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VASCOVID: hybrid diffuse optical platform combined with a pulse-oximeter and an automatized inflatable tourniquet for the assessment of metabolism and endothelial health in the intensive care

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Abstract: VASCOVID project is developing and testing a hybrid diffuse optical monitor for evaluating endothelial function and metabolism in intensive care including COVID-19.

1. Introduction

Worldwide, a quarter of the patients affected by the coronavirus disease-19 (COVID-19) that are admitted to intensive care unit (ICU), suffer from severe oxygenation impairment in the lungs driven by acute respiratory distress syndrome (ARDS) with an associated high mortality rate [1, 2]. Preliminary results from HEMOCOVID-19 multi-center study displays that COVID-19 patients show an impairment of their microcirculation. This effect is associated with the severity of ARDS [3] (trial registration *TrialsGov.* NCT04689477). VASCOVID has benefited from the HEMOCOVID-19's experience to design and develop a hybrid platform that deploys two photonics techniques, time domain near infrared spectroscopy (TD-NIRS) and diffuse correlation spectroscopy (DCS) alongside pulse oximetry and an automatized inflatable tourniquet to perform a vascular occlusion test (VOT). During a VOT an extended ischemia is performed to the target muscle (typically the forearm or thenar muscle) and upon cuff release, both tissue oxygen saturation (StO_2,%), as calculated by TD-NIRS, and blood flow (BFi, cm^2/s) as obtained by DCS, show an overshoot that soon recovers to baseline. This dynamic is altered when microcirculation is impaired (*e.g.* endothelial dysfunction) and it has shown clinical potential in ARDS, septic patients and in prediction of extubation trials in other previous studies [4–6]. This platform is being tested at the intensive care unit of university hospital of Parc Taulí to (i) stratify critically ill patients (*e.g.* sepsis and ARDS) admitted to the ICU, including COVID-19, according to their endothelial function to better personalize therapies that target the endothelium and (ii) predict extubation failure in mechanically ventilated patients during spontaneous breathing trial.

2. VASCOVID platform description

The combination of TD-NIRS and DCS has reached its maturity during the European LUCA and Babylux projects by developing multimodal platforms that are now under clinical validation for thyroid cancer screening and preterm infants monitoring, respectively. Based on this experience we developed the device shown in Fig. 1a. The light

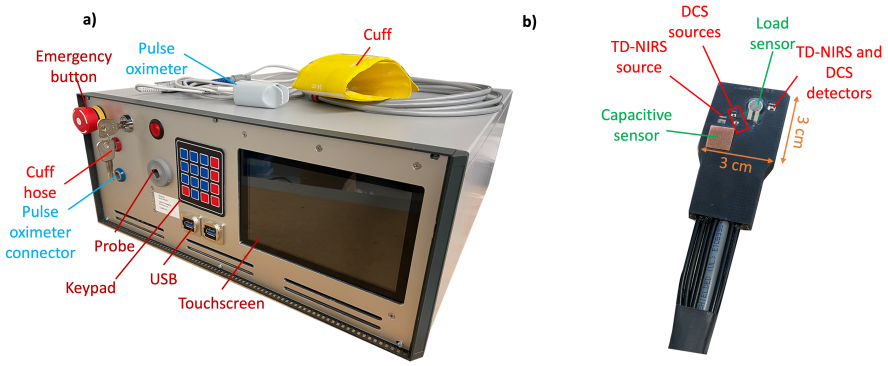

Fig. 1. (a) VASCOVID platform. (b) 3x3 cm^2 multimodal probe with DCS, TD-NIRS source and detector fibers and finally sensors for ensuring patient and operator safety.

is delivered to targeted muscles (forearm and thenar muscle) by means of two distinct 3x3 cm^2 bio-compatible multimodal probes that host both TD-NIRS and DCS source detector fibers with interfiber distances of 2.5 and 1.5 cm, respectively (Fig. 1b). Optical cross-talk has been carefully taken into account when designing the probes, such as smart positioning of the fibers. The probes are also provided with sensors that can detect the detachment from the subjects' skin within few ms and communicate with an interlock system for switching off the laser emission, in compliance with the latest safety standard ISO 60601-2-22. The optical probes are also equipped with an accelerometer and a photodiode to detect unwanted movements and ambient light that can further affect the quality of the measurements. The quality of the diffuse optical modules is ensured by dedicated phantom measurements. TD-NIRS and DCS are synchronized by available hardware signals and controlled together with the other modules by a homemade Java software running on a single board computer (SBC). Real time fitting results can be shown for all the parameters of interest such as, tissue oxygen StO_2 and BFi, baseline metabolic rate of oxygen consumption (MRO_2), ascending and descending slopes, area under the curve of both StO_2 and BFi during the VOT, and finally parameters for data quality check. A summary of these parameters is directly available to the operator on a 7" touchscreen. Furthermore, it is possible to connect and remotely control the device through bluetooth connection by using a tablet, and mark events through a keypad on the front panel of the device. The device hosts four batteries and associated power management systems that can seamlessly switch from battery operation to main supply. Battery operation can last up to 5 hours.

3. Conclusion

We will present the VASCOVID platform characterization and preliminary results on the on-going clinical validation.

4. Acknowledgments & Disclosures

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