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Brain monitoring revisited: What is it all about?

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To easily measure the depth of anaesthesia during routine surgical procedures has always been a goal in anaesthesiology. For decades, scientists have been developing indices to describe and evaluate the depth of anaesthesia. Historically, mean alveolar gas concentration (MAC) values for volatile anaesthetics have been used to target a predefined level of anaesthesia. MAC values were however not established to differentiate between the hypnotic and analgesic components of anaesthesia. Indices were therefore developed that measure the effect of hypnotics predominantly on the brain (in contrast to an effect on the spinal cord) with the vision to be able to measure the transition from consciousness to unconsciousness. Although monitors measuring the depth of anaesthesia are still not capable of measuring the transition from consciousness to unconsciousness, brain monitoring has proved to help clinicians control the depth of anaesthesia. Clinical trials have shown that the use of brain-monitoring devices can lead to a reduction of intraoperative drug consumption, reduced incidence of postoperative nausea and vomiting, facilitate recovery from anaesthesia compared to routine care and can also lead to a reduction of intraoperative awareness. However a study demonstrating both a reduced intraoperative drug consumption and at the same time a reduction of intraoperative awareness due to the use of brain-monitoring devices has not been published yet.

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Depth of anaesthesia (DoA) monitors have been increasingly established in clinical routine within the last three decades. Most monitors investigate the electroencephalogram (EEG) as a surrogate parameter of anaesthetic depth. The most common monitors, the Bispectral Index© (BIS) monitor (Covidien, Boulder, CO, USA), the Entropy Module© (GE Healthcare, Helsinki, Finland) and the Narcotrend Monitor© (NCT, MonitorTechnik, Bad Bramstedt, Germany), transfer the raw EEG signal into a power spectrum by applying fast Fourier transformation (FFT) to the signal. According to the Fourier theorem, any seemingly irregular and complex signal can be decomposed and transferred to sinusoidal waves of different amplitudes, different frequencies and different phases. By summation of these different sinusoidal waves the same irregular and complex signal can be reconstructed (see Fig. 1 A and B). Furthermore, this

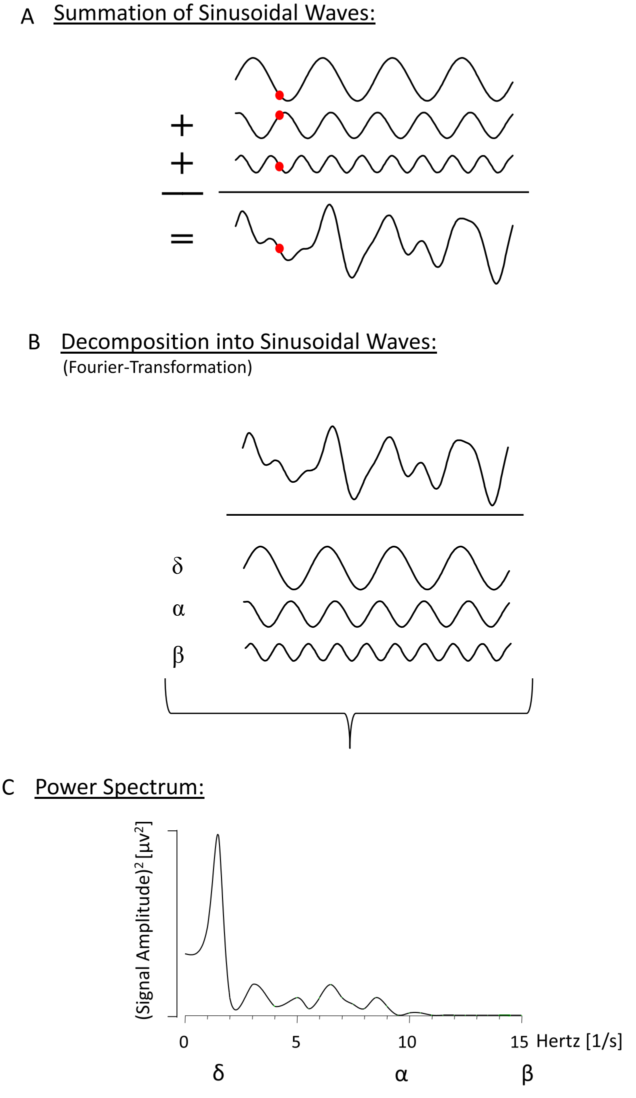

Fig. 1. A illustrates how a seemingly complex and irregular signal can be composed by the summation of 3 different sinusoidal waves. B shows how Fourier-Transformation can decompose a seemingly complex and irregular signal into 3 different sinusoidal waves. C: These waves can be transferred into a power spectrum with the different frequencies of the waves diplayed on the *x*-axis and the (amplitude)^2 of these waves displayed on the *y*-axis.