University of Pennsylvania Medical Center

LICOX® Brain Tissue Oxygen Monitor Provides Missing Link in the Care of Traumatic Head Injuries

In October 2001, the University of Pennsylvania Medical Center began using the LICOX Brain Tissue Oxygen Monitoring System as an important adjunct to other monitoring modalities used for head injury and subarachnoid hemorrhage patients. Established in 1874, the 725-bed medical center is a renowned Level I trauma center serving suburban Philadelphia, as well as Southern New Jersey and Delaware.

Recognizing the vital role brain tissue oxygenation plays in the outcomes of these seriously ill patients, Peter D. Le Roux, M.B., Ch.B., M.D., F.A.C.S., associate professor and vice chairman of neurosurgery, and his colleagues decided to trial the LICOX System to evaluate its efficacy in the management of the center's head injury patient population. After the trial period, faculty gave positive feedback to the hospital administration, which provided a capital budget to purchase the system. To date, the LICOX System has been used to monitor brain tissue oxygenation in more than 100 patients in the center’s 24-bed trauma intensive care unit and 14-bed neurointensive care unit.

Brain Tissue Oxygenation—The Missing Link

Traumatic brain injury is a leading cause of death and disability in the United States, with nearly 1.5 million cases reported annually. Of those, 50,000 people die, and 80,000–90,000 people leave the hospital with long-term disability—exerting an enormous emotional and financial toll on the individuals, families, and society. Secondary brain damage following severe head injury plays a major role in this morbidity and mortality. As a result, there is an ongoing effort by the medical community to develop treatment protocols aimed at preventing secondary injury.

According to Dr. Le Roux, the cornerstone of head injury management currently is the concept of controlling intracranial pressure (ICP). “While it has never been proven in a randomized trial that intracranial pressure monitoring is effective, there’s other good evidence that ICP monitoring makes a difference in patient outcomes,” he said. “But some studies have documented that the amount of oxygen the brain tissue extracts is more predictive of whether there will be an infarction or a bad outcome. Intracranial pressure, therefore, provides only one side of the equation. We have come to realize that the Holy Grail in head injury management is a multimodality monitoring strategy that includes ICP, cerebral perfusion pressure, cerebral blood flow, and cerebral metabolism. Brain tissue oxygen monitoring begins to address these needs.”

—Dr. Peter D. Le Roux, Associate Professor & Vice Chairman of Neurosurgery
Studies conducted over the past 10 years have led to a greater understanding about optimal levels of partial pressure of oxygen in brain tissue (PbtO2) and the effects of low PbtO2 on outcomes and survival. These studies have shown that numerous hypoxic episodes occur in head injury patients despite aggressive management of ICP and cerebral perfusion pressure (CPP). Levels of PbtO2 in uninjured brain tissue range from 20–35 mm Hg. Extended periods with PbtO2 less than 15 mm Hg correlated with a greater chance of death, and any occurrence of PbtO2 less than 6 mm Hg was associated with an increased risk of death. Further, PbtO2 of less than 10 mm Hg has been associated with poor outcomes, including severe disability and death.

“The LICOX System adds another weapon to our armamentarium for treating a serious condition,” Dr. Le Roux said. “The system is very useful for showing you whether treatment is having a positive or negative effect and providing an objective indication of what the likely prognosis will be. We don’t use it in isolation—we consider it in light of other factors such as the clinical exam, the CT scan, the ICP monitor, and everything else. It all plays together in creating an effective monitoring strategy.”

Eileen Maloney-Wilensky, R.N., M.S.N., C.R.N.P., director of the Neurosurgery Clinical Research Division of the University of Pennsylvania’s Department of Neurosurgery, works closely with Dr. Le Roux and has been active in developing protocols for using the LICOX monitor. She said the LICOX System is a critical facet of their multimodality monitoring program, providing important information that was previously unavailable.

“We are noticing things earlier—ischemia that can lead to secondary injuries,” she said. “The primary event occurs, and there isn’t anything we can do about it. Where we can make the difference, however, is preventing ischemic events that occur from all the other hemodynamic changes in a person who has been critically injured. That is the beauty of the LICOX System’s design, and that’s why we are so excited about it. It gives us the information—and the ability—to intervene early.”

**LICOX System in Clinical Practice**

The LICOX System provides direct, real-time measurement of oxygenation of injured brain tissue, allowing clinicians to identify patients with inadequate oxygenation and make immediate adjustments to restore PbtO2 to safe levels. The LICOX System measures PbtO2 and brain temperature using an intraparenchymally placed oxygen-sensing catheter, typically inserted at the site of injury. The catheter is placed into the white matter of the brain using a proprietary bolt system with a single or multilumen design that allows monitoring of single or multiple parameters through one burr hole. The easy-to-use system is proven safe for patients, with a unique, patented hermetic seal for tight closure and infection control. The LICOX monitor features quick, easy, smart-card calibration and an easy-to-read digital display, and it connects readily to bedside monitors.

