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(2006.01)

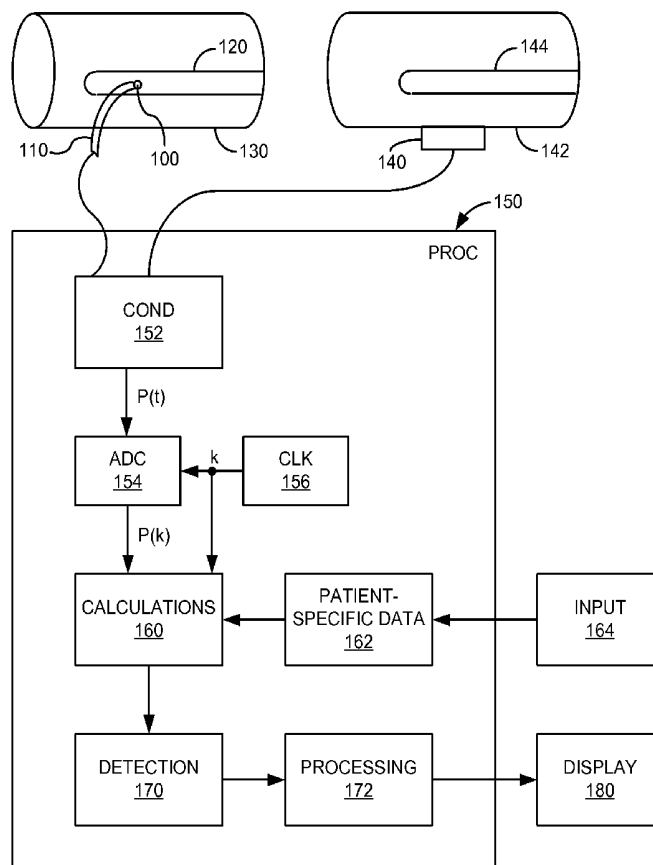


FIG. 1

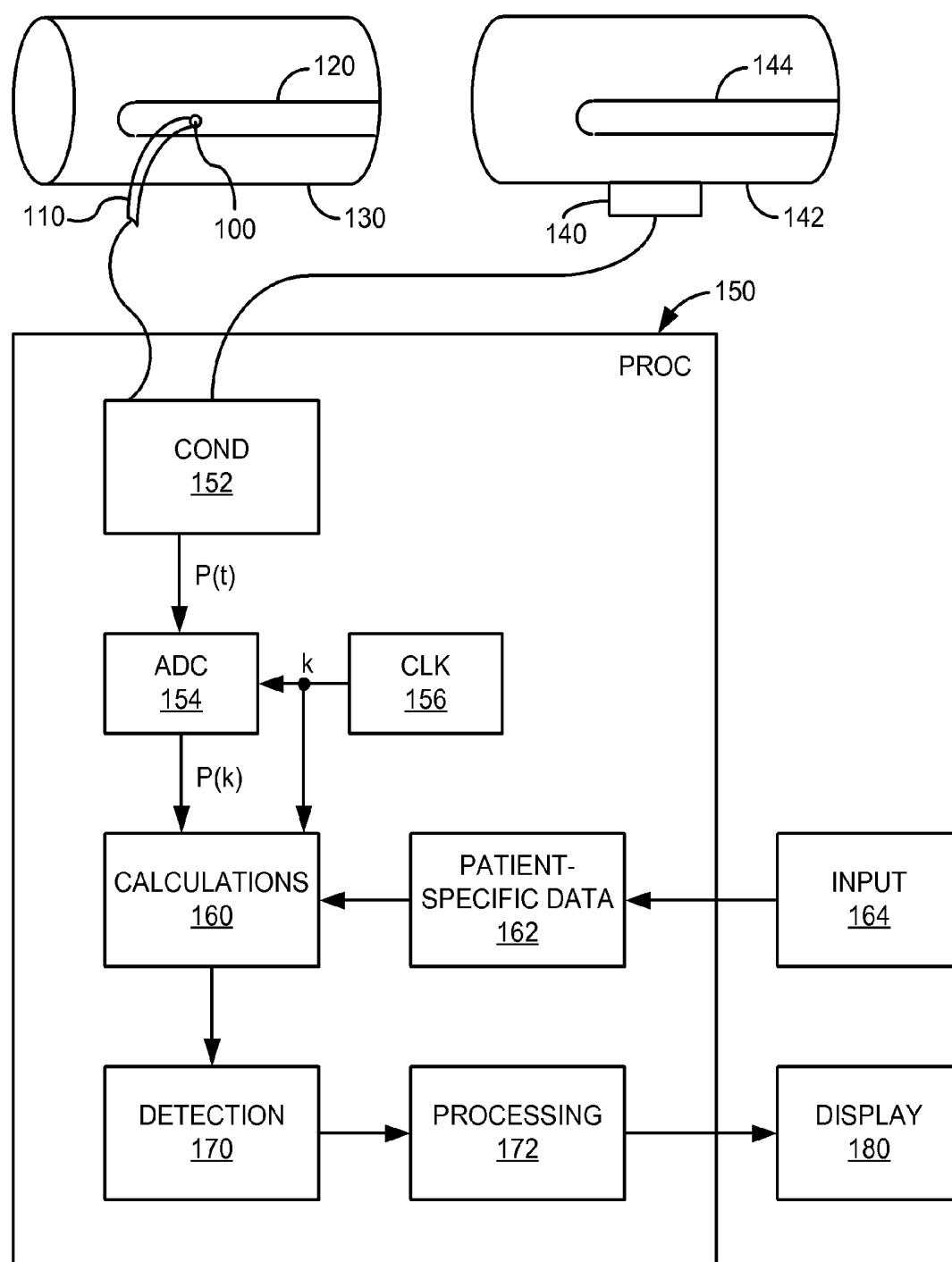


