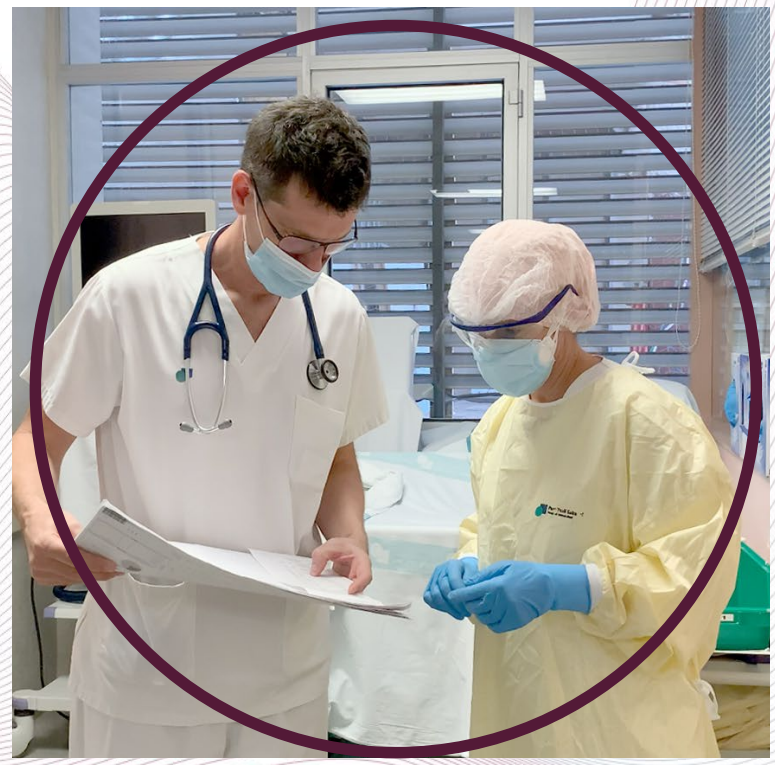
Portable platform for the assessment of microvascular health in COVID-19 patients at the intensive care.

VASCOVID



Partners

ICFO

Politecnico Milano

HemoPhotonics

BioPixS

Parc Taulí Hospital Universitari

splendofit

ASPHALION

PIONIRS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101016087.

VASCOVID consortium

VASCOVID is a project funded by the European commission's Horizon 2020 programme under the grant agreement No. 101016087.

VASCOVID main goal is to develop a device based on diffuse optics which will enable the study of the endothelial and microvascular function in COVID-19 patients.

To seek its goal, the VASCOVID consortium is made of academic, industrial and clinical partners.

[VASCOVID website]

The role of VASCOVID project

More information about the partners and people involved in the project can be found here: VASCOVID partners

Academic

ICFO

Co-ordination- management –Communication - dissemination – integration - analysis

POLITECNICO MILANO 1863

Time-resolved spectroscopy (TD-NIRS) module

Clinical

Parc Taulí Hospital Universitari

Clinical studies; evaluation of future potential

Industry

HemoPhotonics

Commercialization - diffuse correlation spectroscopy (DCS) module

splendo

Artificial intelligence - machine-learning - remote control - cloud computing

BioPixS a new era in BioPhotonics Standards

Phantom development - standards

ASPHALION

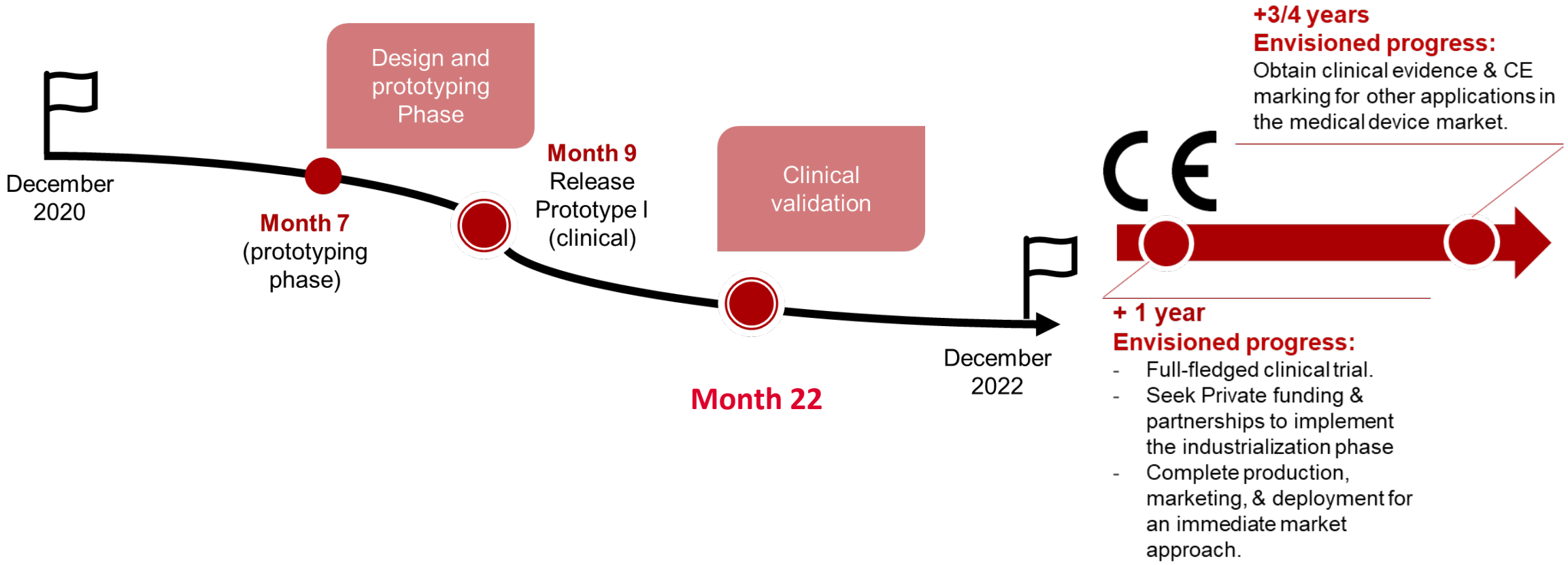
Regulatory affairs - CE & FDA certification - quality management system

PIONIRS

Deployment and development of the VASCOVID prototype and modules

Roadmap of the project

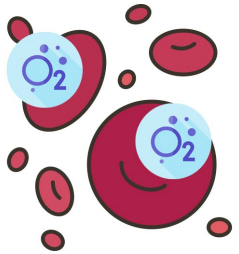
VASCOVID project is a 2 years projects that started in December 2020 and it is expected to finish in December 2022. During the project, the consortium designed two prototypes: i) one clinical prototype that is now, as per September 2022, undergoing clinical validation in the Hospital universitari Parc Taulí in Sabadell, Spain; ii) a second industrial prototype which documentation will be ready to seek CE marking certification, by the end of the project.



