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Cerebral and tissue oximetry

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The use of near-infrared spectroscopy (NIRS) has been increasingly adopted in cardiac surgery to measure regional cerebral oxygen saturation. This method takes advantage of the fact that light in the near-infrared spectrum penetrates tissue, including bone and muscle. Sensors are placed at fixed distances from a light emitter, and algorithms subtract superficial light absorption from deep absorption to provide an index of tissue oxygenation. Although the popularity of NIRS monitoring is growing, definitive data that prove outcome benefits with its use remain sparse. Therefore, widespread, routine use of NIRS as a standard-of-care monitor cannot be recommended at present. Recent investigations have focused on the use of NIRS in subgroups that may benefit from NIRS monitoring, such as pediatric patients. Furthermore, a novel application of processed NIRS information for monitoring cerebral autoregulation and tissue oxygenation (e.g., kidneys and the gut) is promising.

Background

The principal discoveries that underlie the monitoring of regional cerebral oximetry ($rScO_2$) include those by Jöbsis in the late 1970s and the theoretical framework by Norris before [1,2]. He demonstrated that light in the near-infrared spectrum penetrates tissue, including bone and muscle, and that certain chromophores (e.g., cytochrome oxidase C) absorb light in this spectrum. In 1985, Ferrari and colleagues demonstrated that light emitted at the wavelength specific for the peak absorption of the

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chromophores oxyhemoglobin (920 nm) and total hemoglobin (760 nm) can be used to measure brain oxygenation in humans (Fig. 1A) [3]. Cerebral oximetry has since gained widespread popularity, especially in adult and pediatric cardiac surgery [4,5]. Today, physicians can choose from a wide variety of devices for monitoring $rScO_2$, including INVOS™ (Somanetics/Covidien, Inc., Boulder, CO, USA), FORE-SIGHT™ (CAS Medical Systems, Branford, CN, USA), EQUANOX™ (Nonin Medical Inc., Plymouth, MN, USA), CerOx™ (Ornim Medical, Lod, Israel), NIRO™ (Hamamatsu Photonics, Hamamatsu City, Japan), and TOS-96™ (Tostec, Tokyo, Japan). Now, these methods are also being used to monitor oxygenation in other tissue beds, such as extremities distal to the site of arterial cannulation during intra-aortic balloon counter-pulsation or cardiopulmonary bypass (CPB). Newer applications of cerebral oximetry include its use as a surrogate for cerebral blood flow (CBF) for bedside monitoring of autoregulation [6] and regional tissue perfusion [7]. Monitoring $rScO_2$ and tissue oxygenation may provide important clinical data on the balance between tissue oxygen supply and demand in near real time, allowing for therapeutic interventions to prevent tissue ischemic injury [8]. However, despite a multitude of anecdotal reports, recent reviews have tempered the enthusiasm for routine use of $rScO_2$

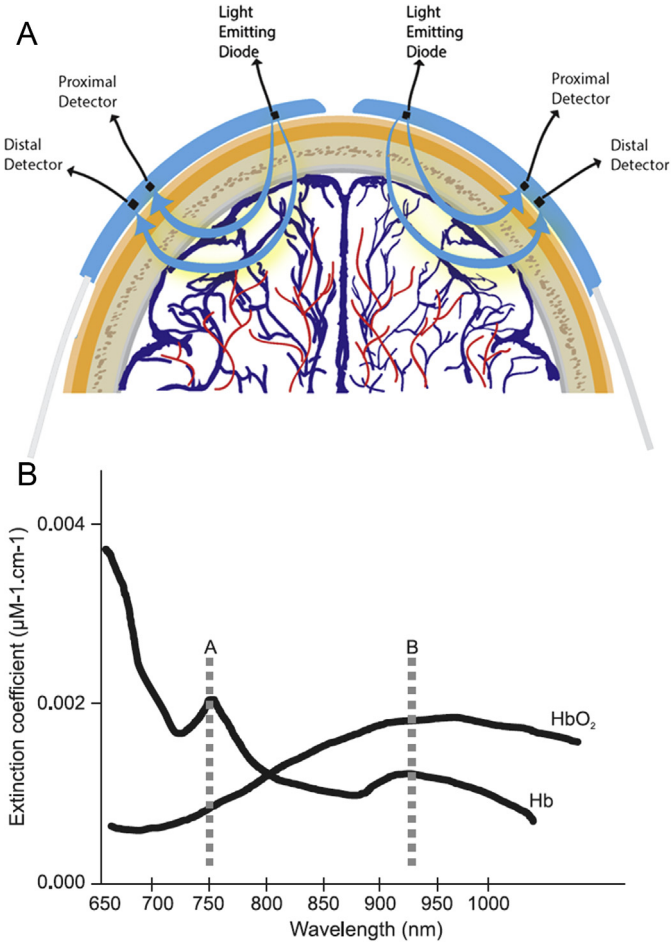

Fig. 1. Cerebral oximetry. A: Schematic illustration of cerebral oximetry. Used with permission from Anesth Analg. 2013 Mar; 116(3):663–76. B: Absorption spectrum of hemoglobin and oxyhemoglobin with the peak absorption wavelength of oxyhemoglobin (B: 920 nm) and total hemoglobin (A: 760 nm). Hb, deoxyhemoglobin; HbO_2, oxyhemoglobin. Used with permission from Lima et al., Rev Bras Ter Intensiva. 2011 August 23(3):341–351.