FIG. 2

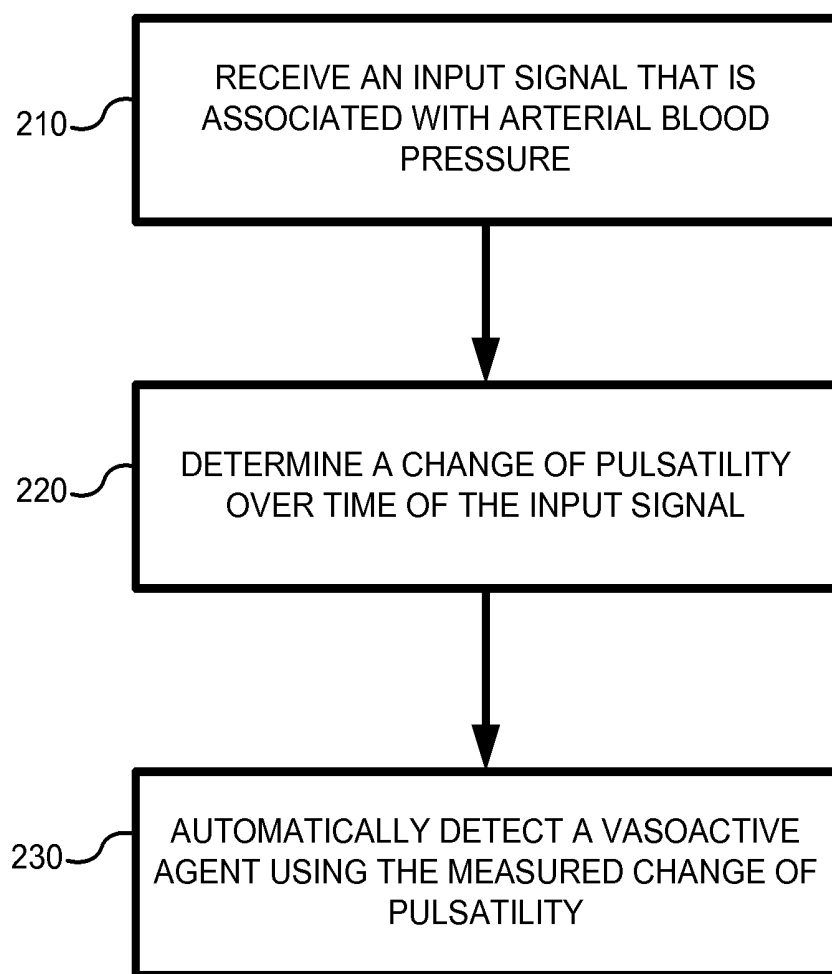


FIG. 3

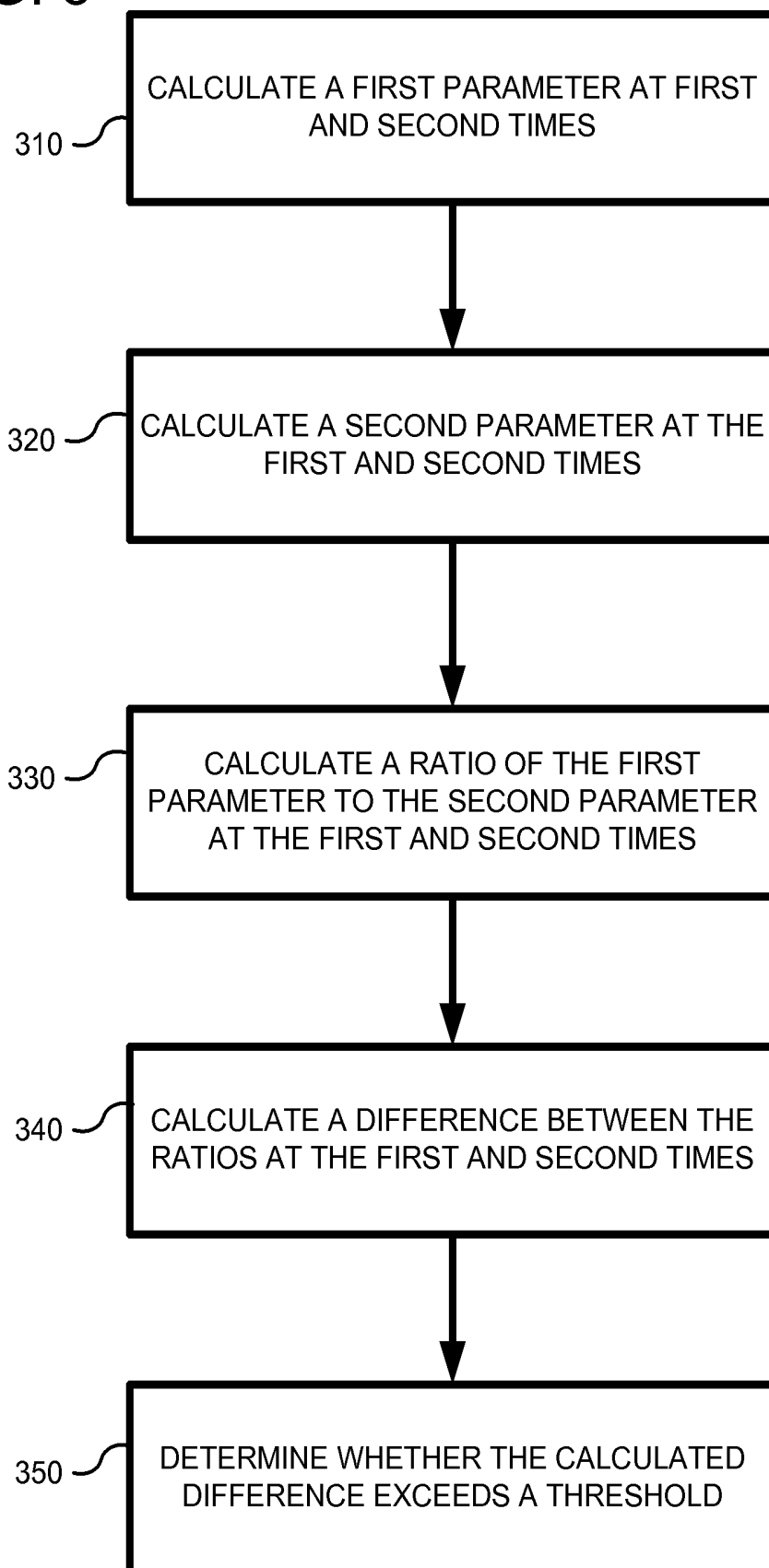
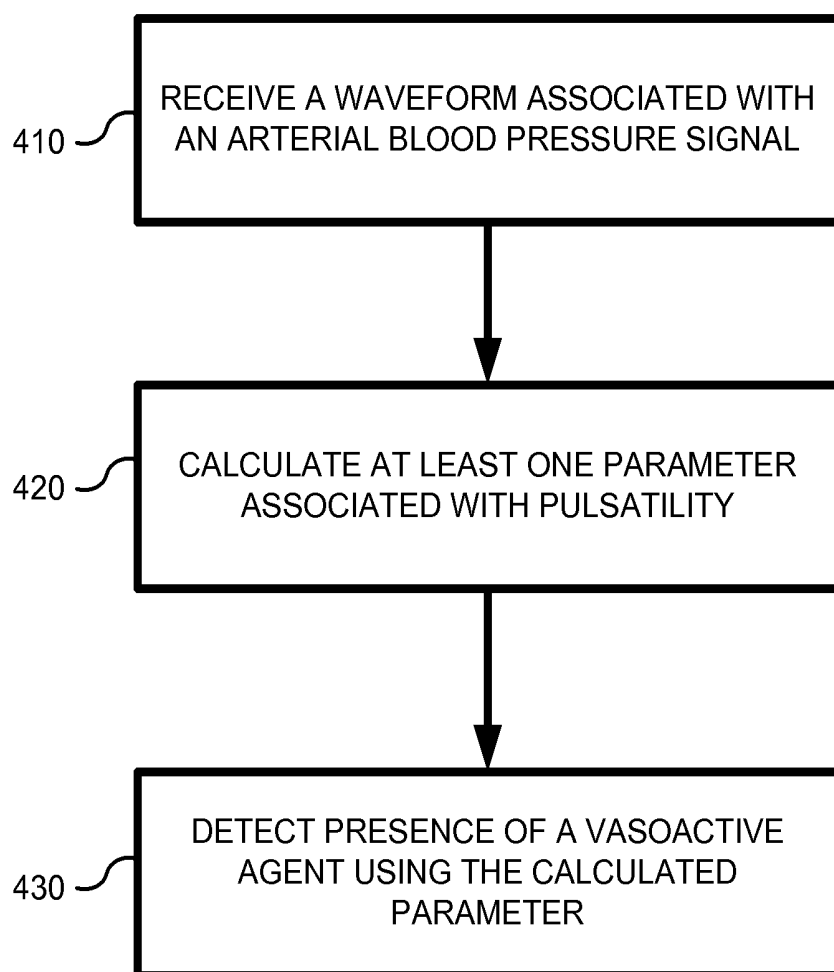


