REVIEW

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Neuralink and Neuro-monitoring Concerns in Neuroanaesthesia

Rachna Bajaj[1], Kunal Kumar Sharma[2], Sharath Krishnaswami[3]

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Abstract

Context: Brain computer interface devices like Neuralink implants will pose a significant challenge in the present understanding and learning curve for Neuromonitoring techniques during neurosurgery and Neurocritical care.

Aims: We hereby enlist our concern with regards to electroencephalography, trans-cranial doppler and cerebral oxygenation monitoring in patients with such implants for neurosurgical procedures.

Settings and Design: Short communications

Conclusions: There exists minimal published research with regards to EEG monitoring, cerebral oxygenation monitoring and cerebral blood flow monitoring in patients coming for neurosurgeries for brain tumors with these kind of brain computer interfaces implanted in their cerebral cortex. This brief communication will help in generating research interest in this upcoming evolution in medical care.

Keywords: Neuralink; Brain computer interface; Electroencephalography; Trans-cranial doppler; Cerebral oxygenation.

Key Message: Emphasis on need of understanding Neuro-monitoring during altered physiological state

INTRODUCTION

The ever-growing daily buzz pertaining to the Neuralink brain computer interface for the patients enrolled in the PRIME (Precise Robotically *Implanted* Brain-Computer Interface) study, has put forth a paradigm of neuro-monitoring implications for patients with such implants coming for neurosurgery.[1]

REVIEW OF CURRENT LITERATURE

The PRIME study has enrolled patients above 18 years of age who are suffering from Amyotrophic

Author's Affiliation: [1]Resident, Department of Anaesthesia, [2]Assistant Professor, Department of Neuroanaesthesia Super-speciality Cell, Indira Gandhi Medical College, Shimla, Himachal Pradesh, India, [3]Associate Consultant, Department of Neuroanesthesia and Neurocritical care, Aster Whitefield Hospital, Bangalore, Karnataka, India.

Corresponding author: Kunal Kumar Sharma, Assistant Professor, Department of Neuroanaesthesia Super-speciality Cell, Indira Gandhi Medical College, Shimla, Himachal Pradesh, India.

E-mail: kunaal_kumar@yahoo.com

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lateral sclerosis (ALS) or quadriplegia. ALS affects the motor neurons of brain and spinal cord, however the patient's intelligence, thinking and hearing are preserved. As the disease progresses, the Broca's area in the left cerebral hemisphere gets affected and motor speech dysfunction starts to occur in the patient.[2] Therefore the device aims at placing the electrodes in the cerebral cortex and relaying the information to a brain-computer interface (BCI) avatar for speech production. Another aim of this implant is to check its efficacy to perform the motor tasks of the affected hand (like clicking a desktop mouse button).

The PRIME study differs from the previous works on BCI from Willet at al.[3] and Metzger et al.[4] The difference has arisen due to the usage of R1 surgical robot for placing the N1 chip containing 64 fine threads having an aggregate of 1024 electrodes. In our concern for intra-operative neuro-monitoring, we shall address with the probability of changes in EEG signatures for patients coming to neurosurgery or neuro-intervention procedures with this implanted device.

Neuralink induced cortical modulation can be performed from different perspectives, either by using cognitive protocols or by studying the direct cortical activation following Neuralink pulses. These Neuralink pulses may induce high amplitude artefacts on EEG recordings. The correction of these artefacts during intraoperative stimulation will depend upon the pulse width and the type of stimulation. Averaging these recordings with inverted cathode and anode positions might be of value to the neuroanesthetist. A low pass filter with a cut off rate at 50 Hz may suffice. However its use may further generate synchronized artefact activity. The high amplitude artefacts with lower frequency shall most likely require the usage of notch filters. In the event of insufficient filtering, an independent component analysis can be applied as a spatial method of signal decomposition. The components corresponding to Neuralink artefact can be identified and removed from the data based on their typical topographical distribution, temporal pattern and spectral pattern. The cortical networks modulated by this implant can be studied by recording their electrophysiological responses to single pulses. A keen area of interest will be its effect on the evoked beta power, alpha desynchronization and beta synchronization. Neuralink might also affect the coherence spectrum, phase coherence and phase amplitude coupling. This will probably occur due to the differences in cortico-cortical coupling.[5]

Another beguiling question that arises is, how will cerebral oxygenation and cerebral blood flow get affected in the patients implanted with this device? Near-infrared spectroscopy (NIRS) and functional near-infrared spectroscopy (fNIRS) are both being used to observe the changes in chromophore concentration of oxygen, non-invasively. The use of wavelengths between 700-900 nm of spectral interval, has helped researchers to assess functional connectivity in cerebral infarcts. It has also helped in early detection of subarachnoid hemorrhage (SAH)[6]. While the data acquisition for Masimo O3 sensor, and NONIN Equanox Advance sensor is primarily from the frontal lobes, it strikingly undermines to the data acquired by a fNIRS sensor having multiple LED sources and detectors that collect the data from prefrontal, parietal, temporal and occipital lobes. The use of fNIRS during arteriovenous malformation (AVM) embolization and aneurysmal coiling in patients with such implants is a key area for future research.

Our vested interest revolves around observing the modulation in regional cerebral blood flow after N1 chip implant. We do expect the baseline regional cerebral oxygenation levels to be asymmetric, owing to the location of implant on one side. The integral question to ponder is, does the device have its stimulatory activity even after administration of general anesthesia ? If yes, then will the subsequent change in cerebral blood flow and regional cerebral oxygenation be of significant concern for the neuroanesthetist. This will generate atypical waveform morphology during trans-cranial doppler assessment for cerebral blood flow velocity. To add more intrigue into this question, we have the paradox of altered cerebral physiology due to the existing brain lesion in the patient with implanted chip.

CONCLUSION

Therefore, the future will be filled with immense challenges and research that will redefine the current neuro-anaesthetic practice. Perhaps, we need to enhance our learning curve of neuro-monitoring by incorporating more complex simulation models during the clinical training for the Neuroanaesthetists.

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Conflict of Interest: None

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