VASCOVID hybrid technology

VASCOVID is multimodal technology that integrates diffuse optical techniques alongside pulse oximetry and an automatized tourniquet in order to study microvascular reactivity through vascular occlusion tests and baseline metabolism of oxygen consumption by combining the information from each technology.

Time domain near infrared spectroscopy (TD-NIRS)

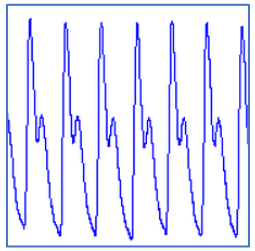


→ Total Hemoglobin **(tHb, μM)**
→ Microvascular oxygen saturation (**StO_2, %**)

Diffuse correlation spectroscopy (DCS)

→ Microvascular blood flow index (**BFI, cm^2/s**)

Pulse oximetry



→ Heart rate (**HR, beats/min)**

→ Arterial oxygen Saturation (**SpO_2 %**)

Automatized tourniquet

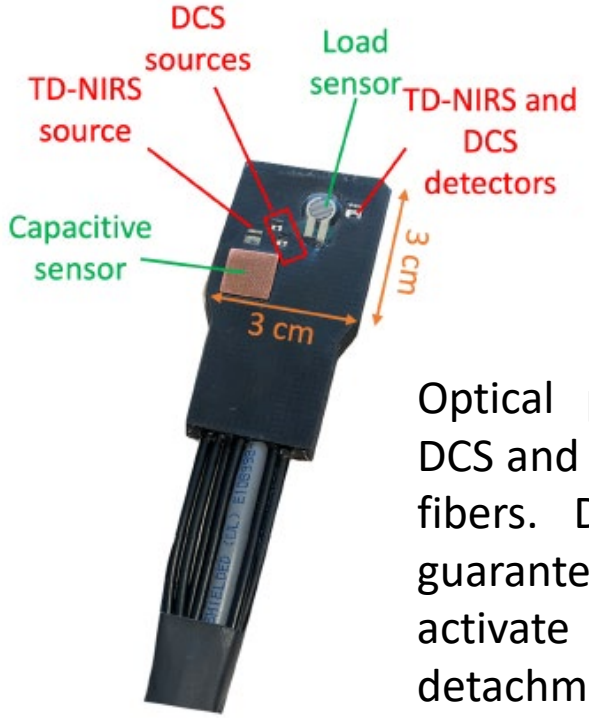
→ Vascular occlusion tests

VASCOVID device

The VASCOVID device hosts all its components in a single portable 19'' 4U rack. The device is completely accessible through a touch screen or wireless via a tablet. Measurements are performed by means of an optical probe that embeds all the relevant sources and detectors fibers while ensuring optimal data quality.

FEATURES

- Non invasive
- Wireless
- Portable
- Multi-modal
- Real-time
- Low cost

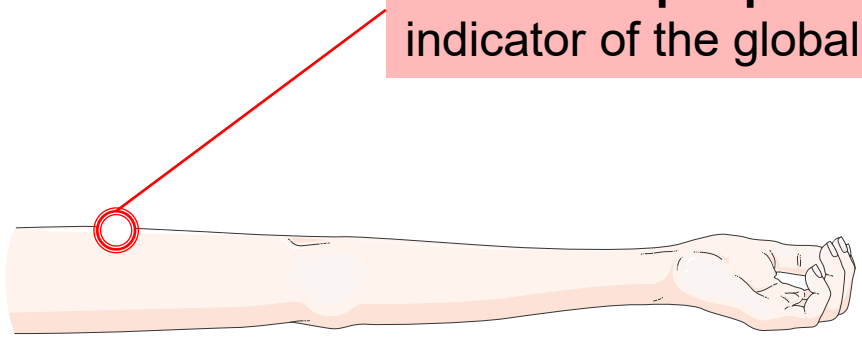


Optical probe that combines both DCS and TD-NIRS source and detector fibers. Data quality and safety is guaranteed by the use of sensors that activate an interlock system when detachment is sensed.

How can we be relevant?

In the intensive care, when performing resuscitation procedures, clinicians act on perfusion and tissue oxygenation, with the goal of restoring its metabolic demand in order to keep the patient alive.

Measure in **peripheral areas**, such as skeletal muscle, can be an indicator of the global hemodynamic status of the patient.

