## CLAIMS

What is claimed is:

1. A peripheral intravenous (IV) waveform analysis (PIVA) system, comprising:

a peripheral IV device configured to acquire, from a vein of a living subject, peripheral venous signals; and

an processing device communicatively connected to the peripheral IV device, configured to:

receive the peripheral venous signals from the peripheral IV device;

perform a spectral analysis on the peripheral venous signal to obtain a peripheral venous pressure frequency spectrum; and

perform a statistical analysis on amplitudes of peaks of the peripheral venous pressure frequency spectrum to determine an intravascular volume status of the living subject in real time.

2. The PIVA system of claim 1, wherein:

the intravascular volume status of the living subject indicates hypovolemia when amplitude decreases greater than a first threshold are detected from the peaks of the peripheral venous pressure frequency spectrum; and

the intravascular volume status of the living subject indicates hypervolemia when amplitude increases greater than a second threshold are detected from the peaks of the peripheral venous pressure frequency spectrum.

3. The PIVA system of claim 1, being applied to the living subject during ultrafiltration/dialysis or diuresis of the living subject, wherein the processing device is further configured to:

generate an alert message when the intravascular volume status of the living subject indicates hypovolemia.

4. The PIVA system of claim 1, being applied to the living subject during resuscitation of the living subject, wherein:

the intravascular volume status of the living subject indicates a return of euvolemia from a hypovolemic state when the living subject is determined to be in the

hypovolemic state at an earlier time period, and amplitude increases greater than a third threshold are detected from the peaks of the peripheral venous pressure frequency spectrum; and

the intravascular volume status of the living subject indicates over-resuscitation when the living subject is determined to be in an euvolemic state at the earlier time period, and amplitude increases greater than a fourth threshold are detected from the peaks of the peripheral venous pressure frequency spectrum.

5. The PIVA system of claim 4, wherein the processing device is further configured to:

detect efficacy of treatment and the return to euvolemia in the living subject based on the intravascular volume status of the living subject.

6. The PIVA system of claim 1, wherein the processing device is communicatively connected to the peripheral IV device through a wireless connection.

7. The PIVA system of claim 1, wherein the peripheral IV device comprises:

a peripheral IV catheter being inserted into the vein of the living subject; and

a monitoring device connected to the peripheral IV catheter, configured to capture and record the peripheral venous signals from the peripheral IV catheter at a sampling rate.

8. The PIVA system of claim 7, wherein the monitoring device comprises a pressure transducer directly connected to the peripheral IV catheter, wherein the peripheral venous signals are captured and recorded by the pressure transducer.

9. The PIVA system of claim 1, wherein the processing device is a computing device.

10. The PIVA system of claim 1, wherein the spectral analysis is a spectral fast Fourier transform (FFT) analysis, wherein the statistical analysis comprises:

obtaining a plurality of baseline peaks $\{B_{N-1}\}$ on a baseline peripheral venous pressure frequency spectrum, wherein N is a positive integer, and the plurality of baseline peaks $\{B_{N-1}\}$ respectively corresponds to a plurality of frequencies $\{F_0, F_1,$

. . . , $F_N$}, 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 $F_{N-1}$;

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

determining the intravascular volume status of the living subject in real time by comparing the amplitudes of the peaks {$P_{N-1}$} to that of the baseline peaks {$B_{N-1}$} respectively.

11. The PIVA system of claim 10, wherein the baseline peripheral venous pressure frequency spectrum is obtained by:

acquiring, by the peripheral IV monitoring device, the peripheral venous signals from the vein of the living subject at an earlier time period; and

processing the peripheral venous signals acquired at the earlier time period by the spectral FFT analysis to obtain the baseline peripheral venous pressure frequency spectrum.

12. The PIVA system of claim 10, wherein:

the plurality of peaks {$P_{N-1}$} comprises a first peak $P_0$ corresponding to a first frequency $F_0$ and a second peak $P_1$ corresponding to a second frequency $F_1$;

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

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

13. The PIVA system of claim 1, further comprises:

a pump connected to the living subject to perform liquid exchange to the living subject; and

a pump controlling mechanism communicatively connected to the processing device, configured to control the pump by intermittently pausing the pump or subtract the pump signal when the peripheral IV device acquires the peripheral venous signals,

and restarting the pump when the peripheral IV device does not acquire the peripheral venous signals;

wherein the processing device is further configured to send a signal to the pump controlling mechanism to notify the pump controlling mechanism to control the pump.

14. The PIVA system of claim 13, wherein the pump is a dialysis pump, a cardiopulmonary bypass pump, an extracorporeal membrane oxygenation (ECMO), or an infusion pump.