Bioingegneria, biotecnologia e tecnologie per la salute
Bioengineering

DII research group
Chemical Bioengineering

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This activity is carried out in collaboration with Dr Romeo Martini (Angiology Unit, Azienda Ospedaliera di Padova).

Main research topics:

- Innovative biomaterials: synthesis of bioactive peptides and covalent functionalization of surfaces.
- Synthesis of DNA mimeticsfor biosensors.
- Matrixes of self-assembling peptides chemoselectively modified for regenerative medicine.
- Biomechanical characterization of animal pericardium for prosthetic heart valves.
- Functional assessment and classification of mechanical heart valve prostheses.
- Analysis of skin perfusion by laser Doppler fluxymetry.

Wavelet transform analysis (WTA) of Laser Doppler signals to assess skin perfusion

The hemodynamics of skin microcirculation can be clinically assessed by means of Laser Doppler Fluxmetry. Laser Doppler signals show periodic oscillations because of fluctuations of microvascular perfusion (flowmotion), which are sustained by contractions and relaxations of arteriolar walls rhythmically changing vessels diameter. Wavelet Transform Analysis (WTA) applied to Laser Doppler signals displays six characteristic frequency intervals (FI) from 0.005 to 2 Hz. Each FI is assigned to a specific structure of the cardiovascular system (Table 1).

WTA is based on an oscillating function of limited duration called "mother wavelet", the shape thereof is chosen depending on signal features. The Morlet's wave was the most suitable to our purposes. To compare the contribution of vascular structures on skin perfusion, absolute amplitude (AA) and relative amplitude (RA), absolute power (AP) and relative power (RP) were calculated for each FI.

Peripheral arterial obstructive disease (PAOD) is a sign of atherosclerosis affecting lower limb. Intermittent claudication (IC) is one of the most frequent manifestations of PAOD. IC patients were studied before and after Post Occlusive Reactive Hyperemia (PORH). PORH was performed following three steps: rest (baseline), occlusion, and reactive hyperemia (Fig. 1). Examples of power spectra obtained by the application of WTA to original perfusion signals at rest and during reactive hyperemia are depicted in Fig. 2.

Significant differences are only detectable for respiration (FI II): RA decreases from 0.772 at rest to 0.598 during hyperemia (-23 %, p = 0.0431); RP decreases from 0.137 at rest to 0.062 during hyperemia (-55 %, p = 0.0492). The reactive hyperemia does not elicit any other structure of the cardiovascular system as compared to the baseline. When significant improvements in local endothelial, sympathetic and myogenic activities are not present, it is possible to hypothesize a primitive damage to microcirculation regardless macrocirculation impairment.

Table 1. Frequency intervals (FI) and vascular activities

FI	Frequency [Hz]	Activity
I	0.6-2.0	cardiac
II	0.145-0.6	respiratory
III	0.052-0.145	myogenic
IV	0.021-0.052	neurogenic
V	0.0095-0.021	endothelial (NO-dependent)
VI	0.005-0.0095	endothelial (NO-independent)

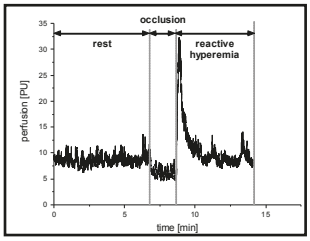

Fig. 1. A typical LDF signal acquired during PORH.

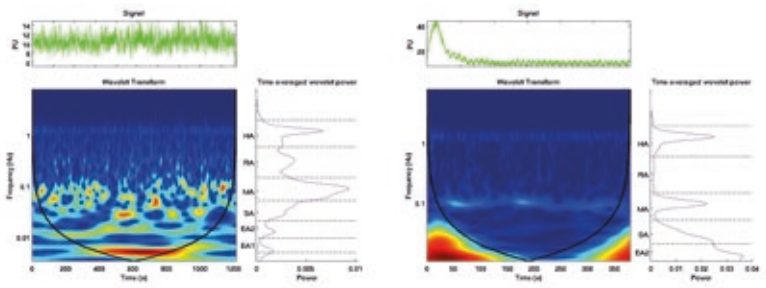

Fig. 2. Left: the original perfusion signal (baseline), the corresponding scalogram and the spectrum. Right: the original perfusion signal (hyperaemia), the corresponding scalogram and the spectrum.