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(54) METHOD AND DEVICE FOR NON-INVASIVE MEASUREMENTS IN A SUBJECT

VERFAHREN UND VORRICHTUNG FÜR NICHTINVASIVE MESSUNGEN IN EINER PERSON

PROCEDE ET DISPOSITIF POUR DES MESURES NON INVASIVES DANS UN SUJET

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Description

FIELD OF THE INVENTION

[0001] This invention is generally in the field of non-invasive measuring techniques and relates to a method and device for non-invasive measurements in a subject (e.g. human body). The invention is particularly useful for measuring blood parameters, such as the concentration of a substance in blood (e.g., hemoglobin, glucose, drugs or cholesterol), or other important blood parameters such as oxygen saturation.

BACKGROUND OF THE INVENTION

[0002] Various non-invasive techniques have been developed for determining blood-related parameters such as hemoglobin, hematocrit, oxygen saturation, etc. These techniques are disclosed for example in the following publications:

[0003] A pulse oxymetry based hemoglobin measurement technique is described in the article "Noninvasive total hemoglobin measurement", by Kye Jin Jeon et al., Journal of Biomedical Optics 7(1), 45-50, January 2002. This technique consists of a wavelength selection and prediction algorithm for determining total hemoglobin concentration. A model has been developed, based on the difference in optical density induced by the pulsation of the heartbeat, by taking an approximation of Twersky's theory on the assumption that the variation of blood vessel size is small during arterial pulsing. The device utilizes a five wavelength light emitting diode array as the light source. The selected wavelengths are two isobestic points and three in compensation for tissue scattering. Data are collected from 129 outpatients who are randomly grouped as calibration and prediction sets. The ratio of the variations of optical density between systole and diastole at two different wavelengths is used as a variable. Several such variables have been selected that show high reproducibility among all variables. Multiple linear regression analysis has been made in order to predict total hemoglobin concentration. The correlation coefficient is 0.804 and the standard deviation is 0.864 g/dL for the calibration set. The relative percent error and standard deviation of the prediction set are 8.5% and 1.142 g/dL, respectively. These investigations demonstrate the possibility of noninvasive hemoglobin measurement, particularly, using the wavelengths below 1000 nm.

[0004] U.S. Patent No. 5,277,181 discloses noninvasive measurement of hematocrit and hemoglobin content by differential optical analysis. This technique utilizes differential optical absorption of two or more wavelengths of light during blood volume changes. The method is also useful for noninvasive measurements of other blood analytes, such as glucose, where variations in hematocrit or blood hemoglobin concentration cause errors in the measurement.

[0005] U.S. Patent No. 4,927,264 discloses a non-invasive measuring method and apparatus of blood constituents. Here, in order to measure the oxygen saturation in venous blood, a venous blood stream is made time-variant by applying pressure with a peak value of the minimum blood pressure to a proximal portion from a measuring part. Light beams with different wavelengths are transmitted from the measuring part and detected by photodiodes. Photodetected signals are logarithm-converted and venous signal components are separated from logarithm-converted signals with a filter circuit. The oxygen saturation of venous blood is calculated on the basis of separated venous signal components.

[0006] U.S. Patent No. 5,827,181 describes noninvasive blood chemistry measurement method and system that isolate measurement contributions due to a patient's blood to accurately measure blood chemistry. According to one embodiment, a noninvasive blood chemistry measurement method decreases the blood volume within a patient's body part relative to the normal blood volume in the body part and performs a baseline measurement. Blood volume is then increased and a second measurement is performed. Comparison of the second measurement to the baseline measurement isolates the measurement attributes of the patient's blood. In accordance with another embodiment, a noninvasive blood chemistry measurement system decreases blood volume by applying mechanical pressure to a body part. According to yet another embodiment, blood volume in the body part is decreased using a pressure cuff. In a further embodiment, a noninvasive probe accurately measures blood chemistry and uses a suction cup to increase blood volume at the blood chemistry measurement site.

[0007] U.S. Patent No. 6,606,509 discloses a method and apparatus for improving the accuracy of noninvasive hematocrit measurements. According to this technique, the changes in the intensities of light of multiple wavelengths transmitted through or reflected light from the tissue location are recorded immediately before and after occluding the flow of venous blood from the tissue location with an occlusion device positioned near the tissue location. As the venous return stops and the incoming arterial blood expands the blood vessels, the light intensities measured within a particular band of near-infrared wavelengths decrease in proportion to the volume of hemoglobin in the tissue location; those intensities measured within a separate band of wavelengths in which water absorbs respond to the difference between the water fractions within the blood and the displaced tissue volume. A mathematical algorithm applied to the time-varying intensities yields a quantitative estimate of the absolute concentration of hemoglobin in the blood. To compensate for the effect of the unknown fraction of water in the extravascular tissue on the hematocrit measurement, the tissue water fraction is determined before the occlusion cycle begins by measuring the diffuse transmittance or reflectance

spectra of the tissue at selected wavelengths.

[0008] A different approach is disclosed in various patents assigned to the assignee of the present application, such as for example US 6,400,972; US 6,587,704; US 6,711,424; US 6,804,002 and US 6,804,002. These techniques provide for measurement of various parameters of the patient's blood, based on the creation of a condition of artificial kinetics at a measurement location, and maintaining this condition during a certain time. Measurements are carried out during a time period including this certain time by applying an external electromagnetic field to the measurement location and detecting a response to the applied field. Measured data is in the form of time evolutions of the responses of the medium corresponding to the different parameters of the applied field. By analyzing the measured data, at least one blood parameter is extracted.

SUMMARY OF THE INVENTION

[0009] There is a need in the art to facilitate non-invasive measurements of various blood parameters, by providing a novel method and device capable of providing the improved accuracy of measurements.

[0010] The inventors have found a certain problem associated with the fact that the methodology of each of the known approaches is based on a different kind of blood related signal. More specifically, pulsatile measurements (e.g., the above-indicated article "Noninvasive total hemoglobin naeasurement", by Kye Jin Jeon et al., Journal of Biomedical Optics 7(1), 45-50, January 2002; US 5,277,181) are based on the arterial blood natural volumetric changes. Under-systolic volume manipulation based measurements (e.g., the above-indicated patents US 4,927,264; US 5,827,181; US 6,606,509) deal with venous blood. Over-systolic occlusion based measurements (disclosed in the above-indicated patents US 6,400,972; US 6,587,704; US 6,711,424 and US 6,804,002) are based on the arterial blood artificial kinetics. The physical and physiological principles underlying the pulsatile signal, under-systolic volumetric signal and post occlusion signals might be different.

[0011] The inventors have found that the accuracy of measurements could be improved by appropriately combining occlusion (no pulse due to blood flow cessation) and pulse-based (during the natural blood flow through the medium) modes of measurements. According to the invention, measurements are applied to the region of interest in a blood-perfused fleshy medium under occlusion and before and/or after the occlusion - to the same region at the steady state (non-occluded) thereof.

[0012] The measurements may include the so-called "pure optical" measurements, namely, illumination of a measurement location and detection of a light response thereof (transmission and/or reflection/scattering), and/or photo-acoustic spectroscopy (illumination of a measurement location and detection of acoustic response thereof), and/or impedance based measurements (total electrical resistance or a component of the impedance) according to which two electrodes are brought into direct contact with the subject (e.g. human body) and real and imaginary components of reflected and/or transmitted electromagnetic signals are spectrally examined as a function of frequency. The measurements are taken with at least two different values of a certain controllable parameter. The latter may include the parameter of the applied electromagnetic field; and/or in case of optical measurements of the concentration of an optically active (scattering) substance (such as glucose) - polarization states of detected light.

[0013] There is thus provided according to one broad aspect of the invention, a method for use in non-invasive measurements in a subject as defined in claim 1.

[0014] The condition of artificial kinetics may be created by applying over-systolic pressure to the vicinity of the measurement location, or to a location on the body upstream of the measurement location with respect to a normal blood flow direction in the body.

[0015] Preferably, the invention utilizes optical measurements: The measurements may include illuminating the measurement location with at least two different wavelengths of light (constituting at least two different values of the controllable parameter being that of the applied electromagnetic field) and detecting the light response of the illuminated portion of the subject (e.g., slight transmitted through the portion under measurement). Alternatively, the measurements may include illuminating the measurement location with at least one wavelength of light and detecting the light response of the body portion while at different polarization states of the detected light (constituting at least two different values of the controllable parameter).

[0016] The first and second relations are preferably determined as a parametric slope of the respective time functions of the responses; or may be determined as AC_1/AC_2 and DC_1/DC_2.

[0017] A pair of the first and second parametric slopes PS_1 and PS_2 obtained for the same pair of wavelengths λ_1-λ_2 (constituting pair of the applied field parameter values) are determined as:

$$PS_1 = \frac{\partial Ln(I^1\lambda 1)/\partial(t)}{\partial Ln(I^1\lambda 2)/\partial(t)} \quad \text{and} \quad PS_2 = \frac{\partial Ln(I^2\lambda 1)/\partial(t)}{\partial Ln(I^2\lambda 2)/\partial(t)}$$

wherein I^1 and I^2 are the first and second light responses and t is time.