The LICOX System is used at the University of Pennsylvania Medical Center to monitor patients with severe head injury, which accounts for about 50 percent of monitored patients. The balance is primarily those with subarachnoid hemorrhage and a small number of tumor patients. Department faculty created two different treatment algorithms—a severe head injury algorithm and a brain oxygen algorithm for other patients who are not trauma patients but qualify for placement of a brain monitor.

“The algorithms are designed to help determine whether a decrease in the brain tissue oxygen number is related to an actual oxygen delivery problem, or if it is related to a metabolic or demand problem in the brain,” Maloney-Wilensky said. “Each of these problems has a list of variables that we address for each patient, and each patient could have competing problems that are going on at the same time, which are resulting in this decline in brain tissue oxygenation.”

The Glasgow Coma Scale is used to determine which patients qualify to be monitored. Patients with a score of eight or less are candidates for the LICOX System. Patients with a score of 9–12, however, may still be
candidates if they have a specific condition or injury of concern. “If the patient is not aware or alert, even though they’re arousable, and we want to closely monitor them so we can react at the earliest time to potential issues, we will place the LICOX System,” Maloney-Wilensky said.

The LICOX System also is effectively used to monitor patients with subarachnoid hemorrhage. According to Maloney-Wilensky, low oxygen levels in these patients often are concurrent with a vasospasm occurrence, providing a warning sooner than would a change in ICP measurement. “When there’s an insult to the brain, the patient may have an edema that causes pressure in the brain,” she said. “In subarachnoid hemorrhage patients, what we’re looking for is the actual ischemic event that is caused by an episode of vasospasm. Oftentimes we can use the LICOX System to determine where the vasospasm is occurring because it’s where the highest amount of blood is. It allows us to actually see the vasospasm occur as indicated by a decline in brain tissue oxygen. We have found this decrease in oxygen often occurs before a change in the clinical exam or intracranial pressure and before significant changes are observed in blood flow velocity detected by a commonly used monitor, transcranial Doppler. So it’s very useful.”

Additionally, the LICOX System is used to identify ischemic events in tumor patients. “We’ve had patients in our tumor population who have developed acute-onset edema or have been in a status epilepticus, where monitoring brain tissue oxygen and looking for ischemic events has been extremely helpful,” Maloney-Wilensky said.

Impact on Patient Outcomes

The center currently is evaluating six-month and one-year outcomes of monitored patients, comparing them with standardized expected outcomes for similar patients. The department also has submitted LICOX System case studies and guidelines to neurosurgery and nursing journals and is developing a brain tissue oxygen monitoring protocol for the American Association of Critical Care procedure manual. Preliminary data on patients monitored to date indicate that brain tissue oxygen monitoring is having a positive impact on outcomes.

“Observations of what we do physiologically to patients in the ICU and the effect on brain oxygen are showing very positive trends that should translate into better outcomes,” Dr. Le Roux said. “Our preliminary analysis shows about a 50 percent mortality reduction in patients with LICOX monitors compared with expected outcomes for similar patients who were not monitored. Our preliminary information is very compelling, very provocative, and suggests better outcomes. I’m confident that when more data become available about the technology’s impact on outcomes, more people are going to use it.”

Collaboration & Education

A critical facet of implementing new technology in the care of trauma patients is collaboration and a systemized, multidisciplinary approach. This collaboration is the guiding concept of a Level I trauma center in the United States. According to Dr. Le Roux, this sort of alliance is central to effective multimodality monitoring and care for trauma patients.

“A patient with severe head injury is taken care of by a number of physicians and nurses from multiple specialties,” he said. “Many people are involved in the care, which is coordinated in most instances by the neurosurgeon or neurointensivist.

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In reality, however, physicians are not always in the trenches doing the minute-to-minute care. That is done by neurointensivist nurses, and they are the ones who have to understand the monitor’s implications and the impact on day-to-day management of the patient.”

Educating and involving nurses in the process of brain tissue oxygen monitoring is vital for optimal use of the technology, Dr. Le Roux said. “It’s easy for me to sit at my desk and say that when the brain tissue oxygen in the patient is low, the patient is going to do badly,” he said. “If that concept is not clearly communicated to nurses at the bedside, a change in management or outcome results won’t occur. We have found that organization, education, and collaboration make all of this effective.”

According to Maloney-Wilensky, the LICOX System has led to an evolution in nursing care. The department’s nurses are enthusiastic about the quality of care the LICOX System can bring to head trauma patients. “In the neurosurgical ICU, we’ve seen the difference it has made at the bedside,” she said. “Information from the monitor allows us to react immediately to changes, and it quickly demonstrates whether therapy is making a difference in the patient. As a result, there’s a definite core of nurses who are committed to the technology and appreciate its positive impact on patient care at the bedside.”

REFERENCES

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