Brain Oxygenation Monitoring

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KEYWORDS

- Cerebral oxygenation • Cerebral perfusion • Brain monitoring
- Brain tissue oxygen tension • Jugular venous saturation
- Near-infrared spectroscopy

KEY POINTS

- The maintenance of adequate cerebral oxygenation is a key goal in the management of patients with acute brain injury (ABI) and in certain perioperative settings.
- A mismatch between cerebral oxygen supply and demand can lead to cerebral hypoxia/ischemia and deleterious outcomes; cerebral oxygenation monitoring is, therefore, an important aspect of multimodality neuromonitoring.
- There is abundant evidence of an association between low cerebral oxygenation and outcomes, but limited evidence that increasing cerebral oxygenation improves outcome.
- Advances in cerebral oxygenation monitoring will be driven by improved technology and randomized studies proving the utility of different monitors.

INTRODUCTION

Maintenance of cerebral oxygen supply sufficient to meet metabolic demand is a key goal in the management of patients with ABI and in perioperative settings. A mismatch between oxygen supply and demand can lead to cerebral hypoxia/ischemia and deleterious outcomes, with time-critical windows to prevent or minimize permanent ischemic neurologic injury. The clinical manifestations of cerebral hypoxia/ischemia may remain occult in unconscious or sedated/anesthetized patients, and brain monitoring is required to detect impaired cerebral oxygenation in such circumstances.

Cerebral oxygenation monitoring assesses the balance between cerebral oxygen delivery and utilization, and, therefore, the adequacy of cerebral perfusion and oxygen

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delivery. It can be used to guide treatment to prevent or minimize cerebral hypoxia/ischemia, and is established as an important component of multimodality neuromonitoring in both perioperative and ICU settings.

This article describes the different methods of bedside cerebral oxygenation monitoring, the indications and evidence base for their use, and limitations and future perspectives.

METHODS OF MONITORING CEREBRAL OXYGENATION

There exist several imaging and bedside methods of monitoring global and regional cerebral oxygenation, invasively and noninvasively (Table 1). Different monitors describe different physiologic variables and, for this reason, they are not interchangeable.

Imaging Techniques

In addition to providing structural information, several imaging techniques are able to evaluate cerebral hemodynamics and metabolism over multiple regions of interest. Imaging provides only a snapshot of cerebral physiology at a particular moment in time and may miss clinically significant episodes of cerebral hypoxia/ischemia, so continuous, bedside monitoring modalities are preferred during clinical management. Readers are referred elsewhere for a detailed description of the role of imaging after ABI.[1]

Jugular Venous Oxygen Saturation Monitoring

Jugular venous oxygen saturation monitoring ($Svjo_2$) was the first bedside monitor of cerebral oxygenation, but its use is being superseded by other monitoring tools.

Table 1
Bedside monitors of cerebral oxygenation

	Advantages	Disadvantages
$Sjvo_2$	• Real time • Global trend monitor	• Invasive insertion procedure with risk of hematoma, carotid puncture, and vein thrombosis during prolonged monitoring • Insensitive to regional ischemia • Assumes stable $CMRo_2$ to infer CBF changes
$Ptio_2$	• Focal monitor permitting selective monitoring of critically perfused tissue • Real time • The most effective bedside method of detecting cerebral ischemia • Relatively safe with low hematoma rate (<2%, usually small and clinically insignificant) • No reported infections	• Focal monitor – the position of the probe is crucial • May miss important pathology distant from the monitored site • Invasive • Small degree of zero and sensitivity drift • One-hour run-in period required and thus critical early hypoxic/ischemic episodes may go undetected • Technical complication rates (dislocation or drift) may reach 13.6%
NIRS	• Real time • High spatial and temporal resolution • Noninvasive • Assessment of several regions of interest simultaneously	• Extracerebral circulation may contaminate cerebral oxygenation measurements • Lack of standardization between commercial devices • Thresholds for cerebral hypoxia/ischemia undetermined • Current devices only monitor relative changes in oxygenation