[0018] The desired blood parameter, BP, can be determined as

$$BP = \sum_{i=1}^{N} A_i \cdot (PS_1)_i + \sum_{i=1}^{M} B_i \cdot (PS_2)_i ,$$

wherein A_i and B_i are calibration coefficients; $(PS_1)_i$ and $(PS_2)_i$ are first and second parametric slopes obtained for the same pair of wavelengths; and i is a number of wavelength.

[0019] The measurements performed under the normal blood flow condition may be carried out before or after the measurements under the artificial kinetics condition.

[0020] The blood and/or tissue related parameter that can be determined by the technique of the invention includes concentration of substance (e.g., hemoglobin, hematocrit, glucose, HbCO, MetHb) and/or oxygen saturation.

[0021] According to yet another broad aspect of the invention, there is provided a device for use in non-invasive measurements in a subject, as defined in claim 9

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] In order to understand the invention and to see how it may be carried out in practice, preferred embodiments will now be described, by way of nonlimiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a device of the present invention, exemplified as being applied to a patient's finger;
Figs. 2A and 2B show two examples, respectively, of a method of the invention;
Fig. 3A-B and 4A-4C show experimental results for the technique of the invention, wherein **Fig. 3A** shows the time variations of the pulse mode light responses for different wavelengths and **Fig. 3B** shows the time variations of the occlusion mode light responses for the same wavelengths, respectively; and **Figs. 4A-4C** show relations between the time variations of the light responses for the pulse and artificial kinetics modes (in terms of parametric slopes), for three different pairs of wavelengths, respectively.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0023] Referring to **Fig.** 1, there is illustrated by way of a block diagram a device, generally designated **10**, constructed and operated according to the invention. In the present example, the device is applied to a patient's finger (constituting a subject or subject's medium), and is configured as a clip-like device or a ring-like device. Also in the present example, the device is configured for carrying out optical measurements. However, it should be understood that the invention is not limited to these specific examples.

[0024] Device **10** includes a measurement unit **12**, a pressure applying assembly **14**, and a control unit **16**. These constructional parts of the device or at least some of them may be made integral with each other (i.e., carried by a common housing, e.g., capable of being applied to the finger, e.g., a ring-like housing) or may be separate units (e.g., measurement unit and pressure applying assembly may be separate ring-like assemblies, or one being a ring and the other being a clip, as the case may be). The measurement unit and the pressure applying assembly may be connectable to the control unit (integrated or stand-alone) via wires or wireless signal transmission.

[0025] Measurement unit **12** includes a source **12A** of an external electromagnetic field to be applied to a measurement location in the body; and a detector **12B** configured for detecting a response of the measurement location to the applied field. In the present example, field source **12A** is operable (e.g., by control unit **16**) to vary at least one of its operational parameters, e.g., a frequency of the applied field (constituting a controllable parameter). Such a field may be light or an electric signal. The response may be in the form of an optical, acoustic or electric signal.

[0026] In the present example, measurement unit **12** is an optical device configured to irradiate a region of interest (finger in the present example) with incident radiation of at least two different wavelengths in Visible, NIR or IR spectra, and detect a radiation response of the illuminated region. To this end, measurement unit **12** includes light source arrangement **12A** (and possibly also a suitable light directing assembly, e.g., optical fiber(s) and/or a lens arrangement

and/or polarizer arrangement); and light detector arrangement **12B** (possibly equipped with suitable optics, and/or spectral filters, and/or polarizer arrangement). Light source arrangement **12A** includes either a single broadband illuminator, or a plurality (at least two light source elements) emitting light of different wavelength ranges.

[0027] It should be understood that light source arrangement **12A** may or may not be carried by the housing applied to the finger. For example, such a light source assembly may be a stand alone unit and an optical fiber arrangement is used for connecting the light source to the housing on the finger. Similarly, detector arrangement **12B** may be mounted on the housing or may be connected thereto via an optical fiber arrangement. The housing (clip or ring) carrying the measuring unit is appropriately provided with optical windows allowing illuminating light to pass to the region of interest and allowing collection of the light response of the region of interest. In this connection, it should be understood that the device may be configured to operate with a reflection mode and/or transmission mode. Namely, the device may include one or more light detectors (i.e., optical window(s) associated therewith) collecting light transmitted through the finger, and/or one or more light detectors collecting light reflected (scattered) from the region of interest in the finger.

[0028] Pressure applying assembly **14** includes a cuff **14A** configured for attaching to the patient's finger, and a drive unit **14B** operated by control unit **16** for operating the squeezing of cuff **14A.**

[0029] Control unit **16** is connectable to measurement unit **12** and pressure applying assembly **14** (via wires or wireless), and is configured to appropriately operate these units and to receive and process data indicative of the detected response of the measurement location. Control unit **16** is configured as a computer system including *inter alia* a memory utility **16A**, a data processing utility **16B,** and a data output utility (e.g., display) **16C**. Also, control unit **16** includes a field source controller utility **16D** (an illumination controller in the present example) and a pressure controller utility **16E** associated with the drive unit **14B**.

[0030] Reference is made to **Figs. 2A and 2B** showing the operational steps in accordance with two examples, respectively, of a method of operating device **10** of the present invention. In the present example, pure optical measurements are considered, but it should be understood that the present invention is not limited to this specific example.

[0031] In the example of **Fig. 2A**, measurements are first taken at the steady state (pulse mode), and then under the artificial kinetics condition (occlusion mode). Accordingly, during a certain time period t_p (e.g., about 20 seconds) pressure applying assembly **14** is kept inoperative, while measurement **unit 12** is operated to perform measurements with at least two different wavelengths, and/or with at least two different states of polarization of the detected light (as described in the above-indicated patent US 6,804,002 assigned to the assignee of the present application). Light source assembly **12A** and detector arrangement **12B** are operated to apply illumination (e.g., with at least two different wavelengths) to a measurement location (region of interest) and detect a light response, I_p, of the illuminated region (for at least two different values of the controllable parameter - that of wavelength of illumination in the present example). Data indicative of the light response, I_p, is received at the control unit.

[0032] After this time period t_p, a condition of artificial kinetics is created at the measurement location and maintained for a certain time period t_{ak} such as not to cause irreversible changes in the fleshy medium (e.g., from a few seconds to about one minute), and optical measurements are performed on the measurement location during at least a part of this time period t_{ak}. This is implemented by operating pressure applying assembly **14** to apply over-systolic pressure in the vicinity of the measurement location or upstream of the measurement location (with respect to a normal blood flow direction) so as to create blood flow cessation at the measurement location and maintain it during the cessation time t_{ak}, and operating the light source and detector assemblies to detect a light response, I_{ak}, of the measurement location to at least two different wavelengths while at the condition of artificial kinetics (under occlusion). Data indicative of the light response, I_{ak}, is received at the control unit. It should be noted that a certain short time (about 0.5sec) exists from the moment when the pressure is initially applied and until the actual start of occlusion. Measurements taken during this short time period may be disregarded, due to the unavoidable influence of motional and/or other artifacts causing non-monotonic fluctuations of the light response signal.

[0033] In the example of **Fig. 2B**, measurements are first taken at the occlusion mode (condition of artificial kinetics), and then during the steady state (pulse mode). Accordingly, pressure applying assembly **14** is operated to apply over-systolic pressure to the vicinity of the measurement location or upstream thereof and maintain this pressure during cessation time t_{ak}. Measurement unit **12** is operated to apply optical measurements with at least two different wavelengths of light during at least a part of the cessation time. Similarly, measurements taken during a short time period from the moment when the pressure is initially applied and until the actual start of occlusion, should be disregarded. Thereafter (after time t_{ak}), the pressure is released, and a transitional state of blood flow takes place, during about 2-3 seconds. Measurements taken during this time period may also be disregarded. After this transitional blood flow state, the normal blood flow is established, and light response, I_p, is measured.

[0034] Common for both examples, data indicative of the light responses I_p and I_{ak} are processed to determine measured data indicative of time variations of these light responses for each of the at least two wavelengths λ_1 and λ_2: $I^{\lambda.1}{}_p(t)$, $I^{\lambda.2}{}_p(t)$ and $I^{\lambda.1}{}_{ak}(t)$, $I^{\lambda.2}(t)$. These measured data are further processed to determine a relation between the time variations of the light responses, namely a relation R_1 between functions $I^{\lambda.1}{}_p(t)$, $I^{\lambda.2}{}_p(t)$, and a relation R_2 between functions $I^{\lambda.1}{}_{ak}(t)$, $I^{\lambda.2}{}_{ak}(t)$, This allows for calculating the desired blood parameter. In this connection, it should be under-

stood that the wavelengths of illumination are appropriately selected for measuring a specific blood parameter.

[0035] The so-determined relations R_1 and R_2 between the time variations of the pulse- and occlusion-mode light responses enable to reduce time element both for the pulsatile and the occlusion related components of the optical response. The use of more than two wavelengths in each measurement session, allows for determining the relation between the light responses' variations for different pairs of wavelengths, which provide different sensitivities to different blood parameters.

[0036] The following are experimental results of the invention. **Fig. 3A** shows the time variations of the pulse mode light responses, $I^1_p(t)$, $I^2_p(t)$, $I^3_p(t)$, $I^4_p(t)$, for, respectively, 610nm, 670nm, 812 and 880nm wavelength; and **Fig. 3B** shows the time variations of the occlusion mode light responses, $I^1_{ak}(t)$, $I^2_{ak}(t)$, $I^3_{ak}(t)$, $I^4_{ak}(t)$, for the same wavelengths, respectively.

