Clinical Neurophysiology

Clinical neurophysiology plays a critical role in neurosurgery by providing **real-time functional assessment of the nervous system**, guiding surgical decisions, and improving patient outcomes. The integration of neurophysiological techniques in neurosurgical procedures has significantly enhanced safety and precision.

1. Role of Clinical Neurophysiology in Neurosurgery

- A New Multi-Parametric MRI-Based Scoring System for Degenerative Cervical Myelopathy: The Severity on Imaging Myelopathy Score (SIMS)
- Transplants of fresh and cryopreserved autologous adipose tissue improve reintegrative phenomena in newly formed muscle tissue in the reconstruction of muscle volume loss: A histological evaluation
- A Refined Approach to Isolate Interneurons for High-Validity Epigenetic Studies in Human Brain Tissue
- Pallidal activity in Parkinson's disease patients with intraoperative dyskinesias
- Response to the letter by Dr. Jongsuk Choi: trigemino-vocal reflex: A potential indicator of brainstem integration
- The potential of OPM-based magnetoencephalography in pre-surgical evaluation of drug-resistant epilepsy
- The GREENBEAN checklist for reporting studies evaluating the effectiveness of EEG-based biomarkers
- Neurophysiology Signal Codecs for the DICOM() Standard: Preliminary Results

Clinical neurophysiology supports neurosurgery in three key areas:

A. Preoperative Assessment

- **Diagnosis of Neurological Disorders**:
  - EEG for epilepsy surgery planning.
  - EMG and nerve conduction studies for peripheral nerve pathologies.
  - Evoked potentials for multiple sclerosis and spinal cord disorders.
- **Functional Brain Mapping**:
  - Identifies eloquent cortical areas (e.g., motor, language regions) before tumor resection.
  - High-density EEG and magnetoencephalography (MEG) locate epileptogenic foci.

B. Intraoperative Neurophysiological Monitoring (IONM)

IONM is essential for preventing **neurological deficits** during surgery. Techniques include:

Modality	Application in Neurosurgery
Somatosensory Evoked Potentials (SSEPs)	Monitors dorsal column pathways during spinal cord surgeries.

Modality	Application in Neurosurgery
Motor Evoked Potentials (MEPs)	Assesses corticospinal tract function in brain and spine surgery.
Electrocorticography (ECoG)	Identifies epileptogenic zones during epilepsy surgery.
Brainstem Auditory Evoked Potentials (BAEPs)	Used in acoustic neuroma and brainstem surgeries.
Visual Evoked Potentials (VEPs)	Evaluates optic nerve function in tumor and vascular surgeries.
Direct Cortical Stimulation	Identifies motor and language areas during awake craniotomies.
Electromyography (EMG)	Detects nerve root irritation during spinal surgery.

C. Postoperative Monitoring and Rehabilitation

- Continuous EEG monitoring in ICU patients with brain injury or post-surgical complications.
- Evaluation of functional recovery through **nerve conduction studies (NCS) and EMG** in patients with peripheral nerve injuries.

---

2. Specific Neurosurgical Applications

A. Epilepsy Surgery

- **Intracranial EEG (iEEG)** and **ECoG** help localize seizure foci.
- Cortical stimulation mapping ensures the safe removal of epileptogenic tissue.

B. Brain Tumor Surgery

- **Awake craniotomy with neurophysiological monitoring** preserves language and motor functions.
- Electrocorticography detects epileptogenic activity around tumors.

C. Spine and Peripheral Nerve Surgery

- Intraoperative Neurophysiological Monitoring prevents spinal cord and nerve root damage.
- EMG identifies nerve compression in brachial/lumbosacral plexopathies.

D. Functional Neurosurgery

- **Deep Brain Stimulation (DBS)** for movement disorders (Parkinson’s, dystonia).
- Cortical and spinal cord stimulation for pain management.

---

3. Benefits of Clinical Neurophysiology in Neurosurgery

- **Reduces postoperative neurological deficits**.
- **Enhances surgical precision and safety**.
- **Improves patient outcomes and quality of life**.

---

4. Future Directions

- **Artificial Intelligence in Electroencephalography/MEG interpretation**.
- **High-density Electroencephalography functional magnetic resonance imaging**.
- **Closed-loop neurostimulation for epilepsy and movement disorders**.

Clinical neurophysiology is indispensable in modern neurosurgery, providing **functional guidance before, during, and after surgery** to optimize patient safety and improve surgical outcomes.

In the 18th century, Luigi Galvani proposed the hypothesis of animal electricity, which is produced by the brain and distributed through the nerves to the muscles. This was the cornerstone of what is known today as the modern study of nerve function, earning him the title of the Father of Clinical Neurophysiology. The 19th century was subsequently marked by two major figures: Santiago Ramón y Cajal (Neuron Theory) and Hans Berger, known for describing cerebral electrical activity and recording the first electroencephalograms. In Mexico, Clinical Neurophysiology emerged in the late 19th century and consolidated itself in the first half of the 20th century. In the year of 1938, Dr. Clemente Robles and Teodoro Flores Covarrubias built the first electroencephalograph, marking the beginning of the era of Clinical Neurophysiology. Initially, this diagnostic tool was primarily applied to psychiatric patients, as there was no clear separation between psychiatry and neurology, and patients were treated jointly at the largest psychiatric center of that time, “La Castañeda.” In 1968, the Mexican Society of Electroencephalography A.C. was founded and later changed its name to the Mexican Society of Clinical Neurophysiology A.C. Simultaneously, its members achieved universal recognition of the medical specialty, which has become established in clinical practice and has shown progressive academic and scientific growth in Mexico [1)]

1)

Bernal López OE, San Juan D, Vidal BE, Collado-Corona MÁ. History of Clinical Neurophysiology in Mexico. J Clin Neurophysiol. 2025 Mar 19. doi: 10.1097/WNP.0000000000001159. Epub ahead of print. PMID: 40105714.