We claim:

1. A method ~~of determining the cardiac output of a heart,~~ comprising:

~~applying hemodynamic support to the heart via a blood pump, the hemodynamic support comprising pumping blood at a first pumping rate during a plurality of beats of the heart, each beat including a systolic rise, a dicrotic notch, and a diastolic fall that occurs after the dicrotic notch;~~

~~detecting~~ measuring, with a sensor, a first aortic pressure ~~measurement~~ at a first time and a second aortic pressure ~~measurement~~ at a second time, wherein the first time and the second time occur during ~~the~~ a diastolic fall of a specific beat ~~of the~~ within a plurality of beats of a heart, and wherein the diastolic fall occurs after a dicrotic notch of the specific beat;

determining, with one or more processors, a first rate of blood flow pumped by ~~the~~ a blood pump at the first time and a second rate of blood flow pumped by the blood pump at the second time; and

determining, with the one or more processors, a cardiac output of the specific beat based on the first aortic pressure measurement, the second aortic pressure measurement, the first rate of blood flow, and the second rate of blood flow.

2. The method of claim 1, ~~further comprising~~ wherein determining the cardiac output of the specific beat comprises:

~~calculating,~~ obtaining, with the one or more processors, using the first aortic pressure measurement, the second aortic pressure measurement, the first rate of blood flow, and the second rate of blood flow, a time dependent non-linear model of ~~the~~ a vascular system to determine systemic vascular resistance and compliance; and

determining, with the one or more processors, the cardiac output ~~during~~ of the specific beat based on the determined systemic vascular resistance and compliance.

3. The method of claim 2, wherein the time dependent non-linear model is a Windkessel model.

4. The method of claim 2, wherein the systemic vascular resistance and compliance are indicative of resistance and compliance of ~~the~~ an aorta.

5. The method of claim 4, wherein determining the cardiac output of the specific beat further comprises taking, with the one or more processors, an average of total cardiac flow over a period of time.

6. The method of claim 5, wherein the period of time is a length of the specific beat.

7. The method of claim 2, further comprising determining, with the one or more processors, a first plurality of cardiac output values, wherein each cardiac output value of the first plurality of cardiac output values corresponds to a respective beat of a first set of beats within the plurality of beats.

~~4~~8. The method of claim ~~2~~7, further comprising determining, with the one or more processors, a first cumulative indicator of cardiac output of the heart based on the first plurality of cardiac output values.

~~5. The method of claim 4, wherein determining cardiac output includes: determining a first plurality of cardiac output values, wherein each cardiac output value of the first plurality of cardiac output values corresponds to a respective beat of a first set of beats within the plurality of beats.~~

~~6~~9. The method of claim ~~5~~8, further comprising:

comparing, with the one or more processors, a first cardiac output value to a second cardiac output value, wherein the first plurality of cardiac output values comprises the first and second cardiac output values; and

determining, with the one or more processors, based on the comparison between the first cardiac output value and the second cardiac output value, a change in cardiac performance of the heart~~; and~~

~~altering the hemodynamic support to the patient based on the determined change of cardiac performance of the heart over time~~.

~~7~~10. The method of claim ~~5~~8, ~~further comprising~~ wherein determining the first cumulative indicator of cardiac output of the heart comprises applying, with the one or more processors, at least one of a summation, average, or linear regression on the ~~determined~~ first plurality of cardiac output values ~~to calculate a first cumulative indicator of cardiac output of the heart~~.

~~8. The method of claim 7, wherein the first cumulative indicator of cardiac output of the heart is indicative of cardiac performance of the heart.~~

~~9~~11. The method of claim ~~8~~10, further comprising:

determining, with the one or more processors, a second cumulative indicator of cardiac output of the heart for a second set of beats within the plurality of beats, wherein the second set of beats occurs after the first set of beats;

comparing, with the one or more processors, the first cumulative indicator of cardiac output to the second cumulative indicator of cardiac output; and

determining, with the one or more processors, based on the comparison between the first cumulative indicator and the second cumulative indicator, (i) an increase in cardiac performance of the heart or (ii) a decrease in cardiac performance of the heart~~; and~~

~~altering the hemodynamic support to the patient based on the determined increase or decrease of cardiac performance of the heart over time~~.

