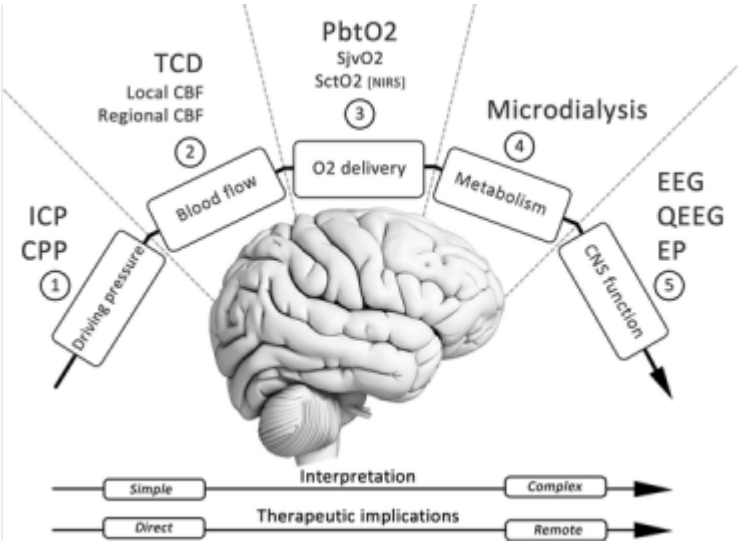
Multimodal neuromonitoring

- Multimodality Monitoring for the Management of Severe Traumatic Brain Injury
- Assessment of Pupillary Light Reflex Alterations in Pediatric Diabetic Ketoacidosis-Induced Encephalopathy: A Retrospective Analysis Using Quantitative Pupillometry
- Traumatic brain injury management in the intensive care unit: standard of care and knowledge gaps
- Diagnostic and Surgical Challenges in Parathyroid Neoplasia: An Extensive Analysis of a Single Endocrine Surgery Center Cohort of Patients
- The metabolic and autoregulatory profile of reversible delayed cerebral ischemia in unconscious patients after aneurysmal subarachnoid hemorrhage: a prospective multimodal neuromonitoring cohort study
- Evaluating the predictive value of multimodal intraoperative neuromonitoring in anterior cervical discectomy and fusion: a retrospective cohort study on 442 patients
- Emerging Advances in the Management of Delayed Cerebral Ischemia After Aneurysmal Subarachnoid Hemorrhage: A Narrative Review
- Assessing the impact of transcranial electrical stimulation on intracranial and cerebral perfusion pressures in patients with severe craniocerebral injury: A novel methodological approach



Aspect	Neuromonitoring (IONM)	Multimodal Neuromonitoring (MMN)
Definition	The use of **one** neurophysiological technique to monitor nervous system function.	The **simultaneous use of two or more** neuromonitoring modalities.
Examples	* SSEPs during spine surgery * EEG in carotid surgery	* SSEPs + MEPs + EMG in scoliosis surgery * MEPs + mapping in glioma
Goal	Monitor a **single functional system** (e.g., sensory or motor).	Monitor **multiple neural systems** for broader safety.
Use Cases	* Low-risk spine procedures * Resource-limited settings	* Complex brain/spinal surgeries * Brainstem or eloquent cortex lesions
Sensitivity	Lower — may miss deficits if only one pathway is monitored.	Higher — cross-checking between modalities improves detection.
Personnel Required	Usually one technologist or neurophysiologist	Typically a team (tech + neurophysiologist + surgeon coordination)
Cost and Setup	Less resource-intensive	More equipment, time, and expertise required

Definition

Multimodal neuromonitoring encompasses the integration of cerebral physiological parameters that assist intensive care unit (ICU) physicians in the management of brain-injured patients. These parameters include intracranial pressure (ICP), cerebral perfusion pressure (CPP), cerebral blood flow (CBF), cerebral oxygenation, cerebral metabolism, and electrocortical activity [1].

Indications

Multimodal Neuromonitoring Indications.

Techniques

Neuromonitoring techniques.

Reviews

Bögli et al. aimed to provide clinicians, researchers, and healthcare professionals with detailed, compelling examples of potential applications of multimodality neuromonitoring, focused on high-resolution modalities within the field of traumatic brain injury. This case series showcases how neuromonitoring techniques such as intracranial pressure, brain tissue oxygenation, near-infrared spectroscopy, and transcranial Doppler can be integrated with cerebral microdialysis, neuroimaging, and systemic physiology monitoring. The aim is to demonstrate the value of a multimodal approach based on high-resolution data and derived indices integrated in one monitoring tool. This allows for improving the diagnosis, monitoring, and treatment of patients with traumatic brain injury. For this purpose, key concepts are covered, and various cases have been described to illustrate how to make the most of this advanced monitoring technology [2].