[0037] **Figs. 4A-4C** show relations R_1-R_2, R_1'-R_2' and R_1"-R_2" for, respectively, the following pairs of wavelengths λ_1-λ_2: 670nm-880nm, 610nm-880nm, 810nm-880nm, where the wavelengths are selected for the concurrent determination of hemoglobin concentration and oxygen saturation, wavelength 880nm being the so-called *"reference wavelength"*. In the present example, the relation R is determined as a parametric slope (PS) namely a ratio between variation of the light response for one wavelength λ_1 and the variation of the light response for the reference wavelength λ_2, for example calculated as: $\frac{\partial \ln(I_{\lambda 1})/\partial t}{\partial \ln(I_{\lambda 2})/\partial t}$.

[0038] As indicated above, different pairs of wavelengths provide different sensitivities to different blood parameters. For example, the value of PS for 670nm and 880nm in the pulse mode (pulsatile signal) is most sensitive for HbO2/(Hb +HbO2) ratio (oxygen saturation), but reveals a small sensitivity to the hemoglobin concentration as well. The value of PS for 610nm and 880nm in the occlusion mode is very sensitive to hemoglobin/hematocrit, and is also sensitive at a certain degree to the blood Hb oxygen saturation. It should be noted that there are additional parameters, like blood flow and/or tissue hematocrit that can affect the PS value. Therefore, the use of additional pairs of wavelength is preferred in order to account or compensate for the variable parameters of management.

[0039] For the determination of Hb(SPO2) or glucose concentration, the following expression can be used:

$$Hb = \sum_{i=1}^{N} A_i \cdot (PS)_i \qquad (1)$$

where A_i are determined by using previous calibration; $(PS)_i$ are different pairs of parametric slopes; and i is a number of wavelength.

[0040] The calibration stage consists of the following: Measurements are taken *in vivo* for the population of patients, ranging from very low Hb values up to very high Hb values. Then, the reference Hb from the patients' blood is taken, using any standard Lab method. Thereafter, PS is calculated for the pulse and occlusion modes, and coefficients of the regression formula are determined using a standard mean least square calculation technique.

[0041] Examples of **Figs. 4A-4C** demonstrate the differences between PS as function of Hb for pulsatile and post occlusion signals.

[0042] Mathematically it means that pulsatile PS is determined as:

$$PS(pulse) = \frac{\partial Ln(I_{\lambda 1})/\partial(x)}{\partial Ln(I_{\lambda ref})/\partial(x)} \qquad (2)$$

wherein x is the blood pulsatile changes, and PS for post occlusion signal is determined as:

$$PS(occlusion) = \frac{\partial Ln(I_{\lambda 1})/\partial(\mu_{\lambda transport1}(\lambda))}{\partial Ln(I_{\lambda ref})/\partial(\mu_{\lambda transport1}(\lambda ref))} \cdot \frac{\partial(\mu_{\lambda transport1}(\lambda))/\partial(t)}{\partial(\mu_{\lambda transport1}(\lambda ref))/\partial(t)} \qquad (3)$$

wherein I is the optical response signal

[0043] The time dependent behavior of $\mu_{\lambda transport1}$ during the occlusion is the optical parameter driven by artificial kinetics.

[0044] Expressions (2) and (3) are supplemental to each other. The combination of these expressions provides additional information. The simplest combination is:

$$Hb = \sum_{i=1}^{N} A_i \cdot (PS(pulse))_i + \sum_{i=1}^{M} B_i \cdot (PS(occlusion))_i \qquad (4)$$

[0045] For example, using only pulsatile component (expression 1) for Hb determination results in correlation of r=65%, using only post occlusion signal on some dataset results in correlation r=63%. However, the combination of both signals (expression 4) provides a 85% correlation between the calculated and real value (invasively measured Hb value).

[0046] Naturally, if the explicit expressions (2) and (3) are provided in any form, then equations (2) and (3) can be solved symbolically or numerically as a set of equations.

[0047] It should be noted that this methodology can be used not only with the parametric slope being a primer parameter, but for any form or derivative of such a parametric slope or a differential thereof or Ln(I), or for any combination of them. The assessment of various parameters can be facilitated by using a combination of signals of pulse, pre-occlusion blood state manipulation and post-occlusion, for example: SPO2, Hb, Glucose, HbCO, MetHb.

[0048] Those skilled in the art will readily appreciate that many modifications and changes may be applied to the invention as hereinbefore exemplified without departing from its scope defined in and by the appended claims. In the method claims which follow, characters which are used to designate claim steps, are provided for convenience only and do not apply any particular order of performing the steps.

Claims

1. A method for use in non-invasive measurements of at least one blood and/or tissue related parameter **BP** in a subject, the method comprising:

(a) performing measurements on a measurement location on the subject during different blood flow conditions, by applying an external electromagnetic field of different pairs of wavelengths to the measurement location including a certain reference wavelength, and detecting responses of the measurement location to each of the wavelengths, and generating data indicative of the detected responses corresponding to said different blood flow conditions respectively, wherein said performing of measurements includes detection of first responses corresponding to the different wavelengths respectively, all measured during a first time period t_p corresponding to a first condition of the blood flow being a normal blood flow in the measurement location thereby enabling generation of first measured data indicative of first time functions of variation of the responses corresponding to the different wavelength values, and detection of second responses corresponding to said different wavelengths respectively all measured during a second time period t_{ak} corresponding to a second condition of the blood flow being a condition of artificial kinetics in the measurement location enabling generation of second measured data indicative of second time functions of variation of the responses corresponding to said different wavelength values, the different pairs of wavelengths being selected to enable different sensitivity of measurements to said at least one blood and/or tissue related parameter during different blood flow conditions; and

(b)processing the first measured data corresponding to the first condition of normal blood flow at the measurement location and determining, from the first measured data, first parametric slopes $PS(pulse)_i$ of the first time functions corresponding to said first time period *tp*, and processing the second measured data corresponding to the second condition of artificial kinetics at the measurement location and determining from the second measured data second parametric slopes $PS(occlusion)_i$ of the second time functions corresponding to said second time period t_{ak}; and

(c) determining the at least one blood and/or tissue related parameter **BP** from a combination of said first and said second different parametric slopes $PS(pulse)_i$ and $PS(occlusion)_i$, according to the following regression formula:

$$BP = \sum_{i=1}^{N} A_i \cdot PS(pulse)_i + \sum_{i=1}^{M} B_i \cdot PS(occlusion)_i ,$$

wherein A_i and B_i are different calibration coefficients corresponding to the different blood flow conditions; and $PS(pulse)_i$ and $PS(occlusion)_i$ are first and second parametric slopes obtained for the same pairs of wavelengths.

2. The method of Claim 1, wherein the condition of artificial kinetics is created by applying over-systolic pressure to the vicinity of the measurement location, or to a location on the subject upstream of the measurement location with respect to a normal blood flow direction in the body.

3. The method of Claim 1, wherein the light response includes light transmitted through and/or scattered from the body portion.

4. The method of Claim 3, wherein a pair of the first and second parametric slopes PS_1 and PS_2 obtained for the same pair of wavelengths λ_1-λ_2 are determined as:

$$PS_1 = \frac{\partial Ln(I^1\lambda 1)/\partial(t)}{\partial Ln(I^1\lambda 2)/\partial(t)}$$

and

$$PS_2 = \frac{\partial Ln(I^2\lambda 1)/\partial(t)}{\partial Ln(I^2\lambda 2)/\partial(t)}$$

wherein I^1 and I^2 are the first and second time functions, respectively, and PS_1 and PS_2 are parametric slopes PS (*pulse*) and PS(*occlusion*), respectively.

5. The method of any one of the preceding Claims, wherein said measurements performed while at the normal blood flow condition include measurements carried out prior to the measurements under the artificial kinetics condition, and/or thereafter.

6. The method of any one of the preceding Claims, wherein said at least one blood and/or tissue related parameter **BP** includes at least one of the following: concentration of substance in blood and oxygen saturation.

7. The method of Claim 6, wherein said substance includes at least one of the following: hemoglobin, hematocrit, glucose.