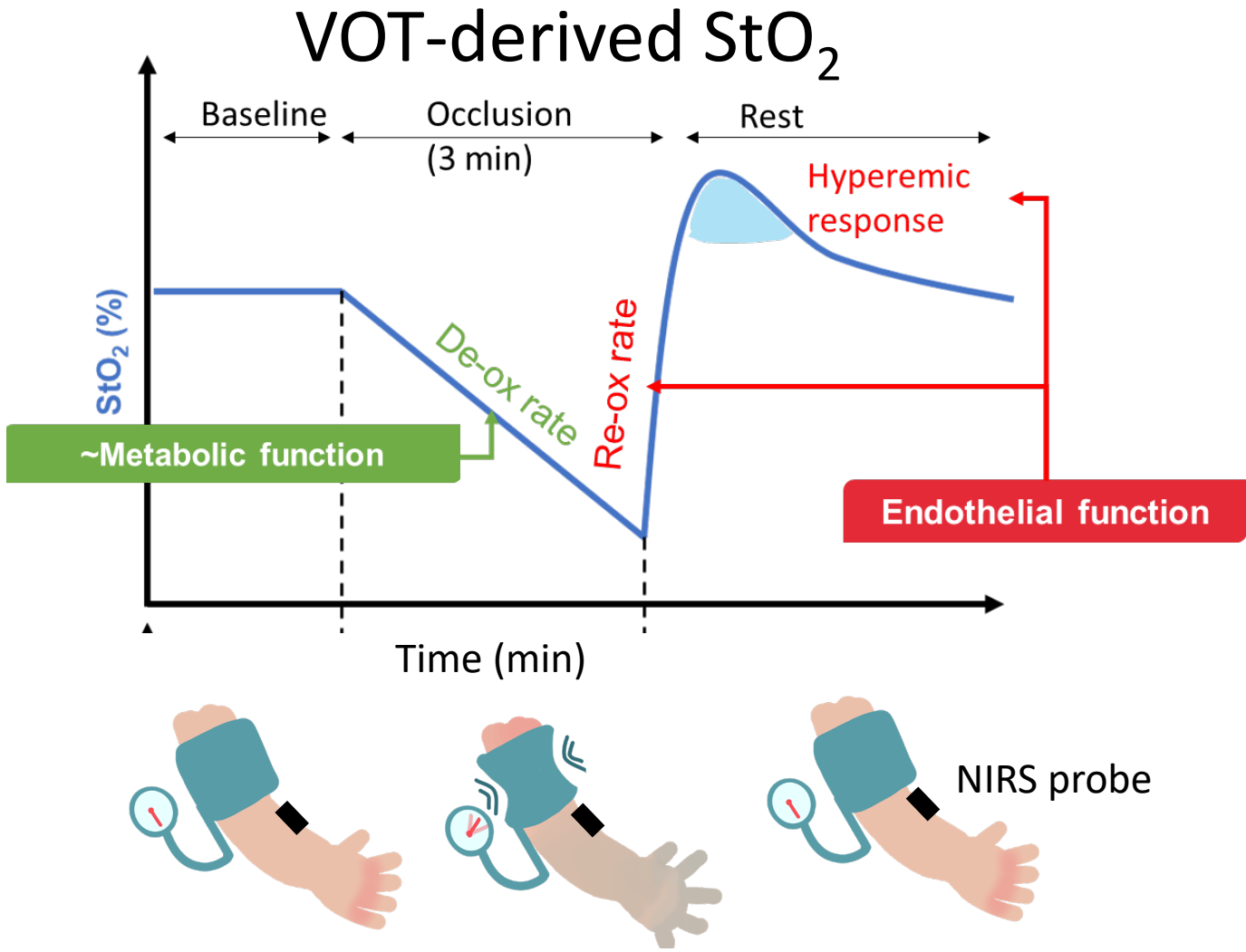


Vascular occlusion test (VOT) and NIRS

VASCOVID

- A vascular occlusion test is a localized ischemia of the muscle performed at a pressure higher than the systolic pressure in order to occlude the blood flow to the targeted area.

- The rate at which StO_2 decreases (de-ox rate, %/min) during the ischemia is related to the metabolism. Upon cuff release, the rate at which StO_2 increases and returns to baseline (re-ox rate,%/min and hyperemic response, %·min) is related to the blood vessels abilities to vasodilate and vasoconstrict (endothelial function)



Microvascular reactivity as measured by NIRS-StO_2 holds potential prognostic value

Potential prognostic values in the literature

Many studies show potential of near infrared spectroscopy in critical care

Monitoring global hemodynamic status in resusitation

- Early detection of tissue hypoperfusion
- Evaluation of persistence of tissue hypoperfusion found in mixed ICU patients, septic shock and trauma/hemorrhagic shock

Cardiovascular challenges: weaning from mechanical ventilation

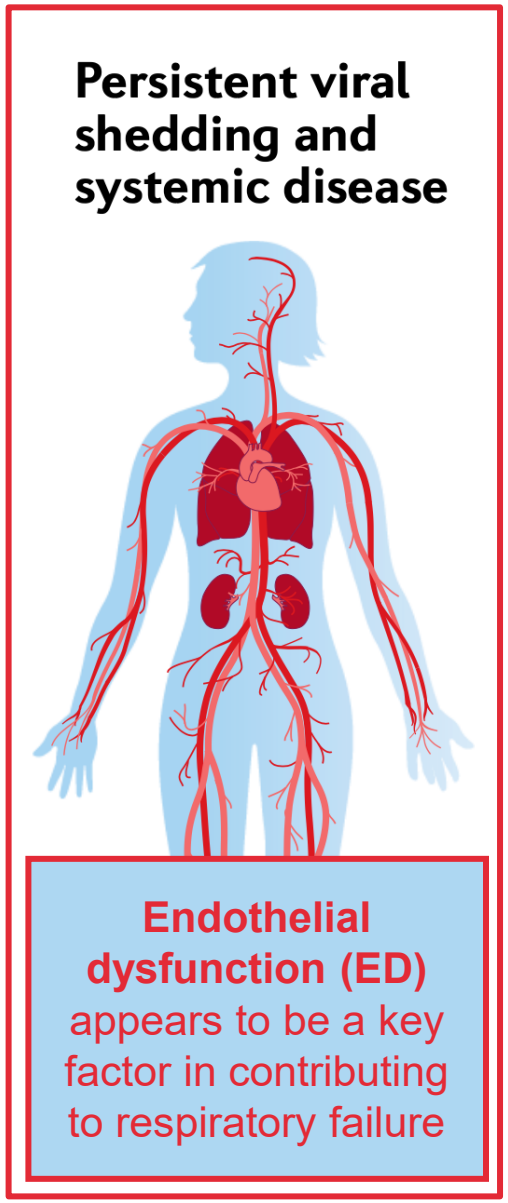
- Unmask poor cardiovascular performances

Endothelial function by monitoring microvascular reactivity

- COVID-19, acute respiratory distress syndrome (ARDS), septic and non-septic shock

VASCOVID

Severe COVID-19



Perico L et al. NatRevNephrol Vol. 17(1) pp: 46-64 (2021)

- COVID-19 is a systemic disease that affects the microvasculature, that involves the endothelium.
- According to the European Centre for Disease Prevention and Control, 16% of the people with COVID-19 were admitted to the intensive care and most of them received invasive mechanical ventilation.

