

Continuous Wave near Infrared Spectroscopy

Children born in critical condition often require extensive amounts of intensive care. As a result, they are placed in neonatal intensive care units (NICU) for close proximity and monitoring purposes. An important part of the monitoring process deals within the realm of proper blood flow to the brain of the infant. This needs to be closely monitored because insufficient blood flow to the brain can result in brain damage or further injury to already existing damage. As a result, the need for portable, non-invasive diagnostic instrumentation arises allowing for minimal to no interference with concurrent intensive care.

Near infrared range spectroscopy, referred to as NIR, involves the shining of light in the mentioned range thru the scalp of a newborn. The injected photons of light react differently to the matter contained in the cranium. Some of the light is absorbed by the skin, tissue, and brain. Additional light exits in a "banana pattern," often referred to as backscattered light. The major absorbers of NIR light are the blood chromophores of both oxygenated and deoxygenated blood. The received changes in amplitude of this backscattered light allow for conclusions pertaining to blood chromophore concentrations. Blood chromophore examination is pertinent to hemodynamics, the motion of blood through the cardiovascular system.

Constant wave near infrared range spectroscopy injects a light of constant amplitude as well as two different wavelengths accounting for the two different chromophores. The diagnostic instrument consists of a probe containing a transmitter and receiver, a processing unit, and a computer. The transmitter or source, consists of an LED driver and wavelength selector. LED's are used rather than lasers because they allow for minimal power consumption. LED intensity can be altered by the user by adjusting current passing through the light source. LED intensity is altered based on the skin type of the patient. Darker skin types require larger intensity light where as lighter skin types require lower powered light (darker skin absorbs more light therefore larger intensity is needed). The wavelengths required to resolve the different chromophores are implemented with the use of a multiplexing IC.

The receiver or detector receives the backscattered waveform. It is located approximately

2mm from the detector. Within the receiver exists an amplifier as well as a filter. The amplifier allows the signal to be brought to the top of the dynamic range of the A to D converter located within the processing unit. The gain is approximately 106 decibels with a bandwidth of 100 hertz. The signal is then low pass filtered with a cutoff frequency of 1.5kHz to avoid aliasing during A to D conversion.

The processing unit consists of a 10 volt, 12 bit resolution, data acquisition card. The signal processing software used is Visual C++. The Beer Lambert algorithm is used to discern concentrations of oxygenated hemoglobin vs. deoxygenated hemoglobin.

The current status of the product is still within the clinical trial phase. The product has been used on a child at St. Peters University Hospital in New Jersey. Here, blood chromophore concentrations were monitored in the temporal region during a mandatory hearing screening test (hearing screening acts as stimulus for temporal region). Increased blood concentration of both oxygenated and deoxygenated hemoglobin was found in the temporal region. There was a greater change in deoxygenated hemoglobin concentration indicating oxygen consumption due to the activity. A 67 decibel signal to noise ratio was obtained for temporal resolution of around 10 kHz.

A portable near infrared spectroscopy system for bedside monitoring of newborn brain

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Quantitation of cerebral blood volume in human infants by near-infrared spectroscopy

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The Accuracy of Near Infrared Spectroscopy and Imaging during Focal Changes in Cerebral Hemodynamics

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