FIG. 4



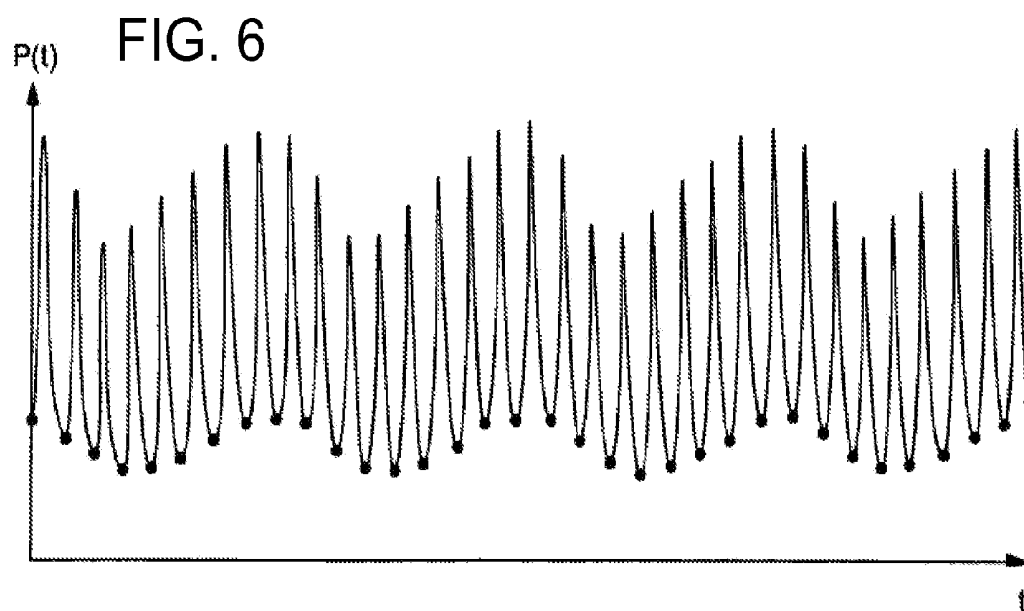
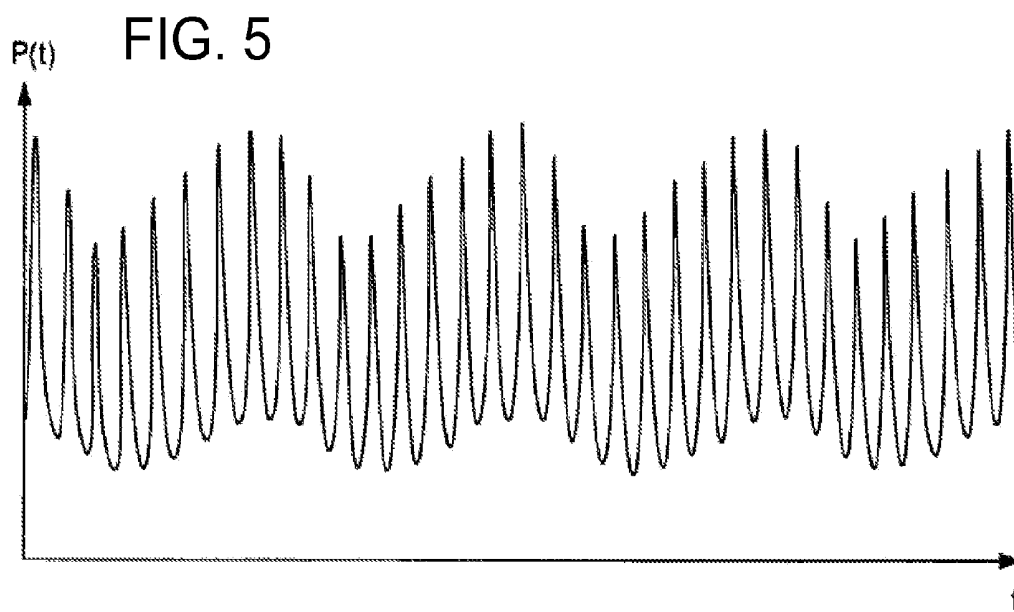


