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Editorial

A Brief Introduction to the Study of Cerebral Blood Flow Measurement in Traumatic Brain Injury Using Optical Imaging Approach

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Perioperative or Intraoperative surveillance of blood flow in the brain and identification of disturbances are among the most critical challenges of modern neurocritical care field. The method for monitoring cerebral blood flow (CBF) is generally indirectly calculated through intracerebral pressure and cerebral perfusion pressure, which is currently widely used in South Korea. However, an accurate quantitative system requires the use of an invasive method, which includes a method using a thermal diffusion probe that measures CBF and a method that measures and calculates tissue oxygen saturation through brain oxygenation. These methods have the disadvantage that it is invasive, the measured values change depending on the installation of the probe, and the accuracy in interpreting these measured values is not relatively guaranteed. Accordingly, optical contrast measurement is a method of monitoring CBF that can compensate for this weakness which is not actively used yet but is mainly studied in laboratories. For the past year, this author has studied surveillance of brain hemodynamics using the above-mentioned optical imaging approach at the University of California, Irvine: Beckman Laser Institute in Irvine, California. Therefore, I would like to briefly introduce these widefield optical imaging approaches which are consisted of three main types of measurement for cerebral hemodynamics including the following optical intrinsic signal imaging, laser speckle imaging (LSI) and spatial frequency domain imaging (SFDI). These optical approaches are a representative multimodal imaging that uses technique called optical absorption, optical scattering, and speckle contrast to detect CBF alteration. Since these change of light contrast fundamentals depending on specific wavelength, it is recommended to match the optimized light wavelength for the characteristics of the equipment.[3] Among these ways, optical imaging properties studied related to traumatic brain injury (TBI) are LSI and SFDI.

First of all, LSI is a wide-field imaging technique used in various fields of optic medicine to analyze specific tissues and cell perfusion related to blood flow using speckle interference patterns of light.[3] The main advantage of the LSI technology is the possibility of evaluating the characteristics of pulsations in addition to the average characteristics, which can help assess the rest or the functional state of blood flow.[5] LSI has been used to analysis the spatiotemporal CBF hemodynamic changes that occur in different models of TBI, such as modified cortical flow impact for more severe TBI and closed head injury for mild TBI. LSI has been introduced in several studies as an important monitoring approach to measure alteration in CBF during surgery in the field of neurosurgery, such as aneurysm clipping,

brain tumor or arteriovenous malformation removal surgery, cerebral bypass surgery, and surgery related to cerebral infarction.[1,4,6,7,9]

On the other hand, applications of SFDI to neuroimaging are a more recent development. By measuring projected spatial patterns at different wavelengths of light, SFDI can be used to quantitatively evaluate structural and functional components of tissue. Through collaborations combining the expertises, we are improving a non-contract tool for investigating of burn wound checking and healing, tissue oxygenation during surgery, and hemodynamics within the injured brain. SFDI in the TBI field has been used as brand new technique for quantitative image measurement to identify changes in CBF and metabolic abnormalities during various brain injuries in rat models over the past 10 years. Among these studies, the first field in which SFDI was studied was a study to monitor cerebral absorption and scattering patterns after closed head injury of rats model.[1)] This study showed that the injured brain attain decreased cerebral perfusion around area of injury and a significant decrease in StO2. A subsequent study presented a similar injury model to demonstrate the positive effects of medications used in a clinical hospital setting to maintain CBF in severe TBI.[8)] The alternative study combined the two-wavelength for LSI with SFDI to show changes in cerebral hemodynamics and brain metabolism in different injury model.[2)] Both of the above techniques suggested that a decrease in CBF and tissue oxygenation and a decrease in brain metabolism were observed within the first hour after TBI.

Advances in multimodal instrumentation using wide-field optical imagings help to clearly understand cerebrovascular mechanisms, and the abundant hemodynamic information obtained thereby is thought to play a very invaluable role in strategizing the treatment of neurological injury. Real time surveillance of CBF using optical advanced approach is currently being actively studied in degenerative brain diseases, especially Alzheimer's disease, and currently, BLI in California is at the active institute of these studies among the laboratories around the world that study the optical medicine. It is thought that the future brain monitoring will be mainly a non-invasive measurement using optical imaging rather than direct measurements of brain hemodynamics using current invasive device.

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