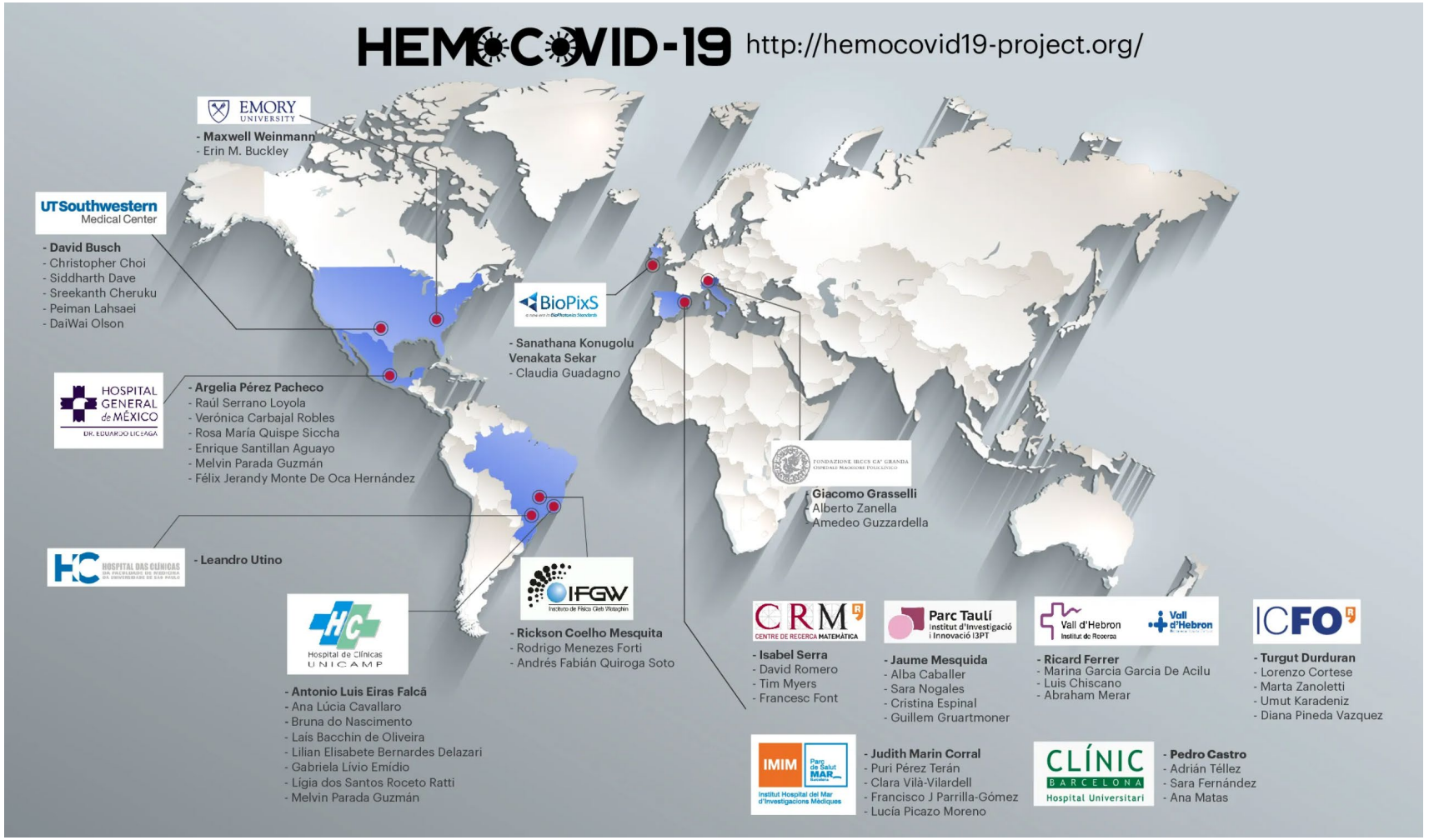
ISARIC, ECDC Europa (19/09/2022)

HEMOCOVID-19 project

VASCOVID

Adapting to the new realities during the COVID-19 lockdown

At the beginning of the pandemic, ICFO adapted 10 commercial NIRS devices and distributed to more than 10 hospitals from 6 participating countries. The aim of HEMOCOVID-19 consortium was to carry out a clinical research campaign aiming to characterize the microvascular health in patients admitted to the intensive care with acute respiratory distress syndrome.



Two clinical trials

- **Study 1 (NCT04689477)**
  Differences between COVID-19 and non-COVID-19 patients
- **Study 2 (NCT04692129)**
  Short-term effects of prone positioning on COVID-19 and non-COVID-19 patients

Highlight

COVID-19 → dysfunction.
Severity → differential.

Relationship to outcome?

