CLAIMS

The invention is claimed as follows:

1. A blood volume evaluation system for monitoring a patient using a measurement associated with a peripheral venous pressure (PVP) within a peripheral vein of a circulatory system of the patient, comprising:

a PVP sensor including a transducer disposed adjacent to or connected to an intravenous (IV) tube in fluid connection with the peripheral vein and configured to generate an electronic signal associated with the PVP; and

an evaluation unit, including a computer processor communicatively connected to the PVP sensor to receive the electronic signal and a memory storing non-transitory computer-readable instructions that, when executed by the computer processor, cause the evaluation unit to:

obtain a time-domain PVP signal, including a plurality of values of the electronic signal over a sample period;

apply a transformation to the time-domain PVP signal to generate a frequency-domain PVP signal;

identify a plurality of frequencies associated with local maxima of the frequency-domain PVP signal, including a heart rate frequency (F_1) and a harmonic frequency (F_H) at a harmonic of the heart rate frequency (F_1), such that the harmonic frequency (F_H) is different from the heart rate frequency (F_1); and

calculate a blood volume metric based at least in part upon the heart rate frequency (F_1) and the harmonic frequency (F_H).

2. The blood volume evaluation system of claim 1, wherein the blood volume metric is an indication of one of the following: hypovolemia, hypervolemia, or euvolemia.

3. The blood volume evaluation system of claim 1, further comprising:

the IV tube, wherein the IV tube is in fluid connection with the peripheral vein by a venous access device, the venous access device including a terminal end that is inserted at an access point into the peripheral vein of the circulatory system of the patient and a connecting end that connects to a primary portion of the IV tube; and

a fluid source in fluid connection with the primary portion of the IV tube to provide fluid to the circulatory system of the patient via the venous access device.

4. The blood volume evaluation system of claim 3, wherein the instructions further cause the evaluation unit to:

control a rate of flow of the fluid from the fluid source based upon the blood volume metric; or

administer a vasopressor or vasodilator drug to the patient from the fluid source.

5. The blood volume evaluation system of claim 4, wherein:

the fluid source includes or is in fluid connection with a pump; and

the evaluation unit controls the rate of flow of the fluid from the fluid source by adjusting operation of the pump.

6. The blood volume evaluation system of claim 3, wherein the venous access device is a catheter.

7. The blood volume evaluation system of claim 1, wherein the transducer is disposed within a portion of a venous access device inserted within the peripheral vein, the venous access device being a part of or connected to the IV tube.

8. The blood volume evaluation system of claim 1, further comprising an alarm unit configured to present alarms to a user, and wherein the instructions further cause the evaluation unit to communicate an alarm indicator to a presentation unit when the blood volume metric indicates the blood volume of the patient is abnormal, the alarm indicator causing the presentation unit to present an alarm.

9. The blood volume evaluation system of claim 8, wherein the alarm includes a recommendation of an action to be taken in response to the determined blood volume metric.

10. The blood volume evaluation system of claim 1, wherein the frequencies are determined by identification of the local maxima of the frequency-domain PVP signal.

11. The blood volume evaluation system of claim 1, wherein the electronic signal is an electronic pressure signal indicative of pressure within the IV tube.

12. The blood volume evaluation system of claim 11, wherein:

the transducer of the PVP sensor is a pressure sensor and is disposed in fluid connection with the interior of the IV tube; and

the interior of the IV tube is in fluid connection with the circulatory system of the patient via the peripheral vein.

13. The blood volume evaluation system of claim 1, wherein obtaining the time-domain PVP signal includes receiving and storing the plurality of values of the electronic signal over the sample period.

14. The blood volume evaluation system of claim 1, wherein obtaining the time-domain PVP signal includes: receiving the electronic signal as an analog signal, sampling the plurality of values of the electronic signal periodically during the sample period, and storing the plurality of values of the electronic signal over the sample period.

15. The blood volume evaluation system of claim 1, wherein the sample period is a fixed duration that is continuously updated on a rolling basis as new values of the electronic signal are obtained.

16. The blood volume evaluation system of claim 1, wherein the transformation is a fast Fourier transformation.

17. The blood volume evaluation system of claim 1, wherein the harmonic frequency (F_H) is a first harmonic frequency (F_2) identified as the frequency associated with a local maximum of the frequency-domain PVP signal nearest to a frequency that is twice the heart rate frequency (F_1).

18. The blood volume evaluation system of claim 17, wherein the first harmonic frequency (F_2) is within a frequency band centered on the frequency that is twice the heart rate frequency (F_1) with a band width of twenty percent of the heart rate frequency (F_1).

19. The blood volume evaluation system of claim 18, wherein the first harmonic frequency (F_2) is identified using a bandpass filter using the frequency band.

20. The blood volume evaluation system of claim 1, wherein the frequencies further include one or more additional harmonic frequencies associated with additional harmonics of the heart rate frequency (F_1).

21. The blood volume evaluation system of claim 20, wherein the one or more additional harmonic frequencies are identified as frequencies associated with the local maxima of the frequency-domain PVP signal nearest to integer multiples of the heart rate frequency (F_1).

22. The blood volume evaluation system of claim 20, wherein the blood volume metric is further determined at least in part based upon at least one of the one or more additional harmonic frequencies.

23. The blood volume evaluation system of claim 22, wherein the blood volume metric is determined based at least in part upon a harmonics ratio between the harmonic frequency (F_H) and the at least one of the additional harmonic frequencies.

24. The blood volume evaluation system of claim 1, wherein the blood volume metric is determined based at least in part upon a harmonic ratio between the heart rate frequency (F_1) and the harmonic frequency (F_H).

25. The blood volume evaluation system of claim 1, wherein the blood volume metric is determined based at least in part upon a change in the harmonic frequency (F_H).

26. The blood volume evaluation system of claim 1, wherein the blood volume metric is determined based at least in part upon an increase or decrease in a magnitude of the frequency-domain PVP signal associated with the harmonic frequency (F_H).

27. The blood volume evaluation system of claim 26, wherein the blood volume metric is determined based at least in part upon the increase or decrease in the magnitude beyond a predetermined threshold associated with a baseline magnitude for the harmonic frequency (F_H).

28. The blood volume evaluation system of claim 27, wherein the baseline magnitude is determined by the evaluation unit based upon previously obtained pressure measurements from the PVP sensor at a time period preceding the sample period.

29. The blood volume evaluation system of claim 1, wherein the sample period is a fixed duration that is periodically updated by obtaining new values of the electronic signal.