Neuromonitoring Techniques

- Neurosurgical Management and Follow-up of Pediatric Lumbosacral Lipomas, Single-Center Experience With 28 Patients
- Neuromonitoring of recurrent laryngeal nerve using continuous intraoperative neuromonitoring system during anterior cervical spine surgery: A porcine model study
- Retrospective evaluation of Facial nerve monitoring to prevent nerve damage during robotic drilling in the largest series of patients undergoing the HEARO-procedure
- Navigate transcranial magnetic stimulation is more reliable than tractography for placing subdural electrodes used for CCEP recording
- Utility of continuous vagal neuromonitoring in thyroid and parathyroid gland surgery: a retrospective study of 500 cases
- Brain ultrasonography in neurosurgical patients
- The Effect of Hypotension on Cerebral Metabolism and Perfusion in Adults Undergoing Cardiopulmonary Bypass: A Prospective Cohort Study
- Near-Infrared Spectroscopy to Assess Covert Volitional Brain Activity in Intensive Care

These techniques are used to assess and monitor the functional integrity of neural structures in real time, especially during surgeries involving the brain, spinal cord, or peripheral nerves.

1. Evoked Potentials (EPs) Measure electrical responses of the nervous system to sensory or electrical stimulation.

Somatosensory Evoked Potentials (SSEPs): Monitor the dorsal columns and sensory pathways. Commonly used during spine surgery. → Stimulate a peripheral nerve (e.g., tibial or median) and record at cortex or spinal cord.

Motor Evoked Potentials (MEPs): Assess the motor pathways, especially corticospinal tracts. → Transcranial stimulation of the motor cortex with recording in distal muscles. Very sensitive to anesthetics.

Visual Evoked Potentials (VEPs): Monitor optic nerve and visual pathways. Used in surgeries involving the optic chiasm or occipital lobe.

Brainstem Auditory Evoked Potentials (BAEPs or ABRs): Evaluate auditory pathways and brainstem integrity. → Useful in CPA (cerebellopontine angle) surgeries, e.g., vestibular schwannoma.

2. Electromyography (EMG) Records electrical activity of muscles.

Free-running EMG: Detects spontaneous activity in muscles—indicates nerve irritation or injury. → Real-time alert for cranial nerve or spinal root manipulation.

Triggered EMG: Stimulates a nerve directly to confirm its identity or function. → Common in pedicle screw testing and facial nerve mapping.

3. Electroencephalography (EEG) Monitors cortical brain activity.

Used in carotid endarterectomy, aneurysm surgery, or during hypothermic circulatory arrest to detect ischemia or seizures.

4. Direct Cortical and Subcortical Stimulation Used in brain mapping—especially in tumor resections

near eloquent cortex.

Cortical mapping: Identifies motor or language areas via direct stimulation of the cortex.

Subcortical stimulation: Helps maintain a safe distance from motor tracts during tumor resection (e.g., distance-to-corticospinal-tract techniques).

5. Intracranial Pressure Monitoring (ICP) Not intraoperative neuromonitoring per se, but crucial in ICU settings for TBI or hydrocephalus patients.

6. Cerebral Oximetry (Near-Infrared Spectroscopy - NIRS) Measures regional cerebral oxygenation. → Used in vascular or cardiac surgery, especially with hypoperfusion risk.

7. Doppler Ultrasound / Micro-Doppler Assesses cerebral or spinal cord blood flow during vascular neurosurgery.

 Clinical Applications: Spine surgery (SSEPs, MEPs, EMG)

Tumor resection (brain mapping, MEPs, subcortical stimulation)

Brainstem surgery (BAEPs)

Epilepsy surgery (EEG, electrocorticography)

Peripheral nerve surgeries (EMG)

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may involve the measurement and analysis of various physiological parameters, including:

Electroencephalography (EEG): Monitoring the electrical activity of the brain by placing electrodes on the scalp. EEG is often used to assess brain function, detect seizures, and monitor the depth of anesthesia.

Intracranial Pressure Monitoring: Measuring the pressure inside the skull to assess and manage conditions such as traumatic brain injury, brain tumors, or hemorrhages.

Cerebral Blood Flow Monitoring: Assessing the Cerebral Blood Flow to ensure an adequate supply of oxygen and nutrients.

Evoked Potentials: Recording electrical signals generated in response to specific stimuli, such as visual, auditory, or somatosensory stimuli. Evoked potentials can provide information about the integrity of neural pathways.

Near-Infrared Spectroscopy (NIRS): Monitoring changes in oxygen levels in brain tissue by measuring the absorption of near-infrared light. NIRS is often used during cardiac and vascular surgeries.