HEMOCOVID-19: results

VASCOVID

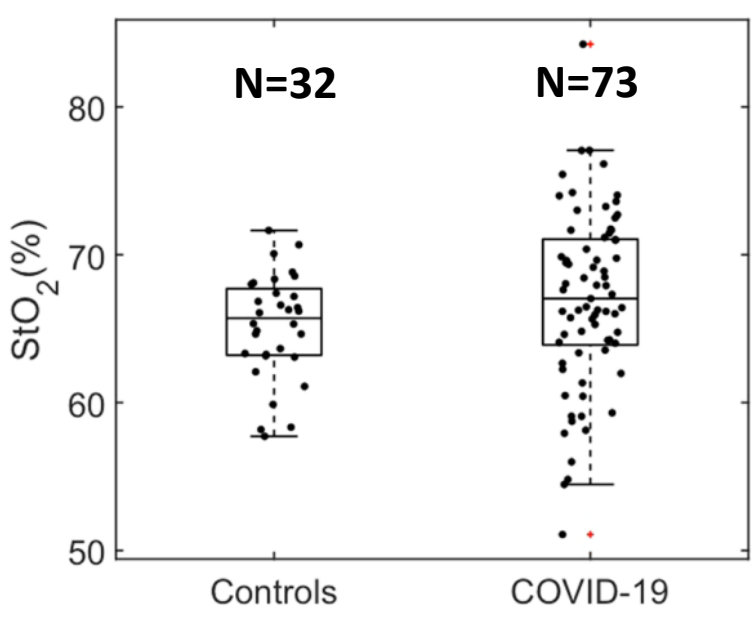
RESEARCH Open Access

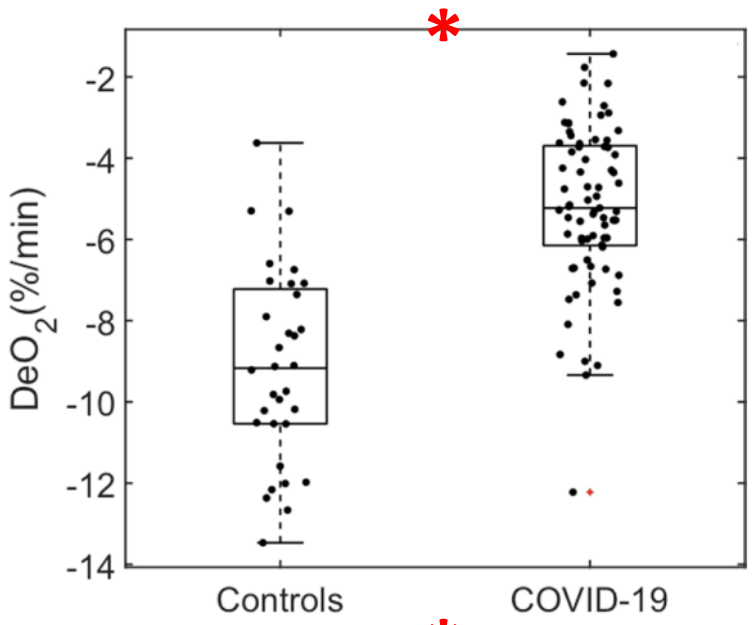
Peripheral microcirculatory alterations are associated with the severity of acute respiratory distress syndrome in COVID-19 patients admitted to intermediate respiratory and intensive care units

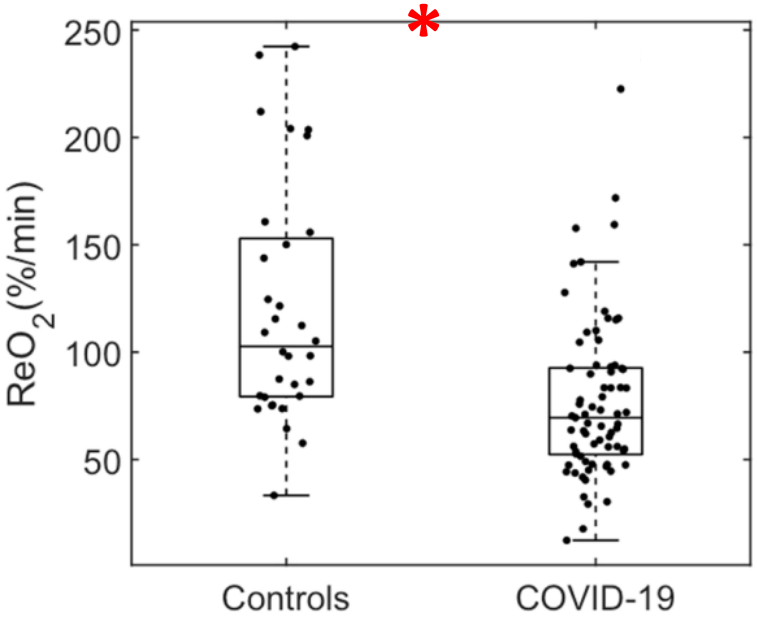
Jaume Mesquida[1*], A. Caballer[1], L. Cortese[2], C. Vila[3], U. Karadeniz[2], M. Pagliazzi[2], M. Zanoletti[2], A. Pérez Pacheco[4], P. Castro[5], M. García-de-Acilu[6], R. C. Mesquita[7], D. R. Busch[8] and T. Durduran[2,9] on behalf of the HEMOCOVID-19 Consortium

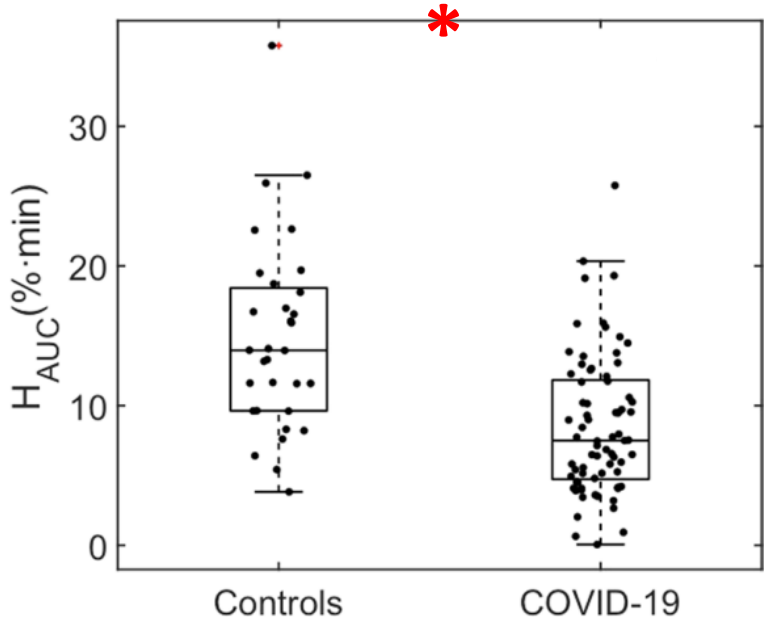
Mesquida J., Caballer A., Cortese L., et al. Critical Care Vol. 25 (1) pp. 1-10 (2021)

HEMOCOVID-19: results









COVID-19 patients:

- Consume less oxygen → Impaired metabolism
- Slower recovery and lower hyperemia → Impaired endothelial function

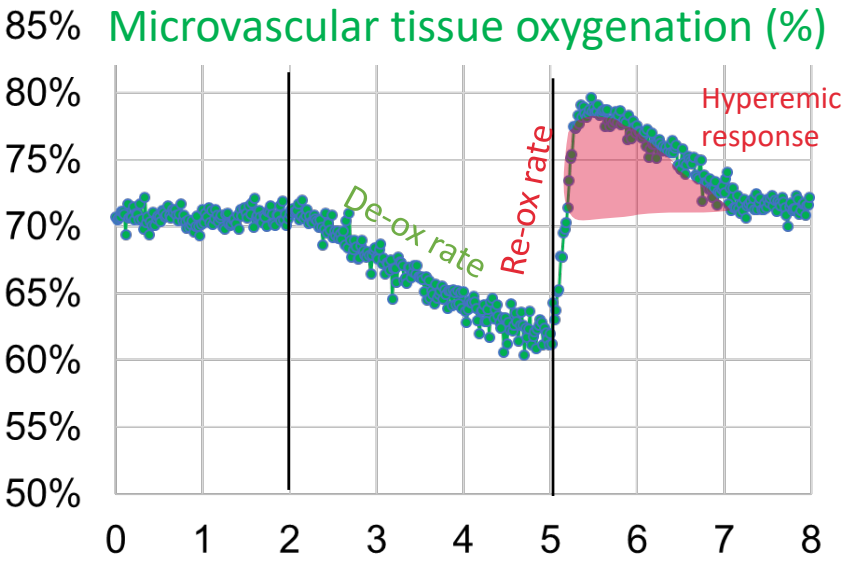
What are we missing?