8. The method of any one of the preceding Claims, wherein said subject is a human body.

9. A device for use in non-invasive measurements of at least one blood and/or tissue related parameter **BP** in a subject, the device comprising:

(a) a measurement unit comprising an electromagnetic field source assembly configured and operable for applying an external electromagnetic field of different pairs of wavelengths including a certain reference wavelength to a measurement location on the body during different blood flow conditions, and a detector arrangement configured and operable for detecting responses of the measurement location to the applied field and generating measured data indicative thereof corresponding to said different blood flow conditions respectively;
(b) a pressure applying assembly configured and operable for controllably applying over-systolic pressure to the body portion so as to create a second condition of artificial kinetics in the measurement location **characterized**

by a blood flow cessation;
(c) a control unit connected to the measurement unit and to the pressure applying assembly for operating them to selectively carry out the following:

operate the measurement unit during a first time period t_p to take the measurements on the measurement location with the different pairs of wavelengths of the electromagnetic field under a first condition of the blood flow being a normal blood flow at the measurement location with substantially no application of pressure during said first time period t_p, thereby causing generation of first measured data indicative of first time functions of variation of the responses corresponding to the respective wavelengths corresponding to said first condition of normal blood flow; and operate the pressure application assembly to apply and maintain the over-systolic pressure for a second time period t_{ak}, and operate the measurement unit during said second time period to take the measurements on the measurement location with said wavelengths under the second condition of artificial kinetics in the measurement location thereby causing generation of second measured data indicative of second time functions of variation of the responses corresponding to said wavelengths corresponding to said second condition of artificial kinetics; the different pairs of wavelengths being selected to enable different sensitivity of measurements to said at least one blood and/or tissue related parameter during different blood flow conditions;
receive and process said first and second measured data, said processing comprising: determining first parametric slopes $PS(pulse)_i$ of the first time functions corresponding to the first time period t_p, and second parametric slopes PS(*occlusion*)$_i$ of the second time functions corresponding to said second time period t_{ak}, and determining at least one blood and/or tissue related parameter **BP** from a combination of said first and said second parametric slopes PS(*pulse*)$_i$ and PS(*occlusion*)$_i$, according to the following regression formula:

$$BP = \sum_{i=1}^{N} A_i \cdot PS(pulse)_i + \sum_{i=1}^{M} B_i \cdot PS(occlusion)_i$$

wherein A_i and B_i are different calibration coefficients corresponding to the different blood flow conditions; and $PS(pulse)_i$ and $PS(occlusion)_i$ are first and second parametric slopes obtained for the same pairs of wavelengths.

10. The device of Claim 9, wherein said field source includes at least one light source and said detector unit includes at least one light detector.

11. The device of Claim 9 or 10, wherein the control unit operates the measurement unit and the pressure applying assembly such that said measurements carried out at the normal blood flow condition include measurements performed prior to the measurements under the artificial kinetics condition, and/or thereafter.

12. The device of Claims 10 or 11, wherein the control unit is preprogrammed to determine a pair of the first and second parametric slopes PS_1 and PS_2 for the same pair of wavelengths λ_1-λ_2 as:

$$PS_1 = \frac{\partial Ln(I^1\lambda 1)/\partial(t)}{\partial Ln(I^1\lambda 2)/\partial(t)}$$

and

$$PS_2 = \frac{\partial Ln(I^2\lambda 1)/\partial(t)}{\partial Ln(I^2\lambda 2)/\partial(t)}$$

wherein I^1 and I^2 are the first and second time functions, respectively, and PS_1 and PS_2 *are* PS(*pulse*) and PS (*occlusion*), respectively.

Patentansprüche

1. Verfahren zur Verwendung bei der nichtinvasiven Messung mindestens eines Blut- und/oder Gewebe-bezogenen Parameters **BP** in einem Subjekt, wobei das Verfahren umfasst:

(a) das Ausführen von Messungen an einem Messpunkt am Subjekt unter unterschiedlichen Blutflusszuständen durch Anlegen eines externen elektromagnetischen Feldes von unterschiedlichen Wellenlängenpaaren an dem Messpunkt, die eine bestimmte Referenzwellenlänge umfassen, und das Ermitteln von Reaktionen des Messpunkts auf jede der Wellenlängen, und das Erzeugen von Daten, die für die ermittelten Reaktionen entsprechend der jeweiligen unterschiedlichen Blutflusszustände indikativ sind, wobei das Ausführen von Messungen das Ermitteln von ersten Reaktionen umfasst, die den jeweiligen unterschiedlichen Wellenlängen entsprechen, wobei alle während einer ersten Zeitperiode t_p gemessen werden, die einem ersten Zustand des Blutflusses entspricht, welcher ein normaler Blutfluss am Messpunkt ist, wodurch das Erzeugen erster gemessener Daten ermöglicht wird, die für erste Zeitfunktionen der Veränderung der Reaktionen indikativ sind, die den unterschiedlichen Wellenlängenwerten entsprechen, sowie das Ermitteln von zweiten Reaktionen, die den jeweiligen unterschiedlichen Wellenlängen entsprechen, wobei alle während einer zweiten Zeitperiode t_{ak} gemessen werden, die einem zweiten Zustand des Blutflusses entspricht, welcher ein Zustand künstlicher Kinetik am Messpunkt ist, wodurch das Erzeugen zweiter gemessener Daten ermöglicht wird, die für zweite Zeitfunktionen der Veränderung der Reaktionen indikativ sind, die den unterschiedlichen Wellenlängenwerten entsprechen, wobei die unterschiedlichen Wellenlängenpaare ausgewählt werden, um eine unterschiedliche Empfindlichkeit der Messungen gegenüber dem mindestens einen Blut- und/oder Gewebe-bezogenen Parameter unter unterschiedlichen Zuständen des Blutflusses zu ermöglichen und
(b) das Verarbeiten der ersten gemessenen Daten, die dem ersten Zustand normalen Blutflusses am Messpunkt entsprechen und das Bestimmen aus den ersten gemessenen Daten von ersten parametrischen Steigungen $PS\,(Puls)_i$ der ersten Zeitfunktionen, die der ersten Zeitperiode t_p entsprechen und das Verarbeiten der zweiten gemessenen Daten, die dem zweiten Zustand künstlicher Kinetik am Messpunkt entsprechen und das Bestimmen aus den zweiten gemessenen Daten von zweiten parametrischen Steigungen $PS\,(Verschluss)_i$ der zweiten Zeitfunktionen, die der zweiten Zeitperiode t_{ak} entsprechen sowie
(c) das Bestimmen des mindestens einen Blut- und/oder Gewebe-bezogenen Parameters **BP** aus einer Kombination der ersten und zweiten unterschiedlichen parametrischen Steigungen $PS(Puls)_i$ und $PS(Verschluss)_i$ gemäß der folgenden Regressionsformel:

$$\mathrm{BP} = \sum_{i=1}^{N} \mathrm{A_i} \times PS(Puls)_\mathrm{i} + \sum_{i=1}^{M} \mathrm{B_i} \times PS(Verschluss)_\mathrm{i},$$

wobei A_i und B_i unterschiedliche Kalibrierungskoeffizienten darstellen, die den unterschiedlichen Zuständen des Blutflusses entsprechen; und $PS(Puls)_i$ und $PS(Verschluss)_i$ erste und zweite parametrische Steigungen sind, die für dieselben Wellenlängenpaare erhalten werden.

2. Verfahren gemäß Anspruch 1, wobei der Zustand künstlicher Kinetik durch das Anlegen von übersystolischem Druck in der Nähe des Messpunkts geschaffen wird oder an einer Stelle des Subjekts, die in Bezug auf die normale Blutflussrichtung im Körper stromaufwärts des Messpunkts liegt.

3. Verfahren gemäß Anspruch 1, wobei die Lichtreaktion Licht umfasst, das durch den Körperteil geleitet und/oder aus dem Körperteil gestreut wird.

4. Verfahren gemäß Anspruch 3, wobei ein Paar von ersten und zweiten parametrischen Steigungen PS_1 und PS_2, die für dasselbe Paar von Wellenlängen λ_1-λ_2 erhalten wurden, bestimmt werden als:

$$PS_1 = \frac{\partial \mathrm{Ln}(\mathrm{I}^1\lambda 1)/\,\partial(\mathrm{t})}{\partial \mathrm{Ln}(\mathrm{I}^1\lambda 2)/\,\partial(\mathrm{t})}$$

und

$$PS_2 = \frac{\partial \mathrm{Ln}(\mathrm{I}^2\lambda 1)/\,\partial(\mathrm{t})}{\partial \mathrm{Ln}(\mathrm{I}^2\lambda 2)/\,\partial(\mathrm{t})}$$

wobei I^1 und I^2 die ersten beziehungsweise zweiten Zeitfunktionen darstellen und PS_1 und PS_2 parametrische Steigungen *PS*(*Puls*) beziehungsweise *PS*(*Verschluss*) sind.

5. Verfahren gemäß einem der vorherigen Ansprüche, wobei die im Zustand normalen Blutflusses durchgeführten Messungen Messungen umfassen, die vor den Messungen im Zustand künstlicher Kinetik ausgeführt werden und/oder danach.

6. Verfahren gemäß einem der vorherigen Ansprüche, wobei der mindestens eine Blut- und/oder Gewebe-bezogene Parameter **BP** mindestens eines der folgenden umfasst: Konzentration der Blutsubstanz und Sauerstoffsättigung.

7. Verfahren gemäß Anspruch 6, wobei die Substanz mindestens eine der folgenden umfasst: Hämoglobin, Hämatokrit, Glukose.

