Cerebral Microdialysis

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KEYWORDS

- Cerebral microdialysis • Brain metabolism • Lactate/pyruvate ratio
- Brain energy crisis • Multimodality monitoring

KEY POINTS

- Cerebral microdialysis (CMD) provides a novel method of regional neuromonitoring of brain biochemistry at the cellular level.
- Controversy exists as to the optimal placement of the probe; however, most clinicians agree that placement in penumbral or perilesional tissue may have the most utility in guiding clinical interventions.
- CMD has been studied most rigorously in traumatic brain injury and subarachnoid hemorrhage, although it may be reasonable to use this monitor in any patient at risk for neurologic deterioration.
- The most commonly measured metabolites include glucose, lactate, pyruvate, glycerol, and glutamate; however, the number of analytes recovered and studied continues to grow.
- CMD is most often used in the treatment of severely injured neurocritical care patients as part of a multimodal approach that includes intracranial pressure monitoring, cerebral perfusion pressure monitoring, and brain tissue oxygen monitoring.

INTRODUCTION

The management of neurocritical care patients focuses on preservation of salvageable brain tissue and prevention of potentially avoidable secondary complications. Traditional neuromonitoring techniques include serial neurologic examination,

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intracranial pressure (ICP) monitoring, brain tissue oxygenation ($P_{bt}O_2$) monitoring, serial imaging studies, and continuous electroencephalography. Despite clinical advances in the care of patients with severe brain injury, secondary ischemic and nonischemic events remain a major cause of poor prognosis. Improved long-term patient outcomes depend on preemptive measures, early detection, and aggressive treatment of conditions that lead to secondary injury. Although basic monitors provide values that serve as proxies for brain health, they do not provide direct measurement of cerebral biochemistry, ischemia, or metabolism.

Cerebral microdialysis (CMD) allows bedside monitoring of the neurochemical state of the brain through collection and analysis of molecular substances from the brain's interstitial fluid. Molecules routinely recovered from brain interstitial fluid by CMD provide direct biochemical readouts of the level of cerebral ischemia (lactate, pyruvate), excitotoxicity (glutamate), and cell death (glycerol) in brain-injured patients that are not possible to obtain using conventional monitoring strategies. CMD has been used in laboratory settings and various clinical applications for several decades, although its use in humans was not initiated until 1992.[1,2] Levels and trends of the analytes obtained through CMD warn of impending detrimental secondary events in patients with severe neurologic compromise.[3,4] This article provides a guide to nursing personnel in the use of CMD and its nursing implications.

USEFULNESS AND INDICATIONS

The utility of CMD has been increasingly evident, with nearly 700 publications since its clinical debut.[5] CMD is indicated for use in patients with severe brain injury who are at risk for developing secondary cerebral hypoxia, ischemia, energy failure, and glucose deprivation and in whom the underlying neurologic status is unclear because of varying degrees of coma.[3,6] Variations in analyte levels reflect metabolic derangements (mainly deficient oxygen and/or glucose) that may signify mitochondrial failure, excitotoxic injury, or cell death within injured brain.[2,7] These changes may herald impending cerebral ischemia, epileptic activity, and intracranial hypertension.[7–12]

In combination with additional monitoring modalities, CMD may lend guidance to clinical decision making.[6–12] Results may guide systemic glucose management[13–20] and inform mean arterial pressure (MAP) and cerebral perfusion pressure (CPP) targets (**Fig. 1**)[21–25] as well as hemoglobin thresholds.[26] CMD may advise the safety and tolerability of episodic discontinuation of sedative infusions[27,28] and monitor cerebral metabolism after decompressive hemicraniectomy.[29,30] Furthermore, analysis of CMD analyte trends has shown correlation with long-term neurologic outcomes in both traumatic brain injury (TBI) and subarachnoid hemorrhage (SAH), which is useful in guiding prognostic efforts.[31–34]

Although CMD-guided algorithms have been most extensively studied in TBI and SAH, the physiologic data provided by CMD apply to brain injury from other causes, including intraparenchymal hemorrhage,[35] ischemic stroke,[36–38] brain tumors,[39] and hepatic encephalopathy.[40] In addition, it may be used to assess central nervous system penetration of pharmacologic agents, neurocytokines, and drug delivery, as well as serving as a biomarker or surrogate end point in research studies.[41,42]

CATHETER PLACEMENT

Cerebral microdialysis requires placement of a thin, fenestrated catheter into the subcortical white matter of the brain parenchyma. The catheter may be inserted through a single-lumen or multilumen cranial bolt system or tunneled percutaneously.