FIG. 7

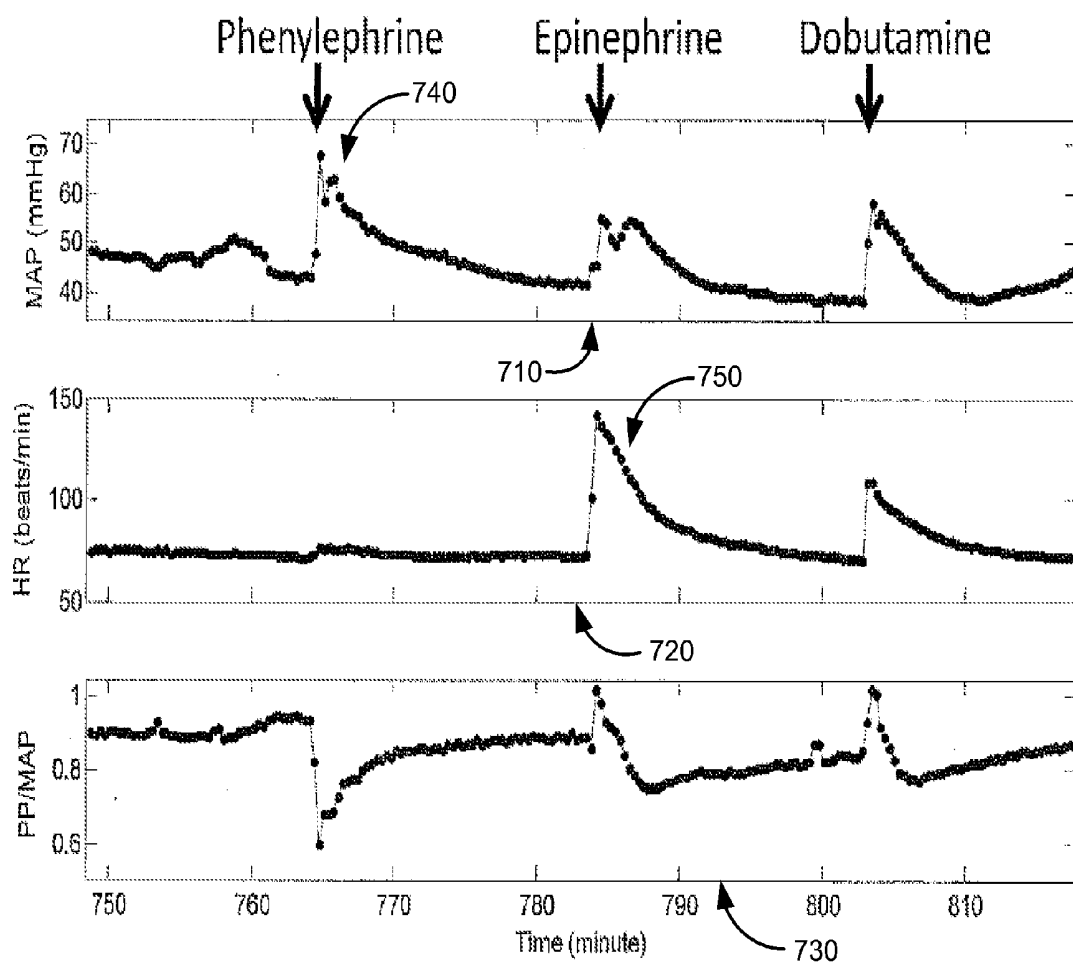


FIG. 8

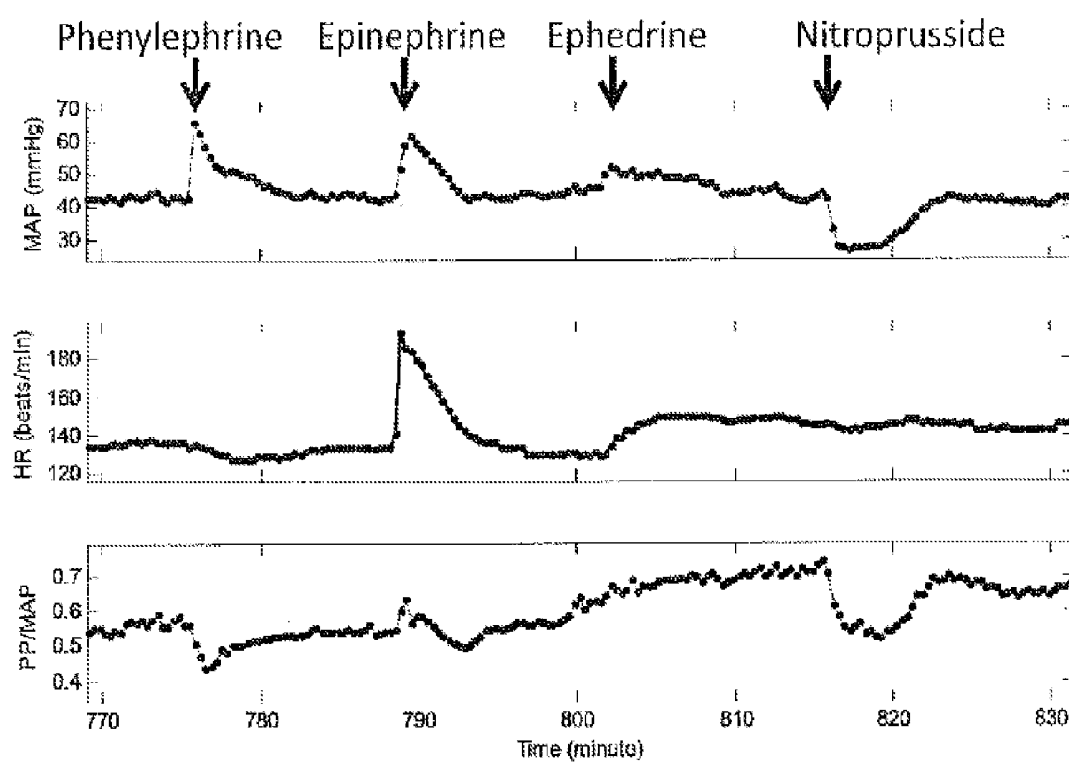
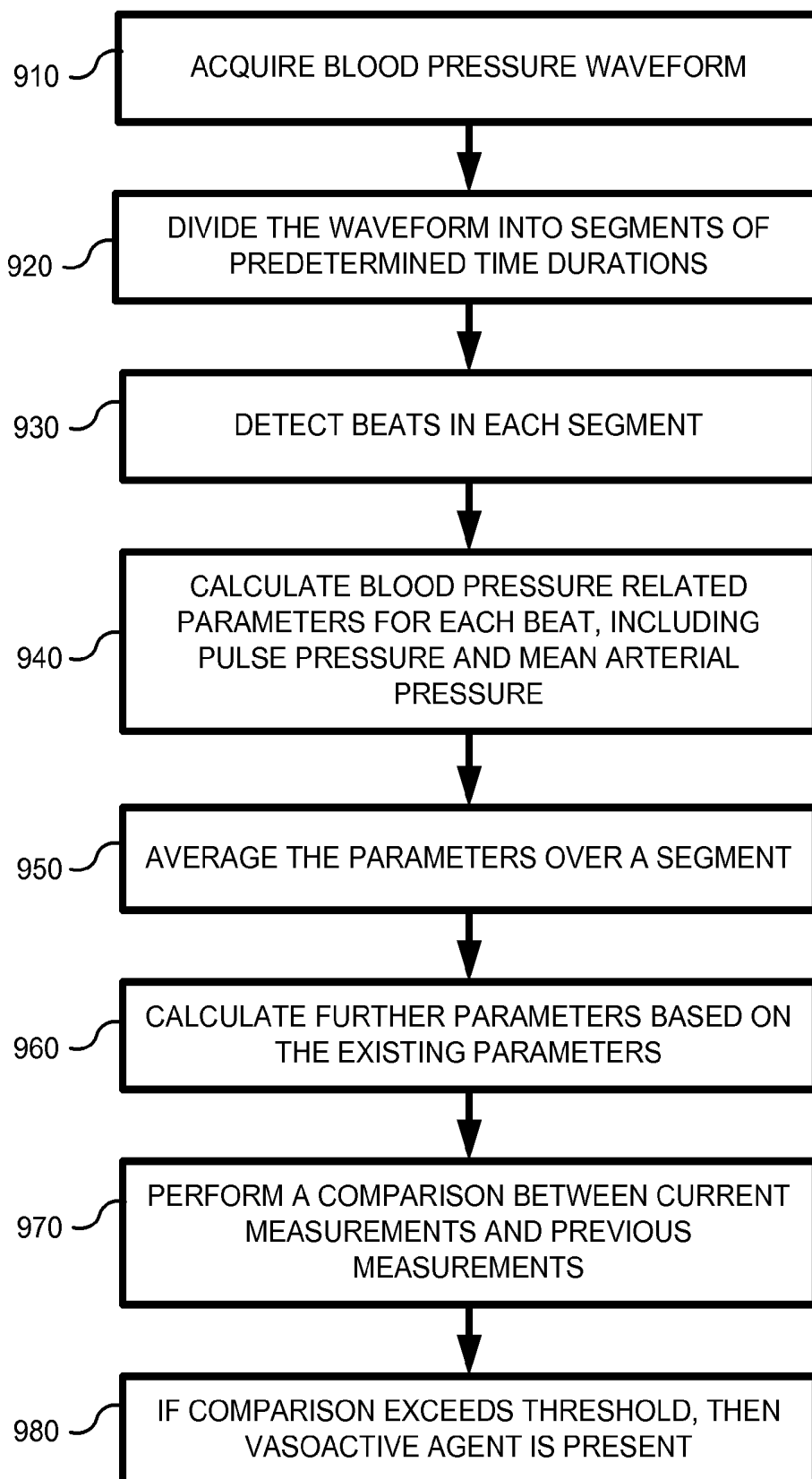