8. Verfahren nach einem der vorherigen Ansprüche, wobei das Subjekt ein menschlicher Körper ist.

9. Vorrichtung zur Verwendung bei nichtinvasiven Messungen mindestens eines Blut- und/oder Gewebe-bezogenen Parameters **BP** in einem Subjekt, wobei die Vorrichtung umfasst:

(a) eine Messeinheit, die eine Quellanordnung eines elektromagnetischen Feldes umfasst, die konfiguriert und betriebsfähig ist, um ein externes elektromagnetisches Feld unterschiedlicher Wellenlängenpaare, die eine bestimmte Referenzwellenlänge umfassen, an einem Messpunkt am Körper unter unterschiedlichen Blutflusszuständen anzulegen, und eine Detektoranordnung, die konfiguriert und betriebsfähig ist, um Reaktionen des Messpunktes auf das angelegte Feld zu ermitteln und gemessene Daten zu erzeugen, die dafür indikativ sind und den jeweiligen unterschiedlichen Blutflusszuständen entsprechen;
(b) eine Druck anwendende Anordnung, die konfiguriert und betriebsfähig ist, um in kontrollierter Weise übersystolischen Druck auf den Körperteil auszuüben, so dass ein zweiter Zustand künstlicher Kinetik am Messpunkt geschaffen wird, der durch einen Stillstand des Blutflusses gekennzeichnet ist;
(c) eine Kontrolleinheit, die mit der Messeinheit und der Druck anwendenden Anordnung verbunden ist, um diese zu steuern, damit sie das Folgende in selektiver Weise ausführen:

Steuern der Messeinheit während einer ersten Zeitperiode t_p, um Messungen am Messpunkt mit den unterschiedlichen Wellenlängenpaaren des elektrischen Feldes in einem ersten Zustand des Blutflusses vorzunehmen, der ein normaler Blutfluss am Messpunkt mit im Wesentlichen keiner Anwendung von Druck während der ersten Zeitperiode t_p ist, wobei das Erzeugen erster gemessener Daten ausgelöst wird, die indikativ sind für erste Zeitfunktionen von Veränderungen der den jeweiligen Wellenlängen entsprechenden Reaktionen, die dem ersten Zustand normalen Blutflusses entsprechen; und Steuern der Druck anwendenden Anordnung, um den übersystolischen Druck über eine zweite Zeitperiode t_{ak} anzulegen und aufrecht zu erhalten, und Steuern der Messeinheit während der zweiten Zeitperiode, um Messungen am Messpunkt mit den Wellenlängen im zweiten Zustand künstlicher Kinetik am Messpunkt vorzunehmen, wobei das Erzeugen zweiter gemessener Daten ausgelöst wird, die indikativ sind für zweite Zeitfunktionen von Veränderungen der den jeweiligen Wellenlängen entsprechenden Reaktionen, die dem zweiten Zustand künstlicher Kinetik entsprechen; wobei die unterschiedlichen Wellenlängenpaare ausgewählt sind, um eine unterschiedliche Empfindlichkeit der Messungen gegenüber dem mindestens einen Blut- und/oder Gewebe-bezogenen Parameter während unterschiedlicher Zustände des Blutflusses zu ermöglichen;
das Empfangen und Verarbeiten der ersten und zweiten gemessenen Daten, wobei das Verarbeiten um-

fasst: das Bestimmen erster parametrischer Steigungen $PS(Puls)_i$ der ersten Zeitfunktionen, die der ersten Zeitperiode t_p entsprechen und zweiter parametrischer Steigungen $PS(Verschluss)_i$ der zweiten Zeitfunktionen, die der zweiten Zeitperiode t_{ak} entsprechen und das Bestimmen mindestens eines Blut- und/oder Gewebe-bezogenen Parameters **BP** aus einer Kombination der ersten und zweiten parametrischen Steigungen $PS(Puls)_i$ und $PS(Verschluss)_i$ gemäß der folgenden Regressionsformel:

$$BP = \sum_{i=1}^{N} A_i \times PS(Puls)_i + \sum_{i=1}^{M} B_i \times PS(Verschluss)_i,$$

wobei A_i und B_i unterschiedliche Kalibrierungskoeffizienten darstellen, die den unterschiedlichen Zuständen des Blutflusses entsprechen; und $PS(Puls)_i$ und $PS(Verschluss)_i$ erste und zweite parametrische Steigungen sind, die aus denselben Wellenlängenpaaren erhalten werden.

10. Vorrichtung gemäß Anspruch 9, wobei die Feldquelle mindestens eine Lichtquelle umfasst und die Detektoreinheit mindestens einen Lichtdetektor umfasst.

11. Vorrichtung gemäß der Ansprüche 9 und 10, wobei die Kontrolleinheit die Messeinheit und die Druck anwendende Anordnung so steuert, dass die im Zustand normalen Blutflusses durchgeführten Messungen Messungen umfassen, die vor den Messungen im Zustand künstlicher Kinetik ausgeführt werden und/oder danach.

12. Vorrichtung gemäß Anspruch 10 oder 11, wobei die Kontrolleinheit vorprogrammiert ist, um ein Paar von ersten und zweiten parametrischen Steigungen PS_1 und PS_2 für dasselbe Paar von Wellenlängen λ_1-λ_2 zu bestimmen als:

$$PS_1 = \frac{\partial \mathrm{Ln}(I^1\lambda 1)/\partial(t)}{\partial \mathrm{Ln}(I^1\lambda 2)/\partial(t)}$$

und

$$PS_2 = \frac{\partial \mathrm{Ln}(I^2\lambda 1)/\partial(t)}{\partial \mathrm{Ln}(I^2\lambda 2)/\partial(t)}$$

wobei I^1 und I^2 die ersten beziehungsweise zweiten Zeitfunktionen darstellen und *PS1* und *PS2* parametrische Steigungen PS (*Puls*) beziehungsweise PS (*Verschluss*) sind.

Revendications

1. Procédé destiné à être utilisé dans des mesures non invasives d'au moins un paramètre BP lié au sang et/ou à un tissu chez un sujet, le procédé comprenant :

(a) la réalisation de mesures sur un emplacement de mesure sur le sujet durant différentes conditions de circulation sanguine, par application d'un champ électromagnétique externe de différentes paires de longueurs d'onde à l'emplacement de mesure externe y compris une certaine longueur d'onde de référence, par détection de réponses de l'emplacement de mesure à chacune des longueurs d'onde, et par génération de données indiquant les réponses détectées correspondant auxdites différentes conditions de circulation sanguine respectivement, dans lequel ladite réalisation des mesures comprend la détection de premières réponses correspondant aux différentes longueurs d'onde respectivement, toutes mesurées durant une première période de temps t_p correspondant à une première condition de circulation sanguine étant une circulation sanguine normale au niveau de l'emplacement de mesure, permettant ainsi la génération de premières données mesurées indi-

quant des premières fonctions temporelles de variation des réponses correspondant aux différentes valeurs de longueur d'onde, et la détection de secondes réponses correspondant auxdites différentes longueurs d'onde respectivement, toutes mesurées durant une seconde période de temps t_{ak} correspondant à une seconde condition de la circulation sanguine étant une condition de cinétique artificielle au niveau de l'emplacement de mesure permettant la génération de secondes données mesurées indiquant des secondes fonctions temporelles de variation des réponses correspondant auxdites différentes valeurs de longueur d'onde, les différentes paires de longueurs d'onde étant choisies pour permettre une sensibilité de mesures différente audit ou auxdits paramètres liés au sang et/ou à un tissu pendant différentes conditions de circulation sanguine ; et

(b) le traitement des premières données mesurées correspondant à la première condition de circulation sanguine normale au niveau de l'emplacement de mesure et la détermination, à partir des premières données mesurées, de premières pentes paramétriques PS(*pouls*)$_i$ des premières fonctions temporelles correspondant à ladite première période de temps t_p, et le traitement des secondes données mesurées correspondant à la seconde condition de cinétique artificielle au niveau de l'emplacement de mesure et la détermination à partir des secondes données mesurées de secondes pentes paramétriques $PS(occlusion)_i$ des secondes fonctions temporelles correspondant à ladite seconde période de temps t_{ak} ; et

(c) la détermination du ou des paramètres BP liés au sang et/ou à un tissu à partir d'une combinaison desdites premières et secondes pentes paramétriques différentes $PS(pouls)_i$ et $PS(occlusion)_i$, en fonction de la formule de régression suivante :

$$BP = \sum_{i=1}^{N} A_i \cdot PS(pouls)_i + \sum_{i=1}^{M} B_i \cdot PS(occlusion)_i ,$$

dans laquelle A_i et B_i sont des coefficients d'étalonnage différents correspondant aux différentes conditions de circulation sanguine ; et PS(*pouls*)$_i$ et PS(*occlusion*)$_i$ sont des premières et secondes pentes paramétriques obtenues pour la même paire de longueurs d'onde.

2. Procédé selon la revendication 1, dans lequel la condition de cinétique artificielle est créée par application d'une pression sur-systolique à proximité de l'emplacement de mesure, ou à un emplacement sur le sujet en amont de l'emplacement de mesure relativement à un sens normal de circulation sanguine dans le corps.

3. Procédé selon la revendication 1, dans lequel la réponse lumineuse comprend la lumière transmise à travers la partie du corps et/ou diffusée par la partie du corps.

4. Procédé selon la revendication 3, dans lequel les pentes d'une paire des première et seconde pentes paramétriques PS_1 et PS_2 obtenues pour la même paire de longueurs d'onde λ_1-λ_2 sont déterminées de la manière suivante :

$$PS_1 = \frac{\partial Ln(I^1\lambda 1)/\partial(t)}{\partial Ln(I^1\lambda 2)/\partial(t)}$$

et

$$PS_2 = \frac{\partial Ln(I^2\lambda 1)/\partial(t)}{\partial Ln(I^2\lambda 2)/\partial(t)}$$

dans laquelle I^1 et I^2 sont les première et seconde fonctions temporelles, respectivement, et PS_1 et PS_2 sont les

pentes paramétriques PS(*pouls*) et PS(*occlusion*), respectivement.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel lesdites mesures réalisées dans la condition de circulation sanguine normale comprennent des mesures réalisées avant et/ou après les mesures dans la condition de cinétique artificielle.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel le ou les paramètres BP liés au sang et/ou au tissu comprennent au moins l'un de ce qui suit : concentration d'une substance dans le sang et saturation en oxygène.

