Exponential power of the alpha wave under general anesthesia: A novel biomarker for intraoperative loss of consciousness

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Tipo de Trabajo

Trabajo Científico

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Introducción

Intraoperative unconsciousness monitoring during general anesthesia is crucial for patient safety and optimizing anesthetic delivery. Traditional methods focus on analyzing brain electroencephalogram (EEG) frequencies to assess unconsciousness depth. However, these methods often miss changes in brain activity during anesthesia. This study uses the Laplace transform to capture how brainwave frequencies, such as alpha waves, change over time. The 'exponent' in this context functions like curve-fitting for the wave, offering insights similar to Fourier analysis, which breaks signals into steady frequencies. The exponent reveals how quickly or slowly these frequencies rise or fade in intensity, providing a novel way to understand the brain's response to anesthesia and potentially improving consciousness monitoring.

Objetivo(s)

This study aimed to develop and evaluate the application of the Laplace function in analyzing alpha wave dynamics in the EEG during general anesthesia. Specifically, we sought to determine if exponents derived from this method offer a more sensitive and accurate measure of the transition into unconsciousness compared to traditional spectral analysis techniques.

Material y Métodos

We performed a post-hoc analysis of EEG data from a published study (REF.1), involving recordings from frontal electrodes of 8 patients undergoing general anesthesia with propofol. Anesthesia was induced with a 15 mg/k/h propofol infusion. We focused on alpha wave frontalization during the loss of consciousness, from the start of propofol infusion to the loss of verbal response, analyzing changes in alpha activity in the frontal regions.

In the first method, we decomposed the EEG signal into frequency components, isolated the alpha band, and examined its dynamics. We fitted an exponential curve to this data and analyzed the exponent, known as the 'pole.' In the second method, we applied the Laplace transform to the EEG signal during the frontalization window, focusing on the alpha band. We calculated the volume under the surface of the Laplace-transformed function, influenced by the exponent or 'pole,' which reflects how quickly or slowly alpha waves change. A larger exponent results in a larger volume, indicating a more pronounced change in alpha activity. We can refer to this volume as the Alpha Power, analogous to the Alpha power in spectral analysis. Both the power and the pole offer insights into the dynamics of alpha wave frontalization, revealing how rapidly alpha activity increases during the loss of consciousness.

Resultados

Among the 8 patients analyzed, 25% were male, with an average age of 79.4 years. The average pole value in the alpha band was 0.0335 (SD:0.0149), indicating a 44% oscillation from the mean. The average alpha power was 0.000365 (SD:0.0001895), with a 52% oscillation (Table1).

Conclusiones

The 44% oscillation in the pole data indicates stability in alpha frontalization. Both markers (pole and alpha power) show potential in detecting variations in alpha frontalization growth, providing insights into transitions from consciousness to unconsciousness. This dynamic behavior may be influenced by factors such as receptor alterations, neurotransmitter activity, drug interactions, or subcortical processes. Further biological and cellular studies could help validate these findings.

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