with a tape or gauze with EEG adhesive paste.

Stick-on electrodes: For better impedance, shave hair at the attachment site. Rub the skin with EEG scrub, wipe excess scrub away and clean skin with a dry cloth before attaching stick-on electrodes (also called hydrogel electrodes).

Cup-electrodes: Shaving hair at the attachment site is not necessary but improves signal quality. Rub the skin with EEG scrub, wipe excess scrub away and attach the cup-electrode with EEG conductive paste. Secure the electrode with tape or gauze with adhesive paste.

When the electrodes are connected to the patient's scalp, attach them one by one to the amplifier (input 1 to 4) after connecting Ref and Neut. Check impedance and start the recording. The recording cannot be done if the reference electrode is not connected, and remember that the neutral adds quality to the signal.

Impedance

As with all EEG recordings, getting good electrode impedance is a major challenge in ICU monitoring. Proper electrode application skill is of high importance in this concern as is the continuous impedance check in the Nervus system.

To activate the continuous impedance check, press the impedance button before or just after starting a recording and you will immediately note if impedance is above the set threshold (red). The continuous impedance check notifies the user when impedance is too high by showing a "bad electrode" event on the screen during recording.

Generally, an impedance below 10 kOhms is acceptable in EEG recordings, but the lower the impedance, the better quality of the signal. Relative impedance is also important and it is highly recommended that users put effort into ensuring good signal quality from all electrodes.

Concerns

In ICU monitoring, the patient's safety is of course a major concern. The user should keep few things in mind:

1. *Patient Safety*: Always keep in mind that the patients head is attached to the amplifier with the elecrodes. Do not attach the electrodes too heavily, since possible pulling of the amplifier could cause trauma to the patient's head or skin.

2. *Amplifier*: Place the amplifier as close to the patient's head as possible, preferrably in the bed if hygene standards allow (the amplifier can be wiped with a sterilized gauze or wipe, but no acetone or sterilization procedures can be used). Secure the amplifier so it will not pull the electrodes.

3. *Electrodes*: Although we want the electrodes to last for hours/days/ weeks, we need to check the patient's scalp for irritation or infection at the site of electrode placement. Replace the electrodes if any sign of irritation or infection is present.

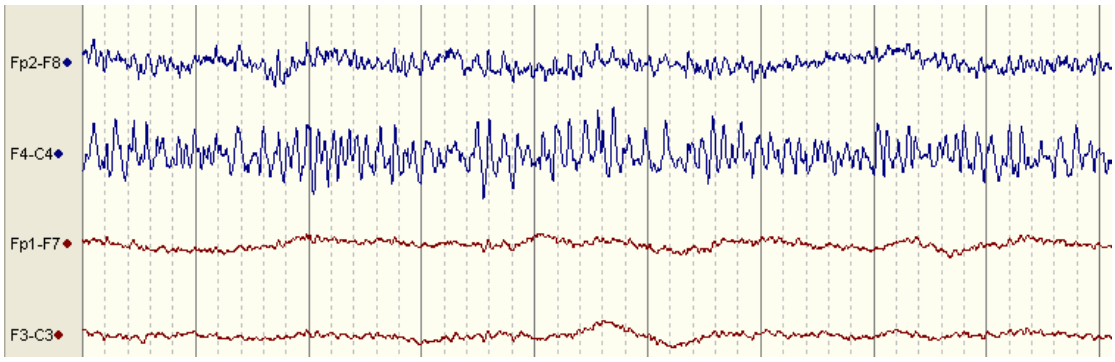
4. *Artefacts*: The user should be aware of all possible artefacts in the environment and identify them into the recording with event placement. This adds quality to the recording and makes it easier to analyze.

5. *Inform relatives*: As with all caring in the ICU, cooperation with relatives is extremely important (ask the nurses!). The user has to explain the purpose of brain monitoring as well as all other monitoring and care giving procedures.

