GE Healthcare

Quick Guide

Entropy

What is Entropy?

Entropy is an innovative monitoring modality which is designed to provide information on the state of the central nervous system during general anesthesia. Entropy monitoring is based on acquisition and processing of raw EEG and FEMG signals by using the Entropy algorithm, a GE Healthcare application of spectral entropy. The GE Healthcare Entropy™ Module for the GE Healthcare Monitoring system may be used as an aid in monitoring the effects of certain anesthetic agents.

How is Entropy measured?

Adequacy of anesthesia is routinely assessed by subjectively observing the patient's clinical signs, such as heart rate, blood pressure, lacrimation, sweating and movement. However, these indices give an indirect indication about the actual state of consciousness.

By adding the measurement of the cortical electrical activity the clinician can assess the effect of anesthetics more comprehensively. Electroencephalography (EEG) changes from irregular to more regular patterns when anesthesia deepens. Similarly, frontalis electromyography (FEMG) quiets down as the deeper parts of the brain are increasingly saturated with anesthetics. Entropy measures the irregularity of EEG and FEMG signals.

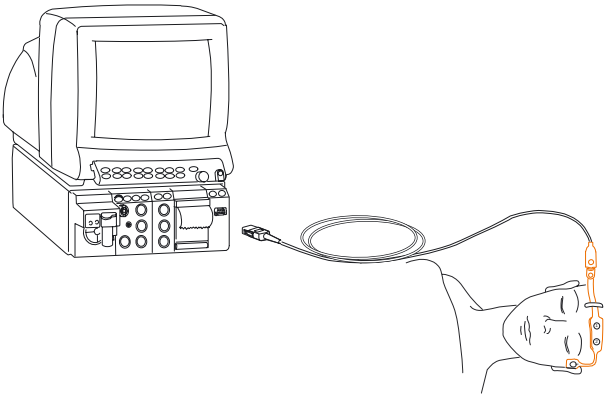


Figure 1: Entropy set-up

Use of Entropy sensor

The special Entropy sensor is easy to attach on the patient's forehead. The sensor features the familiar peel - place - press functionality and forms a good contact with skin. The Entropy sensor cable connects the sensor to the Entropy module; no head-box is required.

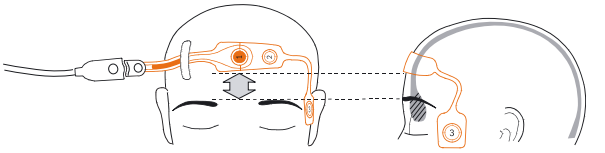


Figure 2: Correct placement of the Entropy sensor

Clinical use of Entropy parameters

Monitoring electrical activity of the brain and facial muscles with the GE Healthcare Entropy Module is intuitive. You just attach the Entropy sensor on the patient's forehead according to the instructions provided on the sensor pouch. The module automatically checks that the electrode impedances are within an acceptable range and starts the measurement. The measurement will continue until the sensor is removed.

Entropy numbers have been shown to correlate to the patient's anesthetic state. High values of Entropy indicate high irregularity of the signal signifying that the patient is awake. A more regular signal produces low Entropy values which can be associated with low probability of consciousness. There are two Entropy parameters: the fast-reacting **Response Entropy** and the more steady and robust **State Entropy**. State Entropy consists of the entropy of the EEG signal calculated up to 32 Hz. Response Entropy includes additional high frequencies up to 47 Hz. Consequently the fast frontalis EMG (FEMG) signals enable a fast response time for RE.

Parameter	Measurement frequency range	Display range
Response Entropy, RE	0 < f < 47 Hz	0 to 100
State Entropy, SE	0 < f < 32 Hz	0 to 91

Table 1: Frequency and Display ranges for Entropy parameters.

The GE Healthcare Entropy module provides a quantitative measurement by producing two parameters describing the effects of anesthetics on the patient's CNS during anesthesia.

Response Entropy

Response Entropy (RE) is sensitive to the activation of facial muscles, i.e. FEMG. Its response time is very fast; less than two seconds. FEMG is especially active during awake state but may also activate during surgery. Activation of Response Entropy to painful stimuli may be interpreted as a sign of inadequate analgesia. Facial muscles may also give an early indication of recovery, and this can be seen as a quick rise in RE.

State Entropy

State Entropy (SE) value is always less than or equal to Response Entropy. Estimation of the hypnotic effect of anesthetic drugs in the brain during general anesthesia may be based on the State Entropy number. State Entropy is not affected by sudden reactions of the facial muscles because it is based on the EEG signal. Neuromuscular blocking agents (NMBA), administered in surgically appropriate doses are not known to affect the EEG.

Why use the GE Healthcare Entropy Module?

