Intraoperative direct electrocortical stimulation

Intraoperative Direct Electrostimulation (DES) at 60 Hz is used to perform real-time functional mapping of the brain, and guide tumor resection during awake craniotomy.

Stimulation-induced seizure (SIS) remains the most common reason for aborted procedures.

Resting-state functional magnetic resonance imaging likely reflects similar neural information as detected with intraoperative direct electrocortical stimulation (DES), but in its current form does not reach the spatial resolution of DES. [1].

Nonetheless, the electrophysiological effects of DES remain largely unknown, both locally and remotely. In a study, Vincent et al. lowered the DES frequency to 1 – 10 Hz and we used a differential recording mode of electrocorticographic (ECoG) signals to improve the focality with a simple algorithm to remove the artifacts due to the response of the acquisition chain. Doing so, we were able to observe different components in the evoked potentials triggered by simulating the cortex or the subcortical white matter pathways near the recording electrodes and by stimulating the cortex remotely from the recording site. More particularly, P0 and N1 components were repeatedly observed on raw ECoG signals without the need to average the data. This new methodology is important to probe the electrophysiological states and the connectivity of the brain in vivo and in real-time, namely to perform electrophysiological brain mapping on human patients operated in the neurosurgical room and to better understand the electrophysiological spreading of DES [2].

Indications

Cortical stimulation indications.

Limitations

DES, however, also has a limitation: its specificity is suboptimal. Indeed, DES may lead to interpretations that a structure is crucial because of the induction of a transient functional response when stimulated, whereas (1) this effect is caused by the backward spreading of the electro-stimulation along the network to an essential area and/or (2) the stimulated region can be functionally compensated owing to long-term brain plasticity mechanisms.

Direct Electrostimulation is still the gold standard for brain mapping, its combination with new methods such as perioperative neurofunctional imaging and biomathematical modeling is now mandatory, in order to clearly differentiate those networks that are actually indispensable to function from those that can be compensated [3].

see Intraoperative stimulation mapping

Case series

Intraoperative direct electrocortical stimulation case series.

1)
van Lieshout J, Debaene W, Rapp M, Noordmans HJ, Rutten GJ. fMRI Resting-State Connectivity between Language and Nonlanguage Areas as Defined by Intraoperative Electrocortical Stimulation in Low-Grade Glioma Patients. J Neurol Surg A Cent Eur Neurosurg. 2021 Feb 22. doi: 10.1055/s-0040-1721757. Epub ahead of print. PMID: 33618418.
2)
Vincent M, Bonnetblanc F, Mandonnet E, Boyer A, Duffau H, Guiraud D. Measuring the electrophysiological effects of direct Electrostimulation after awake brain surgery. J Neural Eng. 2019 Nov 28. doi: 10.1088/1741-2552/ab5cdd. [Epub ahead of print] PubMed PMID: 31778987.
3)
Mandonnet E, Winkler PA, Duffau H. Direct Electrostimulation as an input gate into brain functional networks: principles, advantages and limitations. Acta Neurochir (Wien). 2010 Feb;152(2):185-93. doi: 10.1007/s00701-009-0469-0. Epub 2009 Jul 29. Review. PubMed PMID: 19639247.

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Last update: **2024/06/07 02:57**