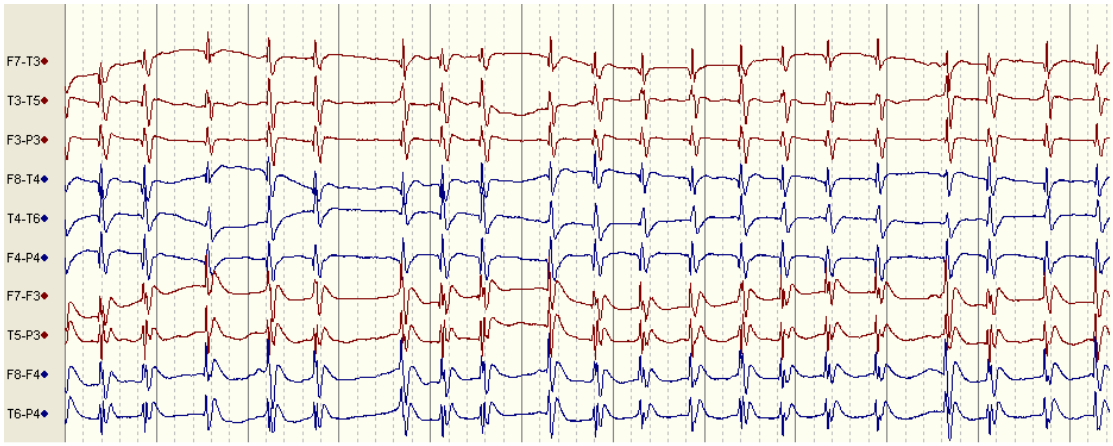
What to look for?

The EEG

Seizure activity in the EEG traces are a rhythmic pattern, usually of high voltage and with slow waves. They can be seen in one or more channels, but the definition of a seizure includes that it lasts for 8 seconds or more. In status epilepticus this pattern can be continuous or have episodes where this abnormal activity ceases for a while (see the definition of status epilepticus earlier) without full recovery of the patient.



Lateralized Status Epilepticus (brain contusions)



Generalized Status Epilepticus (Creuzfeldt-Jacob syndrome)

Trends

The seizure pattern in the EEG is normally obvious, but can be missed in the busy ICU environment. Therefore, we use trends. Trends give us an overall picture of what can be read in the EEG.

Trends are like roadmaps. You can change their scale and settings in order to see what you are looking for more clearly.

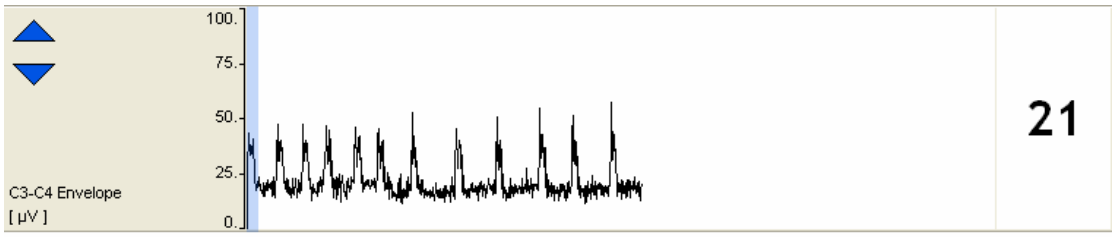
In the following pictures you can see trends that are useful in detecting seizure activity and changes in frequency in the ICU patient. These are two different trends: The Envelope (amplitude) and the Spectrogram (amplitude and frequency).

The Envelope

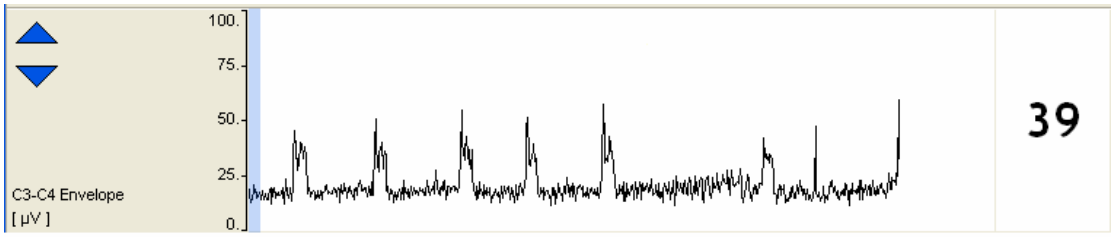
The Envelope reflects the amplitude in the EEG, but is less sensitive to movement artefacts than other amplitude reflecting trends. It is uncomplicated and highly effective, suitable for various applications, but ideal to monitor for epileptic activity.

During seizure, one can clearly see an upward shift in voltage in the envelope (see pictures below). The numerical value (in Recorder) on the screen also clearly shows changes in amplitude. This allows for immediate recognition of seizure pattern in the EEG, which can be difficult to identify in the raw EEG signal.

Try out different settings for the Envelope trend.



Settings: Low cut filter 0,5 Hz, high cut filter 30 Hz. Time resolution is 10 sec and the trend is set to full duration, 4 hours. Remember to show numerical value and to adjust scaling.