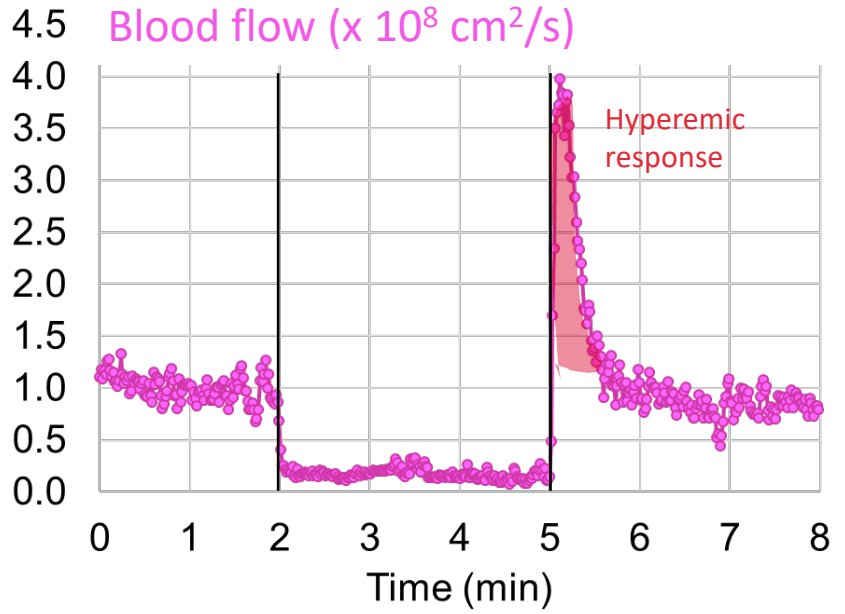
Most of the reasearch, in the intensive care unit, has been conducted with FDA approved or CE marked devices that are commercially available.
Shortcomings are associated with these research devices and studies such as:

- **Limited accuracy and precision** associated to high intersubject variability;
- **Lack of standardization** in the VOT protocol. Many studies utilizes different occlusion time and StO_2 threshold, making it difficult for appropriate comparison;
- **Tissue oxygen saturation** as the only measured parameter.

The VASCOVID project aims to develop a mobile biophotonics platform that will address the shortcomings of currently available NIRS methods

VASCOVID parameters





Microvasculature reactivity:

De-ox rate (%/min)

Re-ox rate (%/s)

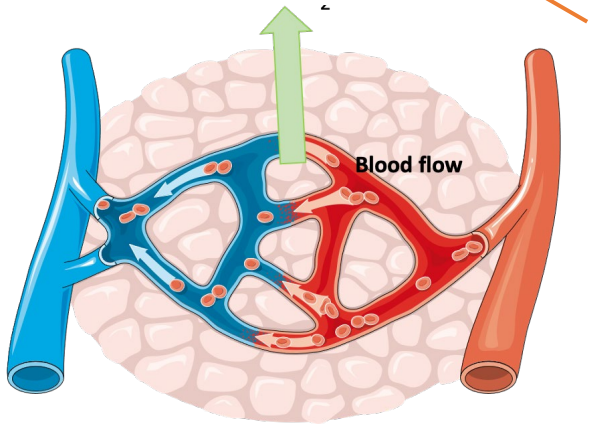
Hyperemic response for both tissue oxygenation and blood flow index (%min)

Baseline metabolism thanks to the simultaneous acquisition of TD-NIRS, DCS and pulse oximetry

Pulse-ox. Blood gas — TD-NIRS — DCS

$$MRO_2 = (SaO_2 - StO_2) / (Y\ SaO_2) \times BF$$

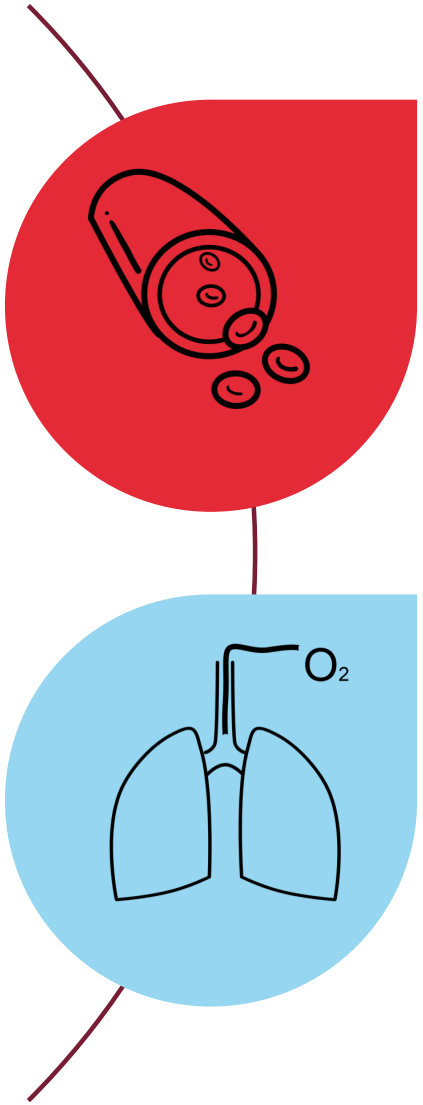
% blood volume in venous component



The Figure was partly generated using Servier Medical Art, provided by Servier, licensed under a Creative Commons Attribution 3.0 unported license

How can this alter the clinical practice?