7. Procédé selon la revendication 6, dans lequel ladite substance comprend au moins l'un de ce qui suit : hémoglobine, hématocrite, glucose.

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit sujet est un corps humain.

9. Dispositif destiné à être utilisé dans des mesures non invasives d'au moins un paramètre BP lié au sang et/ou à un tissu chez un sujet, le dispositif comprenant :

(a) une unité de mesure comprenant un ensemble source de champ électromagnétique configuré et pouvant fonctionner pour appliquer un champ électromagnétique externe de différentes paires de longueurs d'onde y compris une certaine longueur d'onde de référence à un emplacement de mesure sur le corps pendant différentes conditions de circulation sanguine, et un agencement de détecteur configuré et pouvant fonctionner pour détecter les réponses de l'emplacement de mesure au champ appliqué et générer des données mesurées les indiquant et correspondant auxdites différentes conditions de circulation sanguine respectivement ;
(b) un ensemble d'application de pression configuré et pouvant fonctionner pour appliquer sous régulation une pression sur-systolique à la partie du corps de manière à créer une seconde condition de cinétique artificielle au niveau de l'emplacement de mesure **caractérisée par** une interruption de la circulation sanguine ;
(c) une unité de commande connectée à l'unité de mesure et à l'ensemble d'application de pression pour les faire fonctionner et sélectivement réaliser ce qui suit :

faire fonctionner l'unité de mesure pendant une première période de temps t_p pour prendre les mesures sur l'emplacement de mesure avec les différentes paires de longueurs d'onde du champ électromagnétique dans une première condition de circulation sanguine qui est une circulation sanguine normale au niveau de l'emplacement de mesure sensiblement sans appliquer de pression pendant ladite première période de temps t_p, entraînant ainsi la génération de premières données mesurées indiquant des premières fonctions temporelles de variation des réponses correspondant aux longueurs d'onde respectives correspondant à ladite première condition de circulation sanguine normale ; et faire fonctionner l'ensemble d'application de pression pour appliquer et maintenir la pression sur-systolique pendant une seconde période de temps t_{ak}, et faire fonctionner l'unité de mesure durant ladite seconde période de temps pour prendre les mesures sur l'emplacement de mesure avec lesdites longueurs d'onde dans la seconde condition de cinétique artificielle au niveau de l'emplacement de mesure, entraînant ainsi la génération de secondes données mesurées indiquant des secondes fonctions temporelles de variation des réponses correspondant auxdites longueurs d'onde correspondant à ladite seconde condition de cinétique artificielle ; les différentes paires de longueurs d'onde étant choisies pour permettre une sensibilité de mesures différente audit ou auxdits paramètres liés au sang et/ou à un tissu pendant différentes conditions de circulation sanguine ;
recevoir et traiter lesdites premières et secondes données mesurées, ledit traitement comprenant : la détermination de premières pentes paramétriques PS(*pouls*)$_i$ des premières fonctions temporelles correspondant à la première période de temps t_p et de secondes pentes paramétriques PS(*occlusion*)$_i$ des secondes fonctions temporelles correspondant à ladite seconde période de temps t_{ak}, et la détermination du ou des paramètres BP liés au sang et/ou à un tissu à partir d'une combinaison desdites premières et secondes pentes paramétriques PS(*pouls*)$_i$ et PS(*occlusion*)$_i$, en fonction de la formule de régression suivante :

$$BP = \sum_{i=1}^{N} A_i \cdot PS(pouls)_i + \sum_{i=1}^{M} B_i \cdot PS(occlusion)_i ,$$

dans laquelle A_i et B_i sont des coefficients d'étalonnage différents correspondant aux différentes conditions de circulation sanguine ; et $PS(pouls)_i$ et $PS(occlusion)_i$ sont des premières et secondes pentes paramétriques obtenues pour la même paire de longueurs d'onde.

10. Dispositif selon la revendication 9, dans lequel ladite source de champ comprend au moins une source de lumière et ladite unité de détecteur comprend au moins un détecteur de lumière.

11. Dispositif selon la revendication 9 ou 10, dans lequel l'unité de commande fait fonctionner l'unité de mesure et l'ensemble d'application de pression de manière à ce que lesdites mesures réalisées dans la condition de circulation sanguine normale comprennent des mesures réalisées avant et/ou après les mesures dans la condition de cinétique artificielle.

12. Dispositif selon la revendication 10 ou 11, dans lequel l'unité de commande est préprogrammée pour déterminer une paire de première et seconde pentes paramétriques PS_1 et PS_2 pour la même paire de longueurs d'onde λ_1-λ_2 de la manière suivante :

$$PS_1 = \frac{\partial Ln(I^1\lambda 1)/\partial(t)}{\partial Ln(I^1\lambda 2)/\partial(t)}$$

et

$$PS_2 = \left| \frac{\partial Ln(I^2\lambda 1)/\partial(t)}{\partial Ln(I^2\lambda 2)/\partial(t)} \right|$$

dans laquelle I^1 et I^2 sont les première et seconde fonctions temporelles, respectivement, et PS_1 et PS_2 sont PS (*pouls*) et PS(*occlusion*), respectivement.

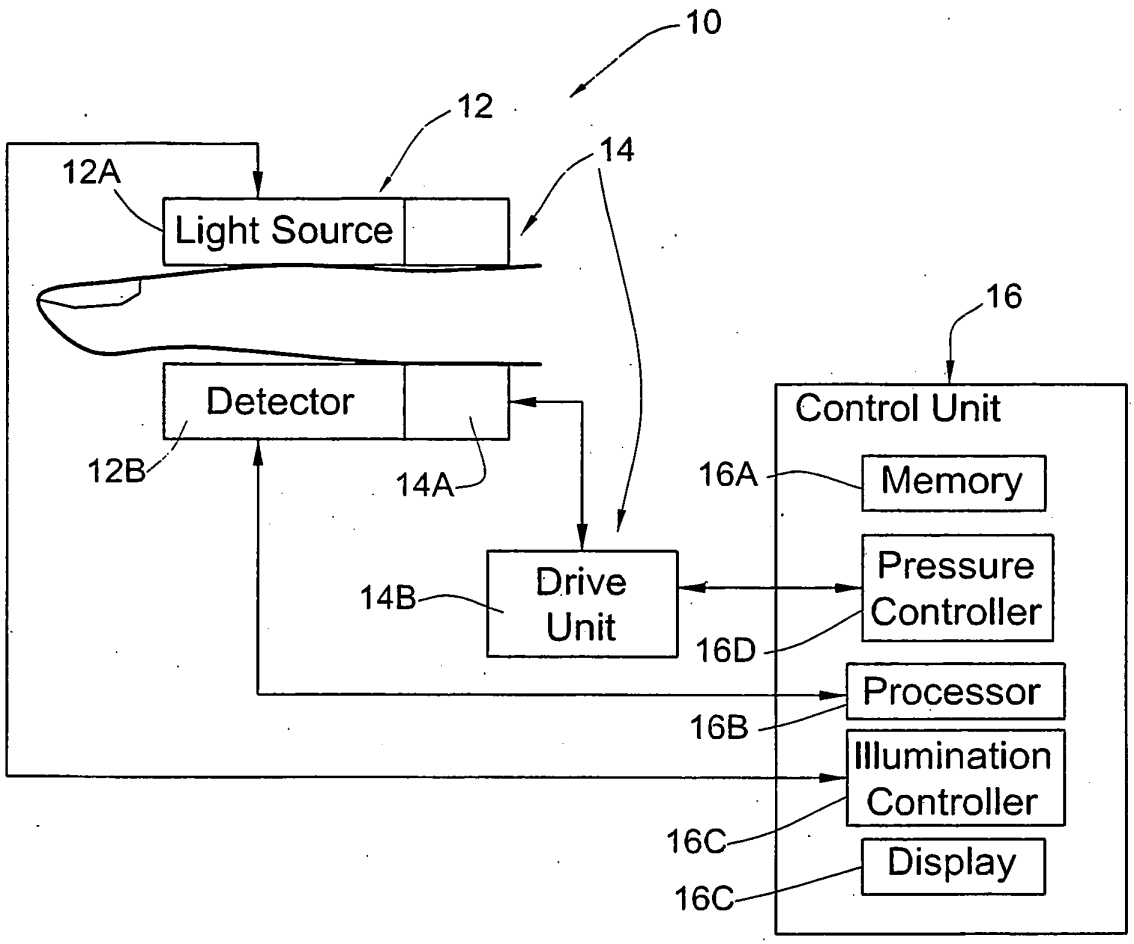
10
12
14
12A
Light Source
16
Detector
Control Unit
12B
14A
16A
Memory
Pressure Controller
14B
Drive Unit
16D
Processor
16B
Illumination Controller
16C
Display
16C

