

CLAIMS

What is claimed is:

1. A non-invasive vascular analysis (NIVA) system comprising:

at least one sensor, configured to acquire, for a time period from T_0 to T_2 , vascular signals from at least one peripheral vein, artery, or perfused tissue of a living subject, wherein the time period is divided into a first time period from T_0 to T_1 and a second time period from T_1 to T_2 , wherein the at least one sensor comprises a piezoelectric sensor, a resistive pressure/force sensor, a tonometer, an ultrasound sensor, a bioimpedance sensor, or a pressure transducer and is configured to acquire the vascular signals while positioned externally to the living subject; and

a processing device communicatively coupled to the at least one sensor, configured to receive the vascular signals transmitted from the at least one sensor, and perform a spectral analysis on the vascular signals, wherein the spectral analysis comprises the steps of:

processing the vascular signals acquired at the first time period to obtain a first peripheral vascular signal frequency spectrum;

obtaining a plurality of baseline peaks $\{B_{N-1}\}$ on the first peripheral vascular signal frequency spectrum, wherein N is a positive integer, and the plurality of baseline peaks $\{B_{N-1}\}$ respectively corresponds to a plurality of frequencies $\{F_0, F_1, \dots, F_N\}$, such that B_{N-1} is a function of F_{N-1} satisfying $B_{N-1} = B_{N-1}(F_{N-1})$, wherein F_N is greater than F_{N-1} ;

processing the vascular signals acquired at the second time period to obtain a second peripheral vascular signal frequency spectrum;

obtaining a plurality of peaks $\{P_{N-1}\}$ on the second peripheral vascular signal frequency spectrum, wherein the plurality of peaks $\{P_{N-1}\}$ correspond to the plurality of frequencies $\{F_0, F_1, \dots, F_N\}$, such that P_{N-1} is a function of F_{N-1} satisfying $P_{N-1} = P_{N-1}(F_{N-1})$; and

determining whether hypovolemia or hypervolemia is present within the living subject by determining whether at least one amplitude of the peaks $\{P_{N-1}\}$ differs by more than a threshold amount when compared to a corresponding amplitude of the baseline peaks $\{B_{N-1}\}$.

2. The system of claim 1, wherein the vascular signals are processed by a spectral fast

Fourier transform (FFT) analysis to obtain the first peripheral vascular signal frequency spectrum and the second peripheral vascular signal frequency spectrum.

3. The system of claim 1, wherein the at least one sensor and the processing device form a non-invasive device, wherein the non-invasive device is a wearable band, an adhesive, or an attachment being in contact with a surface of skin of the living subject overlying the at least one peripheral vein, artery or perfused tissue.
4. The system of claim 3, wherein the processing device comprises:
 - a processor configured to receive the vascular signals transmitted from the at least one sensor, wherein the at least one sensor and the processor form the non-invasive device; and
 - a monitoring device configured to communicate with the processor to receive the vascular signals, and to perform the spectral analysis for monitoring a condition of the living subject.
5. The system of claim 4, wherein the monitoring device is further configured to display results of the spectral analysis on the non-invasive device.
6. The system of claim 4, wherein the monitoring device is configured to communicate with the processor via a wireless protocol, and is a smartphone, a tablet computing device, a laptop computing device, a desktop computing device, or any combination thereof.

7. The system of claim 1, wherein:

the plurality of peaks $\{P_{N-1}\}$ comprises a first peak P_0 corresponding to a first frequency F_0 , a second peak P_1 corresponding to a second frequency F_1 , a third peak P_2 corresponding to a third frequency F_2 and a fourth peak P_3 corresponding to a fourth frequency F_3 ;

the first peak P_0 corresponding to the first frequency F_0 is associated with a respiratory rate of the living subject;

the second peak P_1 corresponding to the second frequency F_1 is associated with a heart rate of the living subject; and

the third peak P_2 corresponding to the third frequency F_2 and the fourth peak P_3 corresponding to the fourth frequency F_3 are associated with harmonics of the living subject.