Describe how near infrared spectroscopy (NIRS) can be applied to determine cerebral oxygenation.

- Cerebral Near-Infrared Spectroscopy (NIRS) utilizes near-infrared light (700-1000 nanometers) to penetrate through the superficial layers of the head (including the scalp and skull) to illuminate cerebral tissue(1). This work was pioneered by F F Jöbsis, who determined that the relatively good transparency of biological material in the near-infrared region allows for sufficient photon transmission through organs to non-invasively detect tissue oxygen saturation(2). A light source (eg LED) generates specific NIR light wavelengths, which is directed into the tissue of interest, and subsequently measured by a probe when it returns to the tissue surface. Within the NIR range, the principle light-absorbing molecules are metal complex chromophores (hemoglobin, bilirubin, and cytochrome)(3). Measurement of tissue oxygen saturation is determined by the difference in intensity between transmitted and received light delivered at specific wavelengths (Lambert-Beer law), which is dependent on a combination of reflectance, scattering, and absorption(3-6). $rScO_2$ is the percentage of oxyhemoglobin over the sum of combined oxyhemoglobin and deoxyhemoglobin in pooled arterial, capillary, and venous blood in the illuminated brain region. This can allow an anesthesiologist to make decisions that can either augment cerebral blood flow and blood oxygen content or decrease the cerebral metabolic rate of oxygen ($CMRO_2$). Various intervention algorithms and protocols have been developed to clinically reverse intraoperative $rScO_2$ desaturations(3, 7, 8).

What are the limitations of this technique?

- There are a number of limitations to NIRS, including: its inability to quantify oxygen molecules, signal attenuation from extracerebral tissue, assumption of a fixed distance for light travel through the sampled region (ie optical path-length), the use of a fixed cerebral arterial/venous ratio (there is considerable variation between patients), potential signal attenuation and impedance from non-heme tissue chromophores (eg bilirubin, myoglobin, melanin pigmentation), and potential confounding signals from non-metabolizing/non-perfusing tissue(3-6). These can lead to a false positives as well as false negatives(5). Routine clinical application of NIRS can also be expensive – extensive cost/benefit analyses have not been performed(1, 9).

What alternative non-invasive cerebral oximeters exist?

- There are various other modalities utilized for intraoperative monitoring of cerebral oxygenation including:, electroencephalogram (EEG), somatosensory evoked potentials (SSEP), motor evoked potentials (MEPs), transcranial doppler (TCD), jugular bulb venous blood hemoglobin saturation ($SjvO_2$) and chemical biomarkers(1). The goal of these is to allow for early diagnosis of cerebral ischemia and hypoxia(9, 10), which results in higher perioperative mortality and morbidity. Some of these sequelae include postoperative stroke, postoperative delirium, and postoperative cognitive dysfunction (POCD)(1).

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