FIG. 9



DETECTING A VASOACTIVE AGENT IN THE BLOODSTREAM

FIELD

[0001] The present application relates to arterial blood pressure and, in particular, to detecting a vasoactive agent using a measurement of arterial blood pressure.

BACKGROUND

[0002] Cardiac output (CO) and Stroke volume (SV) are indicators not only for diagnosis of disease, but also for “real-time” monitoring of patients. Few hospitals are, therefore, without some form of equipment to monitor one or more of these cardiac parameters. Both invasive and non-invasive techniques are available.

[0003] Most of the techniques used to measure SV can usually be readily adapted to provide an estimate of CO as well, as CO is generally defined as SV times the heart rate HR. Conversely, most devices that estimate CO also estimate SV as a sub-step. As is explained in greater detail below, still another cardiac parameter that promises to provide clinically important information is stroke volume variation SVV. One way to estimate SVV is simply to collect multiple SV values and calculate the differences from measurement interval to measurement interval.

[0004] One common way to measure SV or CO is to mount some flow-measuring device on a catheter, and then to thread the catheter into the subject and to maneuver it so that the device is in or near the subject’s heart. Some such devices inject either a bolus of material or energy (usually heat) at an upstream position, such as in the right atrium, and determine flow based on the characteristics of the injected material or energy at a downstream position, such as in the pulmonary artery.

[0005] Still other invasive devices are based on the known Fick technique, according to which CO is calculated as a function of oxygenation of arterial and mixed venous blood.

[0006] Invasive techniques have obvious disadvantages. For example, catheterization of the heart is potentially dangerous, especially considering that the patients typically have a serious condition. Moreover, some catheterization techniques, most notably thermodilution, rely on assumptions, such as uniform dispersion of the injected heat, that affect the accuracy of the measurements depending on how well they are fulfilled. Moreover, the very introduction of an instrument into the blood flow may affect the value (for example, flow rate) that the instrument measures.

[0007] Doppler techniques, using invasive as well as non-invasive transducers, are also used to measure flow and to calculate SV and CO from the flow measurements. Not only are these systems typically expensive, but their accuracy depends on precise knowledge of the diameter and general geometry of the flow channel. Such precise knowledge is, however, seldom possible, especially under conditions where real-time monitoring is desired.

[0008] One blood characteristic that has proven particularly promising for accurately determining parameters, such as CO, SV, and SVV with minimal or no invasion is blood pressure. Most known blood-pressure-based systems rely on the so-called pulse contour method (PCM), which calculates an estimate of the cardiac parameter(s) of interest from characteristics of the beat-to-beat pressure waveform. In the PCM, “Windkessel” (German for “air chamber”) parameters

(characteristic impedance of the aorta, compliance, and total peripheral resistance) are typically used to construct a linear or non-linear, hemodynamic model of the aorta. In essence, blood flow is analogized to a flow of electrical current in a circuit in which an impedance is in series with a parallel-connected resistance and capacitance (compliance). The three required parameters of the model are usually determined either empirically, through a complex calibration process, or from compiled “anthropometric” data, i.e., data about the age, sex, height, weight, and/or other parameters of other patients or test subjects. U.S. Pat. No. 5,400,793 (Wesseling, 28 Mar. 1995) and U.S. Pat. No. 5,535,753 (Petrucelli, et al., 16 Jul. 1996) discloses systems that rely on a Windkessel circuit model to determine CO.

[0009] PCM-based systems can monitor SV-derived cardiac parameters using blood pressure measurements taken using a variety of measurement apparatus, such as a finger cuff, and can do so more or less continuously. This ease of use comes at the potential cost of accuracy, however, as the PCM can be no more accurate than the rather simple, three-parameter model from which it was derived. A model of a much higher order would be needed to faithfully account for other phenomena. Many improvements, with varying degrees of complexity, have been proposed for improving the accuracy of the basic PCM model.

[0010] Vasoactive agents (such as vasoconstrictors, vasodilators, and inotropes) have an impact on vascular tone (vascular compliance and resistance), which usually induces changes in blood pressure. As a result, this could have a negative impact on blood-pressure-based systems that measure CO and introduces errors on the measurement parameters, such as CO, SV, SVR and SVV. Vasoactive agents are a group of bioactive chemicals, which change vasomotor tone through their influence on various peripheral receptors. Most of these agents have inotropic effects (e.g. norepinephrine) as they bind with receptors positioned on the surface of the myocardium. Vasoactive drugs generally affect stroke volume and heart rate, and, thus, determine cardiac output and overall cardiovascular function. When vasoactive drugs are present, CO, SV, and SVV measurements are often inaccurate.

SUMMARY

[0011] A system and method are disclosed for detecting a vasoactive agent in patient’s bloodstream using arterial blood pressure.

[0012] In one embodiment, an input signal is received that is associated with arterial blood pressure. A change of a parameter over time is determined. A vasoactive agent is then automatically detected using the determined change.

[0013] The arterial blood pressure can be measured invasively or non-invasively to produce the input signal. Additionally, the vasoactive agent can be a vasoconstrictor, vasodilator, or inotrope. Example vasoactive agents include Phenylephrine, Epinephrine, Ephedrine, Nitroprusside, Dobutamine, Nitroglycerin, Hydralazine, Trimethaphan, Norepinephrine, Dopamine, Isoproterenol, Amrinone, Milrinone, and Digoxin, but also other vasoactive agents can be detected. Naturally occurring vasoactive agents can also be detected and include, but are not limited to, adrenaline, noradrenaline, histamine, nitric oxide, adrenocorticotrophin (ACTH), vasopressin, etc.

[0014] In another embodiment, a waveform associated with an arterial blood pressure signal can be received. A parameter

associated with the received waveform can be calculated. Then the calculated parameter can be used to determine the presence of a vasoactive agent.

[0015] The calculated parameter can be selected from pulse pressure, standard deviation of pressure waveform, the area under the systolic phase of the arterial pressure waveform (systolic area), the area under the diastolic phase of the arterial pressure waveform (diastolic area), mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each heartbeat, differentiation of pressure with respect to time, time durations of specific phases of the arterial pressure waveform (systolic phase, systolic rise, systolic decay, diastolic phase, diastolic time constant, . . . etc), heart rate (or pulse rate), measures of the morphological parameters of the arterial pressure waveform, or a combination thereof.