Continuous Electroencephalography (cEEG): Continuous monitoring of EEG over an extended period to detect changes in brain activity, especially in critical care settings.

Peripheral Nerve Monitoring: Monitoring the electrical activity of peripheral nerves during surgeries to prevent nerve damage.

Neuromonitoring is particularly valuable in procedures where the nervous system is at risk, such as neurosurgery, cardiac surgery, and major trauma cases. It helps healthcare professionals assess the impact of interventions, detect complications early, and make informed decisions to optimize patient outcomes. The specific type of neuromonitoring employed depends on the clinical context and the specific needs of the patient.

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see Multimodal neuromonitoring.

see Brain tissue oxygen monitoring.

see Intracranial pressure monitoring.

see Intraoperative neuromonitoring.

see Continuous EEG monitoring.

see Hummingbird Neuromonitoring

Novel monitoring techniques include transcranial Doppler ultrasonography, neuroimaging, intracranial pressure, cerebral perfusion, and cerebral blood flow monitors, brain tissue oxygen tension monitoring, microdialysis, evoked potentials, and continuous electroencephalogram. Multimodality monitoring enables immediate detection and prevention of acute neurologic injury as well as appropriate intervention based on patients' individual disease states in the neurocritical care unit. Real-time analysis of cerebral physiologic, metabolic, and cardiovascular parameters simultaneously has broadened knowledge about complex brain pathophysiology and cerebral hemodynamics. Integration of this information allows for more precise diagnosis and optimization of management of patients with brain injury [1)].

Categories

Direct signals which are monitored invasively:

Intracranial pressure (ICP)

Cerebral regional tissue oxygenation

Microdialysis, parenchymal blood flow, etc.);

Variables which may be monitored noninvasively

Transcranial Doppler (TCD)

Near-infrared spectroscopy (NIRS)

variables describing brain pathophysiology which are not monitored directly but are calculated at the bedside by dedicated computer software. The simplest example is the cerebral perfusion pressure (CPP)

More sophisticated examples include various indices of vascular reactivity or cerebral autoregulation [2)], brain compensatory reserve [3)], vascular resistances, and brain compartmental compliances [4)].

Hummingbird neuromonitoring Synergy is a novel single-port access device for multimodal intracranial monitoring that can be placed safely at the bedside or in the operating room with placement accuracy and has a complication profile similar to or better than that for standard external ventricular drains [5)].

Multimodality monitoring of cerebral physiology encompasses the application of different monitoring techniques and integration of several measured physiologic and biochemical variables into assessment of brain metabolism, structure, perfusion, and oxygenation status.

Intracranial pressure monitoring is now widely used in neurosurgical critical patients. Besides mean ICP value, the ICP derived parameters such as ICP waveform, amplitude of pulse (AMP), the correlation of ICP amplitude and ICP mean (RAP), pressure reactivity index (PRx), ICP and arterial blood pressure (ABP) wave amplitude correlation (IAAC), and so on, can reflect intracranial status, predict prognosis, and can also be used as guidance of proper treatment. However, most of the clinicians focus only on the mean ICP value while ignoring these parameters because of the limitations of the current devices. We have recently developed a multimodality monitoring system to address these drawbacks. This portable, user-friendly system will use a data collecting and storing device to continuously acquire patients' physiological parameters first, i.e., ABP, ICP, and oxygen saturation, and then analyze these physiological parameters. We hope that the multimodality monitoring system will be accepted as a key measure to monitor physiological parameters, to analyze the current clinical status, and to predict the prognosis of the neurosurgical critical patients [6)].

1)

Wartenberg KE, Schmidt JM, Mayer SA. Multimodality monitoring in neurocritical care. Crit Care Clin. 2007 Jul;23(3):507-38. Review. PubMed PMID: 17900483.

2)

Lavinio A, Timofeev I, Nortje J, et al. Cerebrovascular reactivity during hypothermia and rewarming. British Journal of Anaesthesia. 2007;99(2):237–244.

3)

Kim DJ, Czosnyka Z, Keong N, et al. Index of cerebrospinal compensatory reserve in hydrocephalus. Neurosurgery. 2009;64(3):494–501.

4)

Kim DJ, Kasprowicz M, Carrera E, et al. The monitoring of relative changes in compartmental compliances of brain. Physiological Measurement. 2009;30(7):647–659.

5)

Chohan MO, Akbik OS, Ramos-Canseco J, Ramirez PM, Murray-Krezan C, Berlin T, Olin K, Taylor CL, Yonas H. A novel single twist-drill access device for multimodal intracranial monitoring: a 5-year single-institution experience. Neurosurgery. 2014 Sep;10 Suppl 3:400-11. doi: 10.1227/NEU.0000000000000451. PubMed PMID: 24887290.

6)

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