FIG. 1

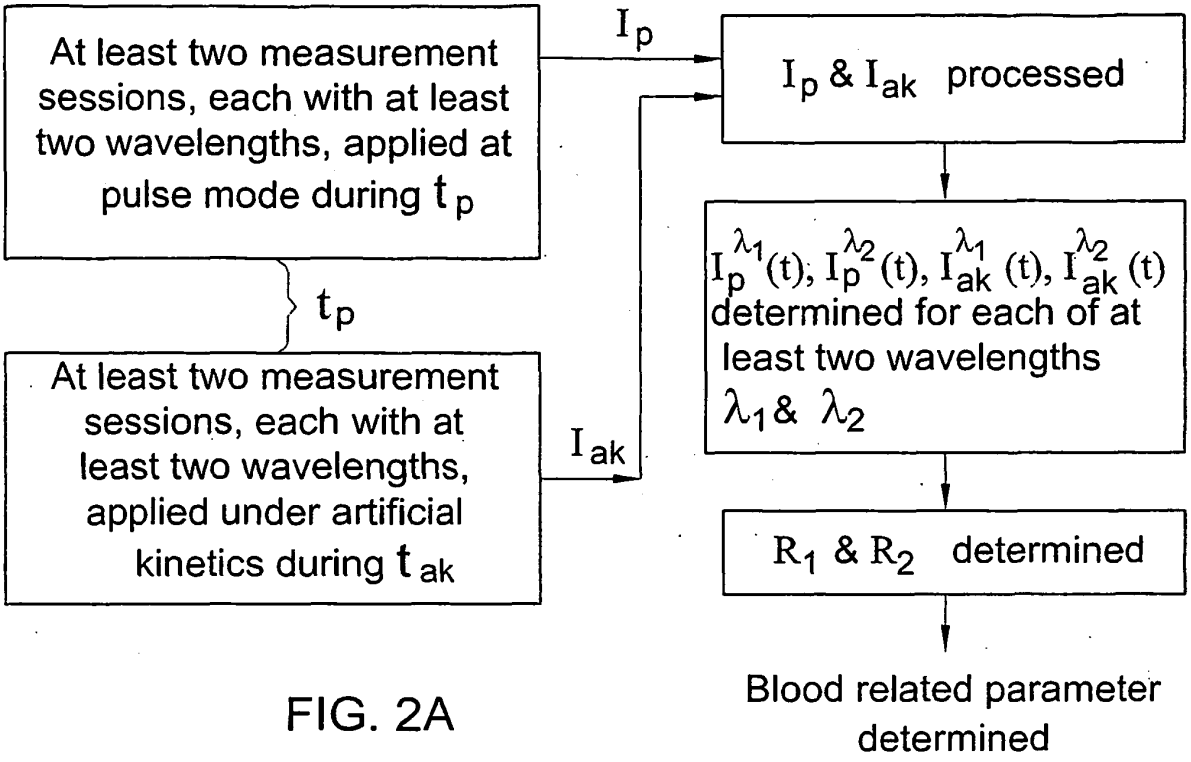
At least two measurement sessions, each with at least two wavelengths, applied at pulse mode during t_p
t_p
At least two measurement sessions, each with at least two wavelengths, applied under artificial kinetics during t_{ak}
I_p
I_{ak}
I_p & I_{ak} processed
$I_p^{\lambda_1}(t), I_p^{\lambda_2}(t), I_{ak}^{\lambda_1}(t), I_{ak}^{\lambda_2}(t)$ determined for each of at least two wavelengths λ_1 & λ_2
R_1 & R_2 determined
Blood related parameter determined

FIG. 2A

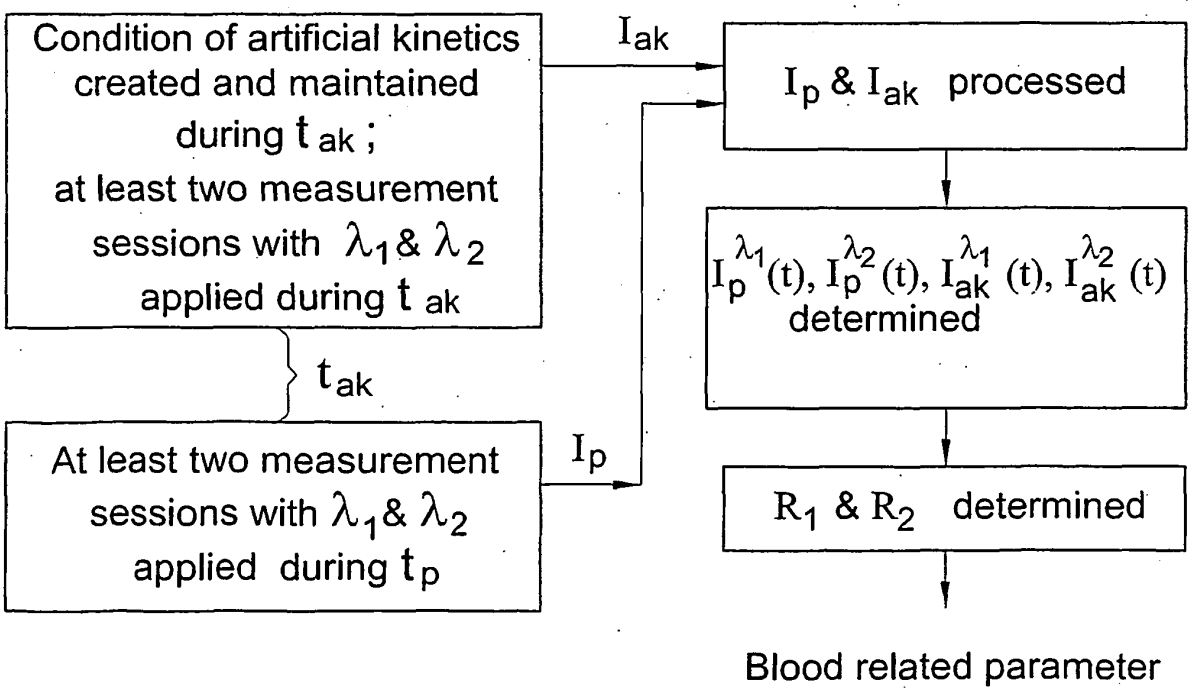
Condition of artificial kinetics created and maintained during t_{ak} ; at least two measurement sessions with λ_1 & λ_2 applied during t_{ak}
t_{ak}
At least two measurement sessions with λ_1 & λ_2 applied during t_p
I_{ak}
I_p
I_p & I_{ak} processed
$I_p^{\lambda_1}(t), I_p^{\lambda_2}(t), I_{ak}^{\lambda_1}(t), I_{ak}^{\lambda_2}(t)$ determined
R_1 & R_2 determined
Blood related parameter

FIG. 2B

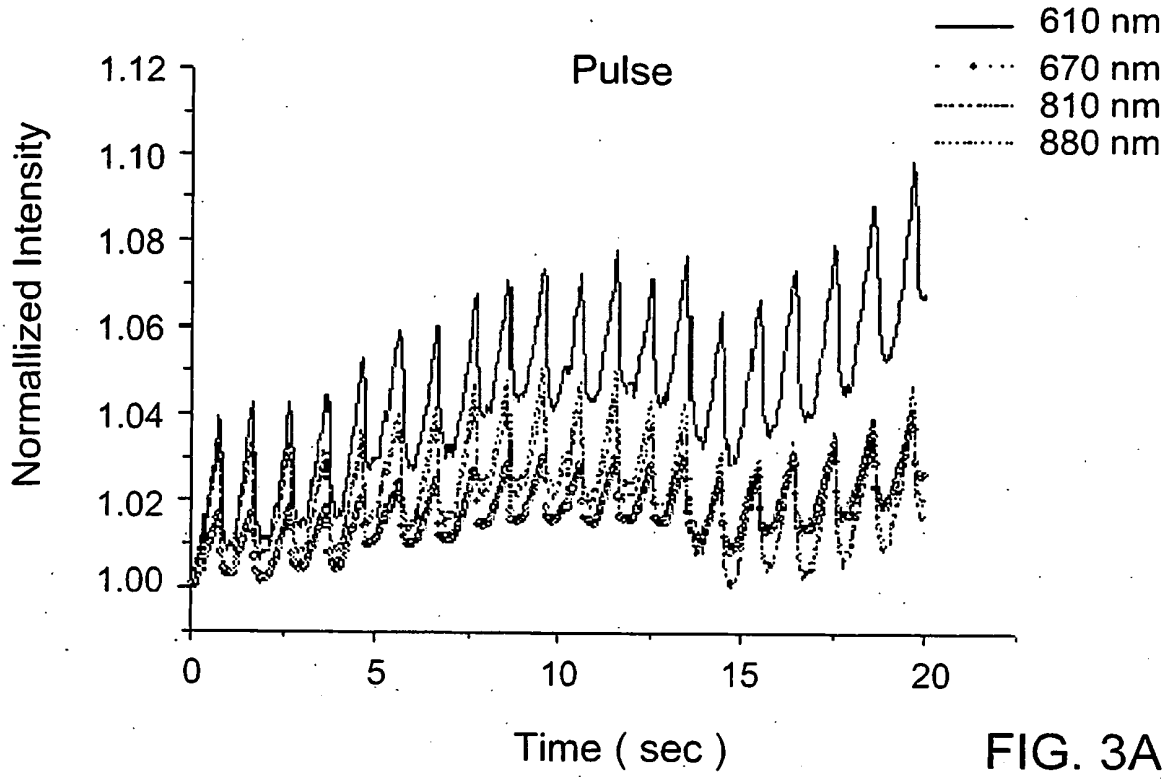
Pulse
610 nm
670 nm
810 nm
880 nm
Normallized Intensity
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0
5
10
15
20
Time (sec)

