Cerebral tissue oximetry in pediatric population: establishing reference values in TD-NIRS measurements.

M. Lacerenza[1], V. Rossi[2], S. Zanelli[2], C. Amendola[3], D. Contini[3], M. Buttafava[1], A. Torricelli[3,4], L. Spinelli[4], G. Zuccotti[2,5] and V. Calcaterra[2,6]

1 PIONIRS s.r.l., 20124 Milano, Italy; 2 Pediatric Department, Buzzi Children's Hospital, 20154 Milano, Italy; 3 Dipartimento di Fisica, Politecnico di Milano, 20133 Milano, Italy; 4 Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche, 20133 Milano, Italy;5 Department of Biomedical and Clinical Science, University of Milan, 20157 Milano, Italy; 6 Pediatric and Adolescent Unit, Department of Internal Medicine, University of Pavia, 27100 Pavia, Italy.

Abstract: A large cohort of healthy pediatric subjects has been studied to define distribution of tissue optical parameters and absolute oximetry values in the frontotemporal brain region, via time-domain near-infrared spectroscopy. Results from 350 subjects are presented, relative to differential pathlength factor, absorption and reduced scattering coefficients distribution and correlation across auxological and demographic indicators. This study provides valuable insights into the expected cerebral optical properties of the brain in the pediatric population, which can be leveraged to improve the reliability of diffuse optical measurements and simulations.

1. Introduction: Precise and reproducible tissue oximetry measurements can play a pivotal role in functional brain measurements [1]. While most of the current fNIRS instruments, based on continuous-wave (CW) near-infrared spectroscopy (NIRS) technology, have demonstrated a good head coverage and effectiveness in numerous applications, they still face limitations and uncertainties that hinder their complete trustworthiness [2]. In this work, 350 healthy pediatric subjects have been enrolled to try defining normal hemodynamic and optical values distribution in frontotemporal locations. The reproducibility and precision of the employed time-domain (TD) NIRS tissue oximeter (NIRSBOX, PIONIRS Srl, Italy) have been assessed and leveraged, together with the capability of the device to be highly user-independent.

2. Methods: The measurement campaign was carried out at the Buzzi Children's Hospital in Milano, Italy, involving 350 healthy patients aged between 0 and 18 years. The study adhered to the ethical principles outlined in the Declaration of Helsinki and received approval from the local ethics committee. Data acquisition was conducted by a team of 5 clinicians, using a compact optical probe (*Goccia G5*, PIONIRS s.r.l., Italy) [3] with a source-detector distance of 2.5 cm and a fully-automated acquisition software with built-in data-quality indicators. The measurement protocol consisted in 5 s -long acquisitions, at a 1 Hz sampling rate, and repeated 5 times over the same location by removing and re-placing the optical probe, in order to assess the repositioning performance. Measurements were acquired on the left prefrontal cortex (Fp1 of the 10/20 EEG system mapping). TD-NIRS data was processed using a semi-infinite homogeneous model [4].

3. Results : Measurements were quickly and successfully conducted across the entire cohort (with an average session duration of 3 minutes per subject). The device exhibited consistent stability and reliability across subjects and over time. No correlation was observed between acquisitions by different operators. Tissue saturation (StO2) showed values of 66.9 % ± 4.4 % (avg ± std), with a measurement precision of 0.9 %. Total Hemoglobin (tHb) showed 106.3 µM ± 17.8 µM (avg ± std) values with a precision of 4.2 µM. Correlation between cerebral StO2, and Age of the participant showed to be substantial. The distribution of differential pathlength factors (DPF), absorption and reduced scattering coefficient values have been assessed, showing no correlation with BMI-z-score (Pearson's R<0.3) and moderate correlation with participants' age (Pearsons's R >0.5). Future efforts will focus on more advanced analysis and models, to leverage the potential of TD_NIRS data in retrieving depth-dependent absolute results.

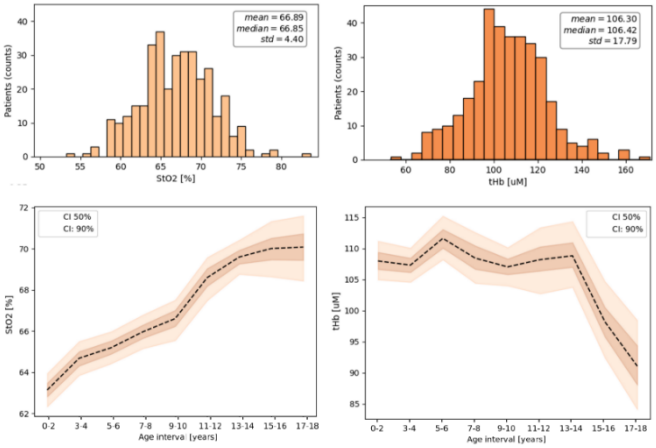

Figure 1 Distribution of StO2 and tHb values and percentiles distribution with age across the full subject population.

4. References

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