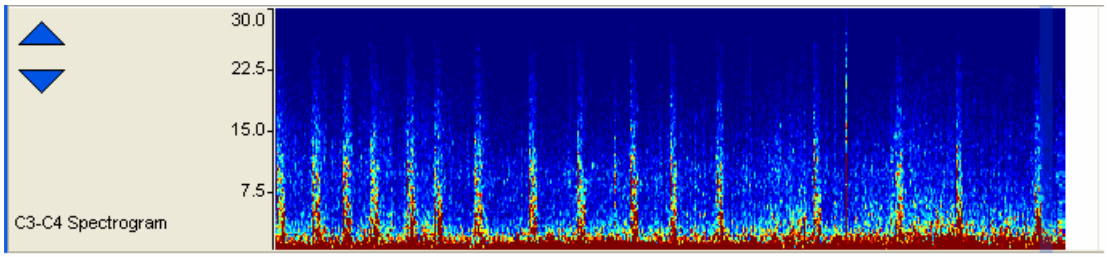
Settings: Low cut filter 0,5 Hz, high cut filter 30 Hz. Time resolution is 30 sec and the trend is set to duration of 2 hours.

The envelope has been tried and tested in real life applications for some years and has proven its usefulness in detecting seizure activity in the EEG and resistance to artefacts. Using the Envelope trend is time saving for the doctor in the analyzing process, since it gives an overview of seizure activity at a glance in the recording.

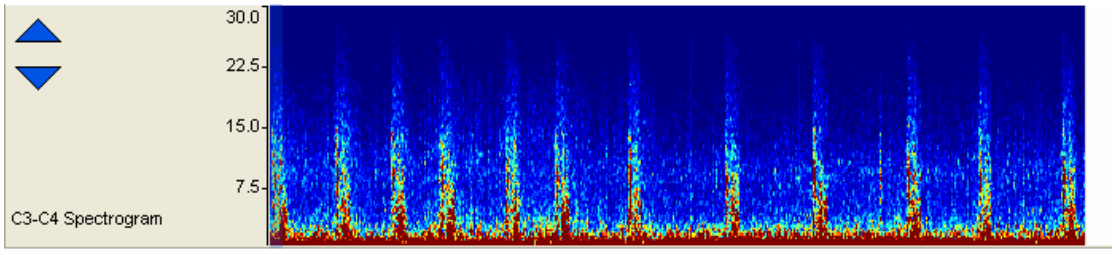
The Spectrogram

The Spectrogram shows the color-coded power spectrum. It is useful for detecting changes in the frequency content of the EEG. Additionally, the spectrogram gives qualitative details of the frequency distribution.

The spectrogram is basically a 3D image (time, frequency, power) projected onto a 2D surface (time, frequency) where the color of each pixel represents the power (e.g. dark blue color represents low power; dark red represents high power).



Settings: Low cut filter 0,5 Hz, high cut filter 30 Hz. Time resolution is 10 sec and the trend is set to full duration, 4 hours.



Settings: Low cut filter 0,5 Hz, high cut filter 30 Hz. Time resolution is the same but the trend is set to duration of 2 hours.

Reference

Chapman, M.G., Smith, M. & Hirsch, N.P.: *Status epilepticus.* Anaesthesia, 2001, 56, pages 648-659.

Garzon, E., Fernandes, R.M.F. & Sakamoto, A.C.: *Analysis of clinical characteristics and risk factors for mortality in human status epilepticus. Seizure* 2003; **12:** 337–345.

Jordan, K.G.: *Continuous EEG Monitoring in the Neuroscience Intensive Care Unit and Emergency Department.* Journal of Clinical Neurophysiology **16**(1):14-39.

Nazire Afsar, Dilaver Kaya, Sevinc Aktan & Canan Aykut-Bingol: *Sroke and status epilepticus: stroke type, type of status epilepticus, and prognosis.* Seizure 2003; **12:** 23–27.

Raggueneau, K.L.: *Le diagnostic des états de mal épileptique par le monitorage de l'EEG en neuroréanimation (Diagnosis of status epilepticus by continuous EEG monitoring in a neuro-intensive care unit).* Ann Fr Anesth Réanim 2001;20:108-14

Scheuer, M.L.:Continuous EEG Monitoring in the Intensive Care Unit. Epilepsia, **43**(Suppl.3):114-127,2002.

Vespa, P.M., Nuwer, M.R., Nenov, V., Ronne-Engstrom, E., Hovda, D.A., Bergsneider, M., Kelly, D.F., Martin, N.A. & Becker, D.P.: *Increased incidence and impact of nonconvulsive and convulsive seizures after traumatic brain injury as detected by continuous electroencephalographic monitoring.* Journal of Neurosurgery, 1999, **91**(5).

Niedermeyer, E. & Lopes da Silva, F: Electroencephalography. Basic Principles, Clinical Applications, and Related Fields. Lippincott, Williams & Wilkins. Fourth Edition, 1999.