Computational techniques in ICU: Neural synchrony predicts outcome after coma

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Coma patients in ICU, e.g. after cardiac arrest, have been targeted in research projects for many years. One of the key questions is how to predict the outcome after coma. Current approaches are often based on qualitative assessment of electroencephalogram (EEG) patterns. They

are relatively slow, time consuming and depend on advanced clinical expertise. Furthermore, they are subject to individual variability among the experts involved. Given the importance and frequency of the problem, new approaches involving computer science and AI are being investigated worldwide.In this study, the research team focused on how sound was processed in the brain on the first day after coma onset. They examined measures of neural synchrony and neural complexity with quantitative methods using computational tools.

Neural synchrony in sound processing is key

The study included two groups: 67 patients in coma after cardiac arrest and 13 healthy controls. A series of pure sounds was played and brain responses were recorded in EEG signals. The study found neural synchrony to be predictive for favorable outcome after coma. Sigurd Lerkerød Alnes, first author explains that they "found in two different patient cohorts that patients who later survive the coma had higher neural synchrony in response to sounds during the first day than those who did not. In fact, the neural synchrony of survivors is at indistinguishable levels from that of healthy and conscious controls."

A new approach

In case the initial findings presented in this publication are confirmed in future larger studies, the new approach will provide a series of advantages in clinical implementation: (a) it relies on a 20-minute EEG recording, performed at the bedside in the ICU; (b) it works with very early data (first day) of coma and provides prognosis for outcome at three months; (c) it relies on computational tools that quantify the neural synchrony of EEG responses to these sounds and provides rapid and unbiased prognostic information.

Surprising neural complexity

According to literature, the complexity of neural activity is expected to be reduced in the absence of consciousness. With the loss of consciousness, the brain's neural processing loses information content, thus decreasing the complexity of its activity. This effect was found in the study only for the survivor group. In the group of non-survivors, complexity was at a vast range, partly below and partly above the complexity values of healthy and conscious controls. Prof. Dr. Athina Tzovara explains that they "focused on a specific case of loss of consciousness—the first day after the onset of coma. This is just a few hours after patients have suffered a global ischemia, and while their electrophysiology and metabolism are undergoing drastic changes. Their brain responses lack structure, resulting in more spontaneous, or 'noisy' neuronal firing, which can lead to greater complexity, or neural noise in their EEG signals."

Next steps and future clinical implementation

The results of this study are encouraging and call for further investigations in larger groups involving additional medical centers. To move forward, the research team wishes to work with larger patient groups. Prof. Dr. Athina Tzovara outlines the next steps: "Our group is situated between NeuroTec, the interdisciplinary platform of the Department of Neurology that focuses on translational research, and the Institute of Computer Science at the University of Bern. Our work strengthens the view that computational methods can be introduced in the clinical routine to assist clinical decision making. We need to validate these findings in larger patient cohorts and multiple hospitals before envisioning their use in the ICU. "

The research was published in *NeuroImage*.

More information: Sigurd L. Alnes et al, Complementary roles of neural synchrony and complexity for indexing consciousness and chances of surviving in acute coma, *NeuroImage* (2021). DOI: 10.1016/j.neuroimage.2021.118638