[0016] In yet another embodiment, detection of a vasoactive agent in any of the other embodiments can be used in a calculation of a hemodynamic parameter, such as cardiac output, stroke volume, systemic vascular resistance, stroke volume variation, pulse pressure or systolic pressure variations, cardiac index, stroke volume index, systemic vascular resistance index, vascular compliance, and vascular tone. Such a calculation using the information of the vasoactive agent provides a significant advantage over prior calculations, which neglect the use of the vasoactive agent.

[0017] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

[0018] The foregoing and other objects, features, and advantages of the invention will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. 1 is an example system diagram illustrating different components that can be used for detecting a vasoactive agent in a patient's bloodstream.

[0020] FIG. 2 is a flowchart of a method for detecting a vasoactive agent in a patient's bloodstream.

[0021] FIG. 3 is a more detailed flowchart of an embodiment for detecting a vasoactive agent.

[0022] FIG. 4 is a flowchart of another embodiment for detecting a vasoactive agent.

[0023] FIG. 5 is an exemplary waveform showing pulsatility of a signal associated with arterial pressure of a patient.

[0024] FIG. 6 is an exemplary waveform showing heartbeats associated with pulsatility.

[0025] FIGS. 7 and 8 are exemplary patterns that can be used to detect different vasoactive agents.

[0026] FIG. 9 shows a detailed flowchart of another embodiment for detecting a vasoactive agent.

DETAILED DESCRIPTION

[0027] FIG. 1 shows the main components of a system that can be used to implement the methods described herein for detecting a vasoactive agent in the bloodstream of a patient. Pressure, or some other input signal proportional to pressure, may be sensed either invasively or non-invasively, or both. For convenience, the system is described as measuring arte-

rial blood pressure as opposed to some other input signal that is converted to pressure. Alternative systems can be used, as is well understood in the art.

[0028] FIG. 1 shows both types of pressure sensing for the sake of completeness. In most practical applications of the methods described herein, either one or several variations can be implemented. In invasive applications, a conventional pressure sensor 100 can be mounted on a catheter 110, which is inserted in an artery 120 of a patient body part 130. The artery 120 is any artery in the arterial system, such as, for example, the femoral, radial or brachial artery. In the non-invasive applications, a conventional pressure sensor 140, such as a photo-plethysmographic or a blood pressure probe, is mounted externally in any manner, for example, using a cuff around a finger 142 or a transducer mounted on the wrist of the patient to read blood pressure of an artery 144.

[0029] The signals from the sensors 100 and/or 140 are passed via any known connectors as inputs to a processing system 150, which includes one or more processors and other supporting hardware and system software (not shown) usually included to process signals and execute code. The methods described herein may be implemented using a modified personal computer, or may be incorporated into a larger, specialized monitoring system. For use with the methods described herein, the processing system 150 can include, or is connected to, conditioning circuitry 152, which performs normal signal processing tasks, such as amplification, filtering, or ranging, as needed. The conditioned, sensed input pressure signal $P(t)$ can then be converted to digital form by a conventional analog-to-digital converter ADC 154, which can take a signal reference from a clock circuit 156. As is well understood, the sampling frequency of the ADC 154 can be chosen with regard to the Nyquist criterion so as to avoid aliasing of the pressure signal, which is known in the art of digital signal processing. The output from the ADC 154 can be the discrete pressure input signal $P(k)$, whose values may be stored in conventional memory circuitry (not shown).

[0030] The values $P(k)$ can be passed to or accessed from memory by a software, hardware, or firmware module 160. For example, module 160 can comprise computer-executable code for calculating parameters associated with a pulsatility of the pressure input signal. The pulsatility parameters can be calculated at multiple points in time and can be any desired parameter. Example parameters include pulse pressure, standard deviation of pressure waveform, systolic area, diastolic area, mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each heartbeat, differentiation of pressure with respect to time, or a combination of these different parameters. If desired, patient-specific data, such as age, height, weight, BSA, etc., can be stored in a memory region 162 (other predetermined parameters, such as threshold or threshold range values can also be stored). Predetermined pulsatility data can also be stored in the memory region 162, so that measurements can be based on historic patient data. Any of the above-described values may be entered using any known input device 164 in the conventional manner. Detection of a vasoactive agent can be accomplished in detection module 170. Detection module 170 can include computer-executable code that can analyze calculations made in module 160 and perform the analysis for detection of a vasoactive agent, as further described below. As illustrated by FIG. 1, the results can be passed to further modules 172 for additional processing. Alternatively, the additional processing can be performed within the detection module. In any

event, the additional processing can include a calculation of a hemodynamic parameter. In such a calculation, whether or not a vasoactive agent was present can be used. The hemodynamic parameter can be associated with a wide variety of cardiovascular-related elements, such as cardiac output, stroke volume, systemic vascular resistance, stroke volume variation, cardiac index, stroke volume index, systemic vascular resistance index, vascular compliance, and vascular tone. The results can be displayed on a conventional display or recording device **180** for presentation to and interpretation by a user.

[0031] FIG. 2 shows a flowchart of an exemplary method for detecting a vasoactive agent. In process block **210**, an input signal is received that is associated with arterial blood pressure. The input signal can be received by an apparatus, such as is shown in FIG. 1, or other desired apparatus, as is well understood in the art. The input signal can be proportional to, or derived from arterial pressure, flow rate, vascular resistance, pulse oximetry, Doppler ultrasound, bioimpedance signal, or related measurements or signals. The input signal can be in a variety of formats, such as a waveform, a digitized signal, or an analog signal. In process block **220**, a change of pulsatility is determined over a period of time of the input signal. Pulsatility is generally known in the art to be a change in a pulse signal in response to each cardiac contraction. The period of time can be any desired period. Some example periods include any time between 1.0 and 60 minutes, but other time limits can be used. In process block **230**, a vasoactive agent can be automatically detected using the measured change of pulsatility. Automatic detection can be achieved using hardware, software, or firmware components, such as shown in FIG. 1. The vasoactive agent can be a vasoconstrictor, a vasodilator, or an inotrope. Example vasoactive agents include, but are not limited to Phenylephrine, Epinephrine, Ephedrine, Nitroprusside, etc.