Case series

In a study Bailey et al., examined the safety and reliability of multimodality monitoring.

Five hundred and one patients, including 300 males and 201 females (mean age 58 + 39 years) were identified retrospectively from a prospective observational database at a Level I Trauma Center. Each patient received a triple lumen bolt and 3 monitors: intracranial pressure, brain temperature and brain oxygen (Licox, Integra NeuroSciences). ICU and hospital records were examined to identify complications, reasons for device replacement, malfunction and infection. Head CT scans obtained both before and after the monitors were inserted, were examined for evidence of monitor-related adverse effects.

A total of 696 triple lumen bolts were placed. The median (IQR) duration of monitoring was 78.88 hours (33.0-133.2). Twenty-two (3.16%) patients had bilateral monitors. Ten (1.43%) monitors were replaced to allow MR imaging and 40 (5.74%) were replaced to facilitate additional cranial surgery.

Thirty-five (5.02%) monitors were replaced because they were thought to not be functioning properly; among these, 19 (54.29%) were subsequently found to be functioning normally. Follow up CT scans were compared with pre-insertion CT scans: 9 (2.13%) small contusions and 10 (2.36%) extra-axial hematomas associated with the devices were identified. Based on the CT findings, the hematomas were thought to be associated with the insertion technique rather than the device. Four hematomas required treatment. Twenty-two (3.16%) devices were incorrectly placed, e.g. the probe was in an infarct or an already existing contusion. Only 1 associated infection was identified.

Placement of intracranial monitors for multimodality neuromonitoring using a triple lumen bolt appears to be safe. The complication rate is similar to that published for single-lumen bolts and single monitors [3].

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included 43 consecutive sTBI patients who required MMM to guide clinical care based on institutional protocol and had a four-lumen bolt placed to measure intracranial pressure, brain tissue oxygen, regional cerebral blood flow, brain temperature, and intracranial electroencephalography.

RESULTS: sTBI patients were aged 41.6 ± 17.5 years (mean ± SD) and 84% were men. MMM devices were placed at a median of 12.5 h (interquartile range [IQR] 9.0-21.4 h) after injury and in non-dominant frontal lobe in 72.1% of cases. Monitoring was conducted for a median of 97.1 h (IQR 46.9-124.6 h) per patient. While minor hemorrhage, pneumocephalus, or small bone chips were common, only one (2.4%) patient experienced significant hemorrhage related to device placement. Radiographically, device malpositioning was noted in 13.9% of patients. Inadvertent device discontinuation occurred for at least one device in 58% of patients and was significantly associated with the frequency of travel for procedures or imaging. Devices remained in place for > 80% of the total monitoring period and generated usable data > 50% of that time.

CONCLUSIONS: A standardized, bedside single burr hole approach to MMM was safe. Despite some probe-specific recording limitations, MMM provided real-time measurements of intracranial pressure, oxygenation, regional cerebral blood flow, brain temperature, and function [4].

1)
Tasneem N, Samaniego EA, Pieper C, et al. Brain multimodality monitoring: a new tool in neurocritical care of comatose patients. Crit Care Res Pract 2017;2017:6097265
2)
Bögli SY, Beqiri E, Olakorede I, Cherchi MS, Smith CA, Chen X, Di Tommaso G, Rochat T, Tanaka Gutiez M, Cucciolini G, Motroni V, Helmy A, Hutchinson P, Lavinio A, Newcombe VFJ, Smielewski P. Unlocking the potential of high-resolution multimodality neuromonitoring for traumatic brain injury management: lessons and insights from cases, events, and patterns. Crit Care. 2025 Mar 31;29(1):139. doi: 10.1186/s13054-025-05360-4. PMID: 40165332.
3)
Bailey RL, Quattrone F, Curtin C, Frangos S, Maloney-Wilensky E, Levine JM, LeRoux PD. The Safety of Multimodal Monitoring using a triple lumen bolt in Severe Acute Brain Injury. World Neurosurg. 2019 Jun 10. pii: S1878-8750(19)31472-X. doi: 10.1016/j.wneu.2019.05.195. [Epub ahead of print] PubMed PMID: 31195129.
4)
Foreman B, Ngwenya LB, Stoddard E, Hinzman JM, Andaluz N, Hartings JA. Safety and Reliability of Bedside, Single Burr Hole Technique for Intracranial Multimodality Monitoring in Severe Traumatic Brain Injury. Neurocrit Care. 2018 Jun 8. doi: 10.1007/s12028-018-0551-7. [Epub ahead of print] PubMed PMID: 29949001.