Diffuse correlation spectroscopy

Diffuse Correlation Spectroscopy (DCS) is a non-invasive optical technique used to measure blood flow in deep tissues. It provides information about the microvascular blood flow by analyzing the temporal fluctuations of near-infrared light that has undergone diffuse scattering within biological tissues.

In DCS, near-infrared light is directed into the tissue, and the scattered light is collected by a detector. The fluctuations in the intensity of the collected light are analyzed to extract information about the motion of red blood cells within the tissue. These fluctuations are related to the velocity of blood flow, and by using correlation analysis techniques, blood flow measurements can be obtained.

DCS has been widely used in various research fields, including neuroscience, oncology, and cardiovascular studies. It can provide valuable insights into the perfusion and oxygenation of tissues, and it has the advantage of being non-invasive and portable, allowing for measurements in real-time and in different clinical settings.

Overall, diffuse correlation spectroscopy is a technique that enables the assessment of blood flow in deep tissues using near-infrared light and correlation analysis of the scattered light intensity fluctuations. It has potential applications in clinical research and monitoring of tissue perfusion in various medical conditions.

It is emerging as a possible method for continuous monitoring of CBF and critical closing pressure (CrCP or zero-flow pressure), a parameter directly related to ICP.

Sathialingam et al. employed a non-invasive optical modality called diffuse correlation spectroscopy (DCS) to quantify the acute microvascular cerebral blood flow (CBF) response to intrathecal nicardipine (up to 90 min) in 20 patients with medium-high grade non-traumatic SAH. On average, CBF increased significantly with time post-administration. However, the CBF response was heterogeneous across subjects. A latent class mixture model was able to classify 19 out of 20 patients into two distinct classes of CBF response: patients in Class 1 (n = 6) showed no significant change in CBF, while patients in Class 2 (n = 13) showed a pronounced increase in CBF in response to nicardipine. The incidence of DCI was 5 out of 6 in Class 1 and 1 out of 13 in Class 2 ($p < 0.001$). These results suggest that the acute (<90 min) DCS-measured CBF response to IT nicardipine is associated with intermediate-term (up to 3 weeks) development of DCI [1)].

Wu et al. optimized DCS hardware and algorithms for the quantification of CrCP. Toward its clinical translation, we validated the DCS estimates of cerebral blood flow index (CBFi) and CrCP in ischemic stroke patients with respect to simultaneously acquired transcranial Doppler ultrasound (TCD) cerebral blood flow velocity (CBFV) and CrCP.

Results: We found CrCP derived from DCS and TCD were highly linearly correlated (ipsilateral R2 = 0.77, p = 9 × 10 - 7; contralateral R2 = 0.83, p = 7 × 10 - 8). We found weaker correlations between CBFi and CBFV (ipsilateral R2 = 0.25, p = 0.03; contralateral R2 = 0.48, p = 1 × 10 - 3) probably due

to the different vasculature measured.

The results suggest DCS is a valid alternative to TCD for continuous monitoring of CrCP [2].

1)
Sathialingam E, Cowdrick KR, Liew AY, Fang Z, Lee SY, McCracken CE, Akbik F, Samuels OB, Kandiah P, Sadan O, Buckley EM. Microvascular cerebral blood flow response to intrathecal nicardipine is associated with delayed cerebral ischemia. Front Neurol. 2023 Mar 17;14:1052232. doi: 10.3389/fneur.2023.1052232. PMID: 37006474; PMCID: PMC10064128.
2)
Wu KC, Sunwoo J, Sheriff F, Farzam P, Farzam PY, Orihuela-Espina F, LaRose SL, Monk AD, Aziz-Sultan MA, Patel N, Vaitkevicius H, Franceschini MA. Validation of diffuse correlation spectroscopy measures of critical closing pressure against transcranial Doppler ultrasound in stroke patients. J Biomed Opt. 2021 Mar;26(3). doi: 10.1117/1.JBO.26.3.036008. PMID: 33774980.