Drug dose adjustment

Entropy parameters correlate with the amount of certain anesthetics administered to the patient. This may enable the physician to use Entropy as an aid in adjusting the anesthesia according to individual needs.

Recovery observation

Quantitative monitoring of the electrical activity of the brain and facial muscles gives the physician a tool which may enable prediction of recovery. On the other hand, processed EEG and FEMG variables may be used as an aid in preventing unexpected recovery.

Integrated information

When Entropy monitoring is integrated into a monitoring system, the measured values are displayed, trended, and automatically documented together with all of the other monitored parameters.

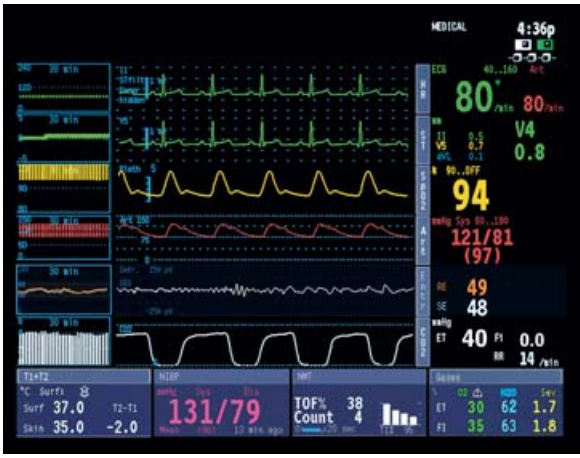


Figure 3: Entropy shown in the waveform field

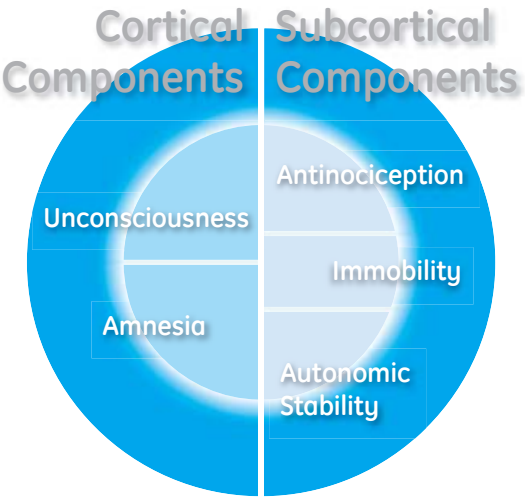
Entropy Range Guidelines*

100	Fully awake and responsive
60 40	Clinically meaningful anesthesia with low probability of consciousness.
0	Suppression of cortical electrical activity

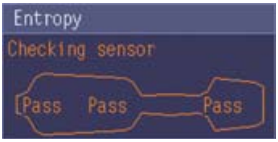
* Individual patients may show different values. Frequent eye movements, coughing and patient movement cause artifacts and may interfere with the measurement. Epileptic seizures may also cause interference. Entropy readings may be inconsistent when monitoring patients with neurological disorders, traumas or their sequelae. Psychoactive medication may cause inconsistent Entropy readings.

Adequacy of Anesthesia

Adequate anesthesia results from a balance of various components. Therefore, adequate anesthesia needs to be assessed with more than only one parameter. Entropy is a part of the bigger picture, as illustrated in GE Healthcare Adequacy of Anesthesia concept. When Entropy is used together with other monitored parameters, such as the hemodynamics and NMT, you can get a complete picture of the patient status combined on one screen.



Clinical use of Entropy



1. After the sensor is attached, the monitor will start the measurement by checking the sensor integrity and impedance level acceptability.

2. During awake state and induction there is a difference between the two Entropies indicating muscle activity on the face.

3. Decrease in Entropy may enable the physician to observe the moment when patient loses responsiveness.

4. Both Entropies stabilize during the operation. Sudden peaks in RE during surgery are primarily caused by activation of FEMG.

5. Burst Suppression Ratio (BSR) can be selected on the screen to indicate the amount of silent periods in the raw EEG.

6. A quick rise in Response Entropy may give an early warning of impending wake-up.

GE Healthcare Finland Oy, a General Electric company,
doing business as GE Healthcare.

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.

Consult the User's Guide of the monitor for detailed instructions.

Healthcare Re-imagined

GE is dedicated to helping you transform healthcare delivery by driving critical breakthroughs in biology and technology. Our expertise in medical imaging and information technologies, medical diagnostics, patient monitoring systems, drug discovery, and biopharmaceutical manufacturing technologies is enabling healthcare professionals around the world discover new ways to predict, diagnose and treat disease earlier. We call this model of care "Early Health." The goal: to help clinicians detect disease earlier, access more information and intervene earlier with more targeted treatments, so they can help their patients live their lives to the fullest. Re-think, Re-discover, Re-invent, Re-imagine.

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