[0032] FIG. 3 shows a flowchart of a particular embodiment that can be used to determine a change of pulsatility and to detect the vasoactive agent. In process block **310**, a first parameter can be calculated at first and second times. A variety of parameters can be used. Example parameters can include pulse pressure, standard deviation of pressure waveform, systolic area, or diastolic area. In process block **320**, a second parameter can be calculated at first and second times. Like the first parameter, a variety of parameters can be used, such as mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each beat, differentiation of pressure with respect to time, systolic area, diastolic area, or a combination thereof. The first and second times can be at any desired time interval apart. Additionally, the first and second times can be averages over first and second time periods. The process block **330** performs mathematical comparison of the first parameter and the second parameter. In one example, the mathematical comparison is performed by calculating the ratio of the first parameter to the second parameter at the first and second times. Alternative waves to perform mathematical comparison could be used as well. The ratio can alternatively be the second parameter to the first parameter. In process block **340**, a difference between the ratios at the first and second times is calculated. The difference or comparison allows for a determination of how the ratio changes with respect to time. In process block **350**, a determination is made whether the calculated difference exceeds a predetermined threshold. As described further below, the presence of a vasoactive agent can result in a

change in arterial blood pressure parameters. The threshold allows for minor variations in such parameters to be ignored, whereas changes that exceed a predetermined limit are indicative of the presence of a vasoactive agent.

[0033] FIG. 4 is a flowchart of another embodiment, wherein detection is not necessarily based on determining a change over time of an input signal. Rather, a parameter associated with pulsatility can be used to detect the presence of a vasoactive agent. In process block **410**, an input signal, such as a waveform, is received that is associated with an arterial blood pressure signal. The received waveform can be in a variety of formats, such as digital or analog data which when plotted represents a waveform. In process block **420**, at least one parameter associated with the pulsatility is calculated using the received waveform. Calculation of such a parameter is well known in the art. In process block **430**, the vasoactive agent is detected using the calculated parameter. Any of the above-identified parameters can be used in the calculation. Moreover, any of the methods of FIGS. 2 and 3 can be used to expand the method of claim 4.

[0034] FIG. 5 illustrates a sequence of measured or otherwise acquired arterial pressure waveforms over approximately three respiratory cycles. In practice, the sequence can be a data set $P(k)$ derived from a sampled measurement of arterial pressure $P(t)$. The $P(k)$ values can be obtained through direct, invasive or non-invasive measurement, or may be input from some other source, such as from a remote monitor or even a pre-recorded data set. Pulsatility can be calculated using one or more of the following techniques on the received input signal: integral analysis, correlation, Fourier analysis, maximum-minimum, derivative, or standard deviation.

[0035] In FIG. 6, dots are included in the waveform of FIG. 5 to indicate the beginning of each cardiac cycle (that is, each "beat") over the illustrated computation interval. The beginning of each cardiac cycle can be determined in any of a number of known ways using any known system that is or includes a heart rate monitor. Assuming, for example, as is often the case, that the patient's cardiac electrical activity is also being monitored by an electrocardiogram system (EKG), then the beginning of each cardiac cycle may be determined to occur at the sampled pressure value immediately following each R-wave. Pressure-based, pulse-rate monitors may also be used and are in fact preferred because they will then be better synchronized with the blood pressure signal than will, for example, an EKG signal.

[0036] FIG. 7 shows various input parameters that are graphed with respect to time, and various vasoactive agents that are indicated as being detected at a time t , as soon as threshold values are reached. At **710**, a graph is shown with mean arterial pressure (MAP) versus time. At **720**, a heart rate (HR) parameter is shown versus time. At **730**, a ratio of pulse pressure (PP) to MAP is shown versus time. As can be seen at **740**, when phenylephrine is introduced in the blood stream, the heart rate is relatively unchanged, while the PP/MAP ratio decreases and the MAP increases. Thus, using different pulsatility parameters, phenylephrine can be identified. Additionally, analysis of such parameters can be used to distinguish phenylephrine from other vasoactive agents. For example, introduction of epinephrine causes an increase in HR as shown at **750**. Additionally, different parameters may have different thresholds. For example, dobutamine can be distinguished from epinephrine by looking at an amount of HR increase, as the HR increase for epinephrine exceeds that of dobutamine. Thus, using a combination of pulsatility

parameters and/or threshold limits, it is possible to distinguish between different vasoactive agents.

[0037] FIG. 8 shows an additional example of vasoactive agents that can be detected using a variety of arterial blood pressure parameters. In this case, phenylephrine, epinephrine, ephedrine, and nitroprusside are detected as being vasoactive agents present in a patient's blood using one or more pulsatility-related parameters. For example, if MAP increases above a predetermined threshold (as an absolute threshold or a differential above a running average), it can be considered that a vasoactive is present, although it can be difficult to know which one. Whereas if a second parameter is used, such as HR, a determination can be made to distinguish phenylephrine from epinephrine. Other vasoactive agents can be distinguished using PP/MAP or other parameters.

[0038] FIG. 9 shows a flowchart of a method of a detailed embodiment that can be used. In process block 910, a blood pressure waveform is acquired using any of the above-described techniques. In process block 920, the waveform can be divided into segments of predetermined durations (e.g., 20 seconds). In process block 930, each beat in a segment can be detected, such as at the dotted points in FIG. 6. At process block 940, blood pressure related parameters are calculated for each beat. Example parameters are HR, MAP, PP, etc. In process block 950, the parameters are averaged over the segment. In process block 960, further parameters can be calculated based on existing parameters. For example, a ratio of PP to MAP can be calculated. Other ratios can also be calculated and used as parameters. In process block 970, a comparison is performed between current segment measurements and previous segment measurements. In process block 980, if the comparison exceeds a threshold, then a vasoactive agent is present. For example, if $\text{Ratio}_{\text{current}} < a * \text{Ratio}_{\text{prev}}$, $\text{HR}_{\text{current}} = b * \text{HR}_{\text{prev}}$, $\text{MAP}_{\text{current}} > c * \text{MAP}_{\text{prev}}$ then Phenylephrine is present at the current measurement, wherein a, b, and c are predetermined constants. If desired, a hemodynamic parameter can be calculated, wherein the calculation includes using the presence or absence of the vasoactive agent in the determination of the parameter.

[0039] Exemplary embodiments of the present invention have been described above with reference to a block diagram of methods, apparatuses, and computer program products. One of skill will understand that each block of the block diagram, and combinations of blocks in the block diagram, respectively, can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create a means for implementing the functions specified in the blocks.

[0040] The methods described herein further relate to computer program instructions that may be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus, such as in a processor or processing system, to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including computer-readable instructions for implementing the described methods. Moreover, the various software modules used to perform the various calculations and perform related method steps described herein also can be stored as computer-executable

instructions on a computer-readable medium in order to allow the methods to be loaded into and executed by different processing systems.

[0041] In view of the many possible embodiments to which the principles of the disclosed invention may be applied, it should be recognized that the illustrated embodiments are only preferred examples of the invention and should not be taken as limiting the scope of the invention. Rather, the scope of the invention is defined by the following claims. We therefore claim as our invention all that comes within the scope of these claims.