Ehrmann, S. *et al.* Lancet Respir Med 2021
Thille A.W., et al. Am J Respir Crit Care Med 2013
Østergaard, L. Physiological reports, 2021



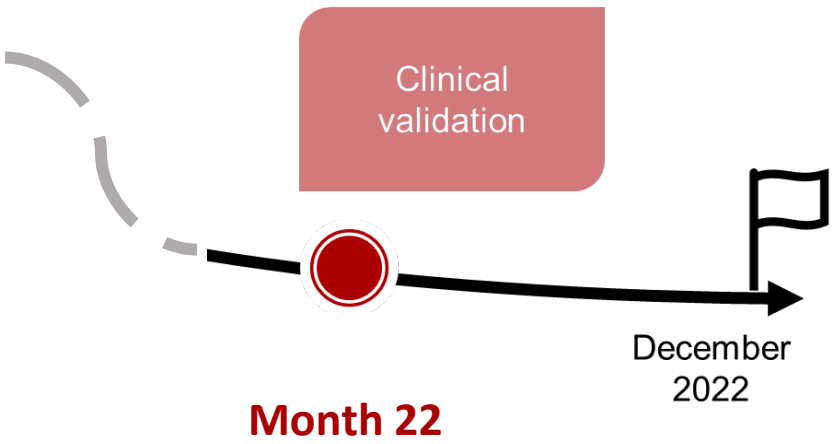
Stratification derived from endothelial function evaluation

The use of treatments targeting endothelial function might not be always beneficial because of the lack of appropriate selection of the patients.

Monitoring hemodynamics in rescue ventilatory strategies (prone positioning)

Predict the readiness to wean from mechanical ventilation (extubation failure occurs in 10-20% of the ICU cases)

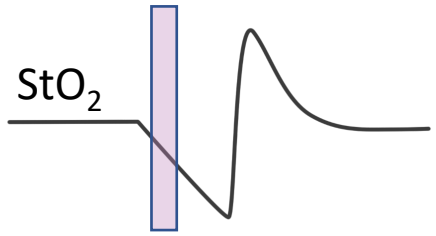
Where are we now?

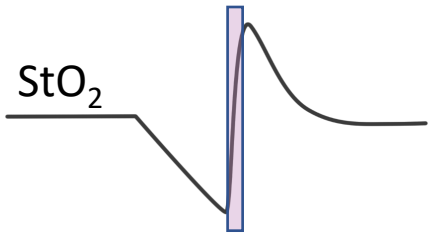


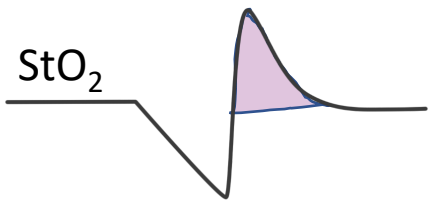
Our clinical partner (Hospital Universitari Parc Tauli, Sabadell, Spain) is now validating in the clinics the VASCOVID device. As per September 18th 2022, data have been collected from **22 healthy young subjects** and **40 patients** admitted to the intensive care. The latter includes mixed ICU population, septic and COVID-19 patients. Our goal is to validate the device in more than 100 patients.