~~10~~12. The method of claim ~~9~~11, wherein determining the second cumulative indicator comprises:

determining, with the one or more processors, a second plurality of cardiac output values, wherein each cardiac output value of the second plurality of cardiac output values corresponds to a respective beat of the second set of beats; and

applying, with the one or more processors, at least one of a summation, average, or linear regression on the ~~determined~~ second plurality of cardiac output values to calculate the second cumulative indicator of cardiac output of the heart.

~~11~~13. The method of claim ~~6~~1, wherein determining the cardiac output of the specific beat comprises:

~~detecting~~ measuring, with the sensor, a plurality of aortic ~~pressure measurements~~ pressures at a plurality of different times during the diastolic fall of the specific beat, wherein each aortic pressure measurement of the plurality of aortic pressure measurements corresponds to a time of the plurality of different times, and wherein the plurality of aortic pressure measurements includes the first aortic pressure measurement and the second aortic pressure measurement;

determining, with the one or more processors, a plurality of rates of blood flow pumped by the blood pump at the plurality of different times, wherein the plurality of rates of blood flow includes the first rate of blood flow and the second rate of blood flow;

~~calculating,~~ obtaining, with the one or more processors, using the plurality of aortic pressure measurements and the plurality of rates of blood flow, a plurality of time dependent non-linear models of ~~the~~ a vascular system to determine a plurality of systemic vascular resistance and compliance values;

determining, with the one or more processors, a plurality of cardiac output values ~~during the specific beat~~ based on the determined plurality of systemic vascular resistance and compliance values; and

applying, with the one or more processors, at least one of a summation, average, or linear regression to the determined plurality of cardiac output values to calculate the cardiac output of the specific ~~heart~~beat.

~~12~~14. The method of claim ~~11~~13, further comprising:

determining, with the one or more processors, a ~~second cumulative indicator of~~ cardiac output of ~~the heart for~~ a second ~~heart~~beat within the plurality of beats, wherein the second ~~heart~~beat occurs after the specific ~~heart~~beat;

comparing, with the one or more processors, the ~~first cumulative indicator of~~ cardiac output of the specific beat to the ~~second cumulative indicator of~~ cardiac output of the second beat; and

determining, with the one or more processors, based on the comparison between the ~~first cumulative indicator~~ cardiac output of the specific beat and the ~~second cumulative indicator~~ cardiac output of the second beat, (i) an increase in cardiac performance of the heart or (ii) a decrease in cardiac performance of the heart~~; and~~

~~altering the hemodynamic support applied based on determining whether cardiac performance of the heart is increasing or decreasing over time~~.

~~13.~~ 15. The method of claim ~~12~~ 14, wherein ~~hemodynamic support is provided by~~ the blood pump is an intracardiac blood pump that has a cannula configured to be positioned within a ventricle of the heart.

~~14.~~ 16. The method of claim ~~13~~ 15, wherein the cannula is configured to be positioned within a left ventricle.

~~15.~~ 17. The method of claim ~~13~~ 15, wherein the sensor is a pressure sensor that is provided with the intracardiac blood pump~~, and wherein detecting the plurality of aortic pressure measurements comprises measuring the aortic pressure via the pressure sensor~~.

~~16.~~ 18. The method of claim ~~15~~ 17, wherein the pressure sensor is positioned within a housing of the blood pump.

~~17.~~ 19. The method of claim ~~13~~ 15, wherein ~~detecting the plurality of aortic pressure measurements comprises receiving the aortic pressure measurements from~~ the sensor is a pressure sensor that is separate from the intracardiac blood pump.

~~18. The method of claim 13, wherein operation of the intracardiac blood pump is adjusted by a controller, and wherein the controller comprises a memory storing the time dependent non-linear model of the vascular system.~~

~~19. The method of claim 1, further comprising adjusting the hemodynamic support applied to the heart based on the determined cardiac output.~~

20. The method of claim ~~19~~ 1, further comprising ~~configuring~~ displaying, with a display, the ~~determined~~ cardiac output ~~for display~~ of the specific beat.

~~21. The method of claim 20, wherein the systemic vascular resistance and compliance are indicative of resistance and compliance of the aorta.~~

~~22. The method of claim 21, wherein determining cardiac output comprises taking an average of total cardiac flow over a period of time.~~

~~23. The method of claim 22, wherein the period of time is the length of the specific beat.~~