We claim:

1. A method for detecting a vasoactive agent in a patient's bloodstream, comprising:
 - receiving an input signal that is associated with arterial blood pressure;
 - determining a change over time associated with pulsatility of the input signal; and
 - automatically detecting a vasoactive agent in the bloodstream using the determined change.
2. The method of claim 1, wherein determining comprises measuring the change associated with pulsatility including calculating a first waveform parameter of the input signal at first and second times, calculating a second waveform parameter of the input signal at the first and second times, and calculating a ratio of the first waveform parameter to the second waveform parameter at the first and second times.
3. The method of claim 2, further including calculating a difference between the ratios at the first and second times to obtain the measured change and wherein automatically detecting includes determining whether the measured change exceeds a predetermined threshold.
4. The method of claim 2, wherein the first waveform parameter is one of the following: pulse pressure, standard deviation of pressure waveform, systolic area, or diastolic area.
5. The method of claim 2, wherein the second waveform parameter is mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each beat, differentiation of pressure with respect to time, systolic area, diastolic area, or a combination thereof.
6. The method of claim 2, wherein the first waveform parameter and the second waveform parameter are exchangeable in the calculation of the ratio.
7. The method of claim 1, wherein determining comprises measuring the change associated with pulsatility by calculating a waveform parameter of the input signal at first and second times.
8. The method of claim 7, further including calculating a difference between the waveform parameters at the first and second times to obtain the measured change and wherein automatically detecting includes determining whether the measured change exceeds a predetermined threshold.
9. The method of claim 7, wherein the waveform parameter is pulse pressure, standard deviation of pressure waveform, heart rate, mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each beat, differentiation of pressure with respect to time, systolic area, diastolic area, and a combination of any of those parameters.
10. The method of claim 1, further including using that the vasoactive agent was detected in a calculation of a hemodynamic parameter.
11. The method of claim 10, wherein the hemodynamic parameter is cardiac output, stroke volume, systemic vascular

resistance, stroke volume variation, cardiac index, stroke volume index, systemic vascular resistance index, vascular compliance, vascular tone.

12. The method of claim 1, wherein the received input signal is a waveform, and wherein the determining the change includes dividing the waveform into segments of a predetermined time duration, detecting each beat in a segment, and calculating a pulse pressure and mean arterial pressure for each beat.

13. The method of claim 12, further including averaging the pulse pressure and mean arterial pressure for all beats in a segment, calculating a ratio of the average pulse pressure to the average mean arterial pressure, and calculating a difference in the ratio between multiple segments.

14. The method of claim 1, further including calculating the pulsatility using one or more of the following techniques on the received input signal: integral analysis, correlation, Fourier analysis, maximum-minimum, derivative, or standard deviation.

15. The method of claim 1, wherein the input signal is proportional to, or derived from one or more of the following measurements: arterial pressure, flow rate, vascular resistance, pulse oximetry, Doppler ultrasound, or bioimpedance signal.

16. The method of claim 1, further including measuring the arterial blood pressure invasively or non-invasively to produce the input signal.

17. The method of claim 1, wherein the vasoactive agent is selected from the following: vasoconstrictor, vasodilator, or inotrope.

18. The method of claim 1, wherein determining includes receiving data associated with measuring a change over time of the pulsatility of the input signal.

19. The method of claim 1, wherein the input signal is a waveform, a digitized signal, or an analog signal.

20. A method of detecting a vasoactive agent, comprising: receiving a waveform associated with an arterial blood pressure signal; using the received waveform, calculating at least one parameter associated with pulsatility of the arterial blood pressure signal; and detecting a presence of a vasoactive agent using the calculated parameter.

21. The method of claim 20, further including measuring an average of the waveform over a period of time and wherein detecting the presence of the vasoactive agent includes detecting a change of greater than a threshold amount of the parameter.

22. The method of claim 20, further including dividing the waveform into segments of a predetermined period of time, detecting heart beats within each segment, and calculating the at least one parameter for each beat.

23. The method of claim 20, wherein the at least one parameter includes one of the following: pulse pressure, standard deviation of pressure waveform, systolic area, diastolic area, mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each heartbeat, differentiation of pressure with respect to time, or a combination thereof.

24. The method of claim 20, further including calculating a hemodynamic parameter using the presence of the vasoactive agent.

25. The method of claim 20, wherein the at least one parameter is a first parameter that includes one of the following: pulse pressure, standard deviation of pressure waveform, systolic area, or diastolic area and further including measuring a second parameter, which includes one of the following: mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each beat, differentiation of pressure with respect to time, systolic area, diastolic area, or a combination thereof.

26. The method of claim 25, further including calculating a ratio comprising the first parameter and the second parameter.

27. The method of claim 25, wherein calculating includes using one or more of the following techniques: integral analysis, correlation, Fourier analysis, maximum-minimum, derivative, or standard deviation.

28. The method of claim 25, further including determining the first parameter at first and second times and the second parameter at first and second times, and calculating a change over time associated with the first and second parameters.

29. The method of claim 25, further including determining a heart rate and differentiating between different vasoactive agents using at least one of the first and second parameters in conjunction with the heart rate.

30. A system for detecting a vasoactive agent, comprising: a sensor that generates a signal corresponding to arterial blood pressure; and

a processor for using the signal to calculate a parameter corresponding to pulsatility and analyzing whether a change in the parameter over time exceeds a predetermined threshold and, if so, calculating a hemodynamic parameter taking into account a presence of a vasoactive agent.

31. The system of claim 30, wherein the parameter is a ratio comprising one of the following: pulse pressure, standard deviation of pressure waveform, systolic area, or diastolic area and one of the following: mean arterial pressure, systolic pressure, diastolic pressure, pressure at a specific time point in each beat, differentiation of pressure with respect to time, systolic area, diastolic area, or a combination thereof.

32. A method for detecting a vasoactive agent in a bloodstream, comprising:

receiving data associated with a blood-pressure parameter at a first point in time;

receiving data associated with the blood-pressure parameter at a second point in time;

comparing the data at the first and second points in time; and

based on the comparison, detecting a presence of a vasoactive agent in the bloodstream.

33. The method of claim 32, further including determining a type of vasoactive agent using the received blood-pressure parameter.

* * * * *

专利名称(译)	检测血流中的血管活性剂		
公开(公告)号	US20140235971A1	公开(公告)日	2014-08-21
申请号	US14/350332	申请日	2012-10-05
[标]申请(专利权)人(译)	爱德华兹生命科学公司		
申请(专利权)人(译)	爱德华兹生命科学公司		
当前申请(专利权)人(译)	爱德华兹生命科学公司		
[标]发明人	JIAN ZHONGPING HATIB FERAS		
发明人	JIAN, ZHONGPING HATIB, FERAS		
IPC分类号	A61B5/00 A61B8/08 A61B5/029 A61B5/1455 A61B5/0205 A61B5/02		
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摘要(译)

公开了一种用于检测患者血流中的血管活性剂的系统和方法。在一个实施例中，接收与动脉血压相关的输入信号。确定动脉血压参数随时间的变化。然后使用确定的变化自动检测血管活性剂。在另一个实施例中，可以接收与动脉血压信号相关联的波形。计算与接收波形相关联的参数。然后，计算的参数可用于确定血管活性剂的存在。在另一个实施方案中，在任何其他实施方案中检测血管活性剂可用于计算血液动力学参数，例如心输出量，每搏输出量，全身血管阻力，每搏输出量变化，心脏指数，每搏输出量指数，全身血管阻力指数，血管顺应性和血管张力。