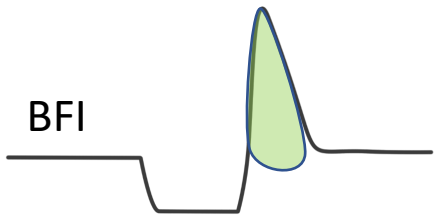
Preliminary data analysis

VASCOVID

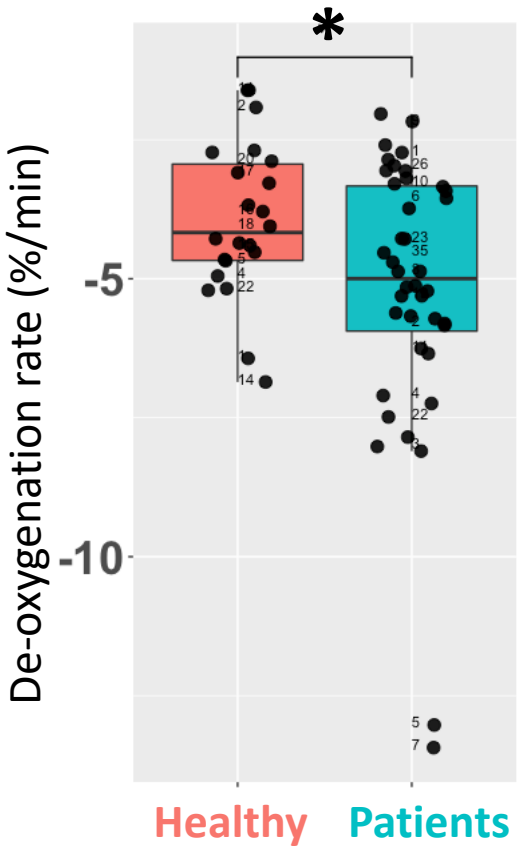


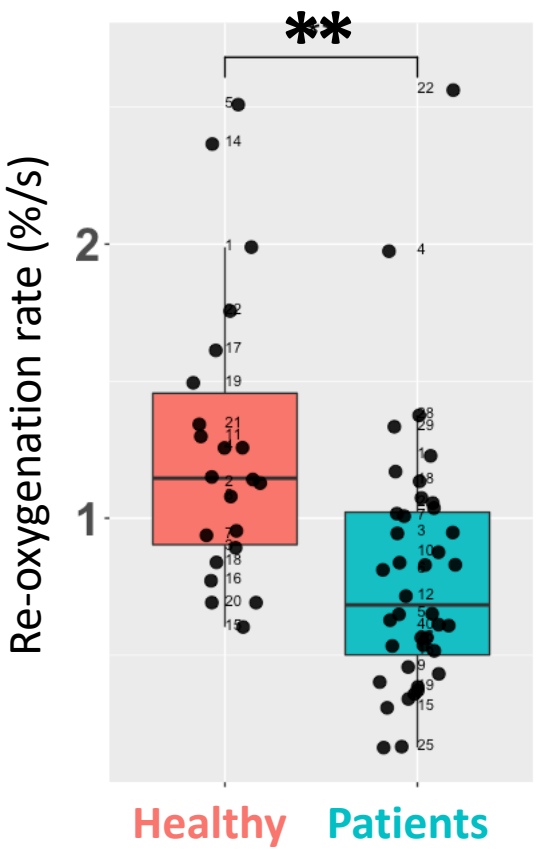


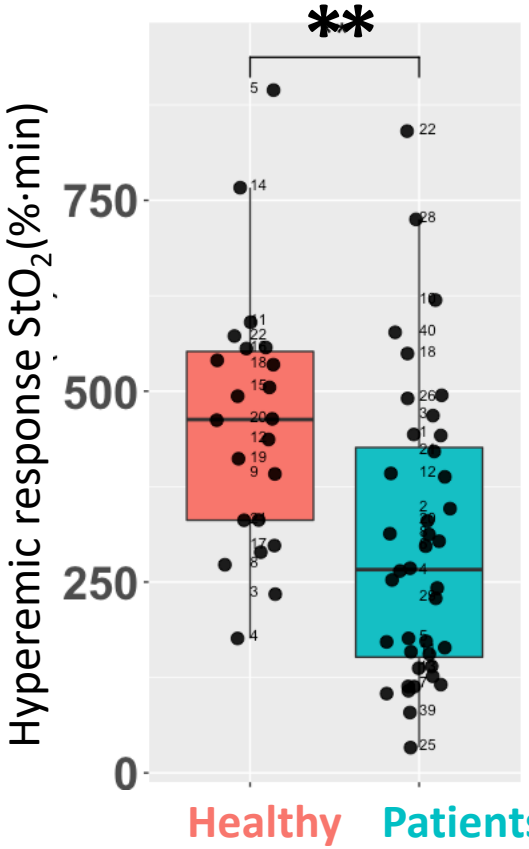


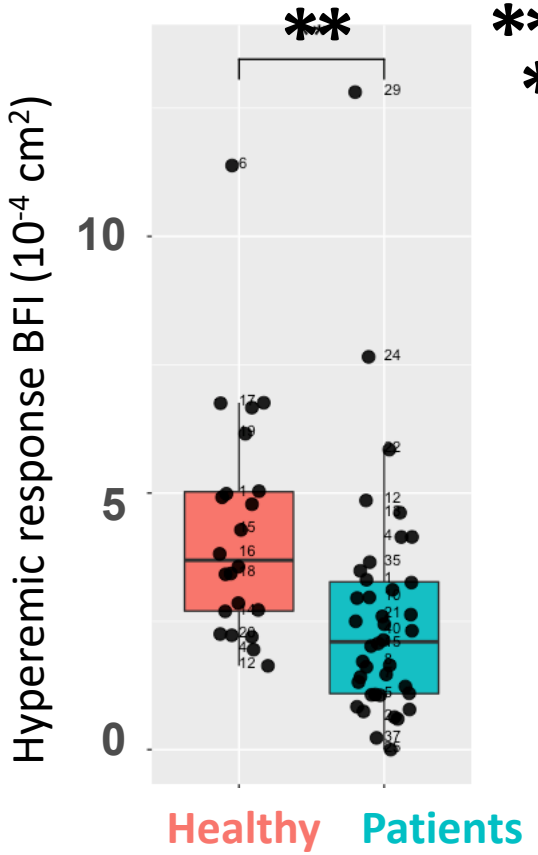


** p<0.001
* p<0.05







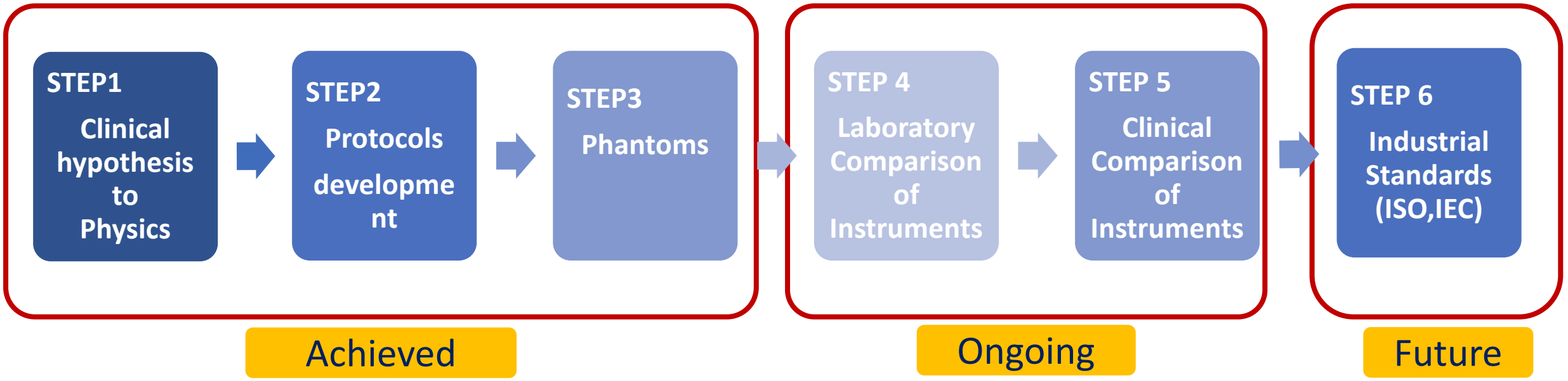


Preliminary analysis reports significant differences in the microvasculature reactivity between patients (N=40) and healthy subjects (N=22).

Beyond VASCOVID: standardization journey

Pifferi, A. Applied optics Vol. 44 (11) (2005)
Wabnitz, H. J. Biomed. Opt. Vol. 19 (8) (2014)

Lanka, P. J. Biomed. Opt. Vol. 27(7) (2022)



Standardization
Joint Working Group **"Oximeters"**
(ISO/TC 121/SC 3/JWG 10 - IEC/TC 62/SC 62D/JWG 5)

fNIRS (IEC 80601-2-71)
pulse oximetry (ISO 80601-2-61)
cerebral tissue oximetry (ISO 80601-2-85)

While for oximeters (NIRS based devices) standard protocols and phantoms have been already developed for the next steps towards their industrialization, protocols and phantoms suitable for standard comparison of diffuse correlation spectroscopy devices are still in their initial phase.


dream's