FIG. 3A

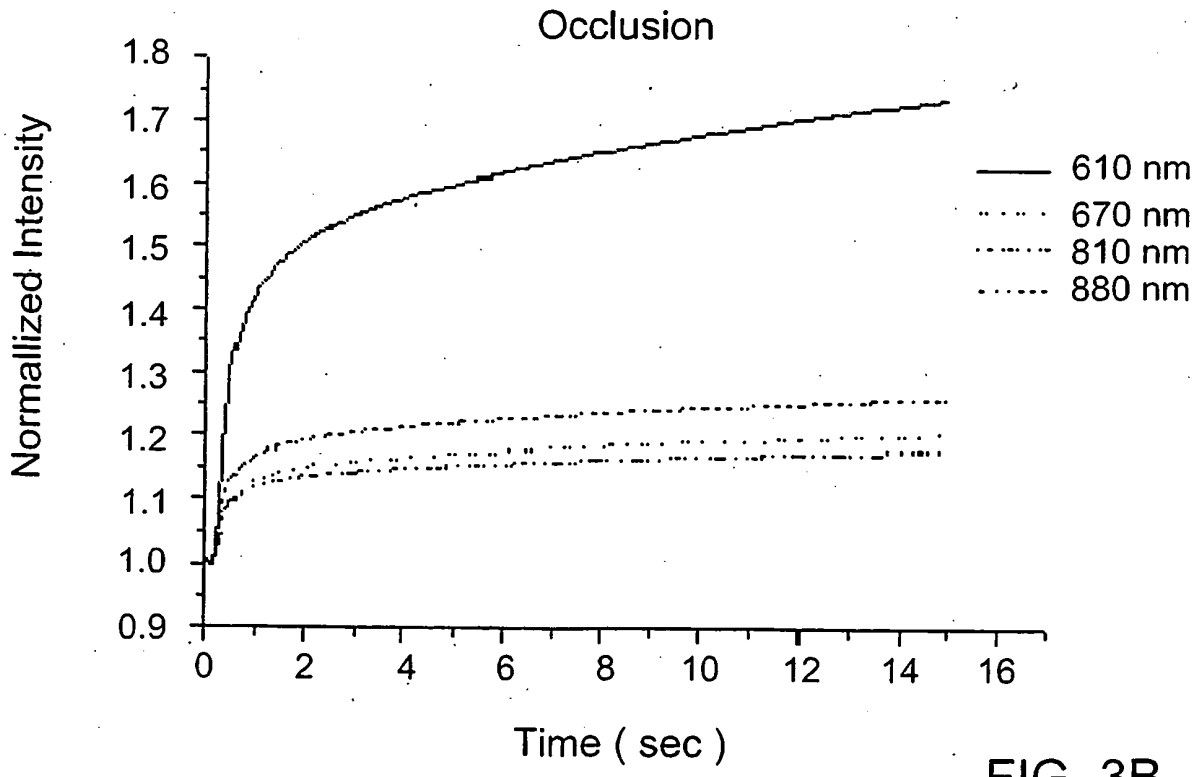
Occlusion
610 nm
670 nm
810 nm
880 nm
Normallized Intensity
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0
2
4
6
8
10
12
14
16
Time (sec)

FIG. 3B

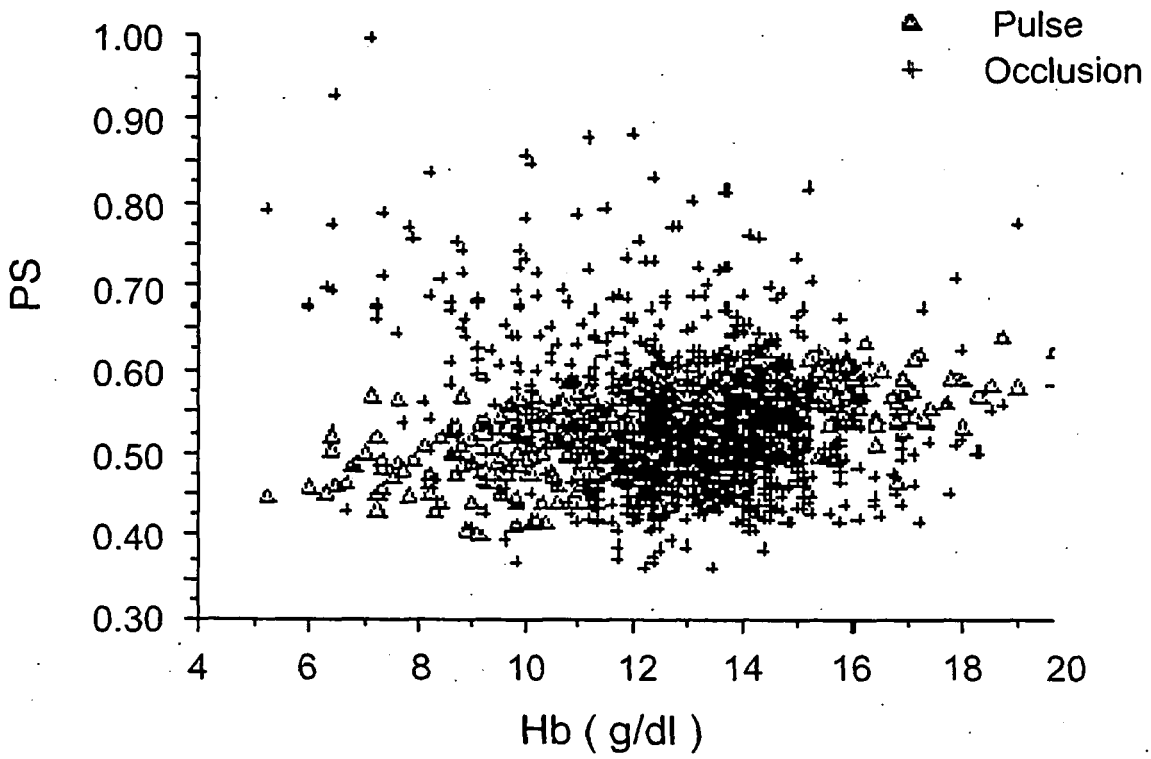
Pulse
Occlusion
PS
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
4
6
8
10
12
14
16
18
20
Hb (g/dl)

FIG. 4A

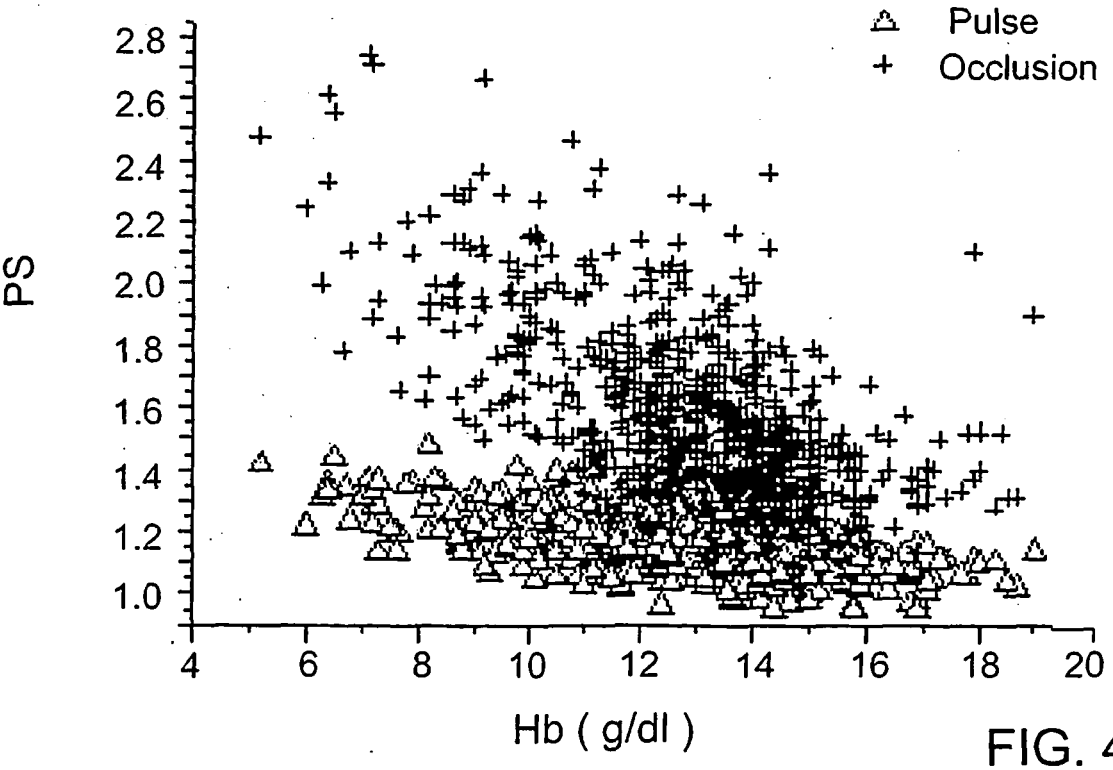
Pulse
Occlusion
PS
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
4
6
8
10
12
14
16
18
20
Hb (g/dl)

FIG. 4B

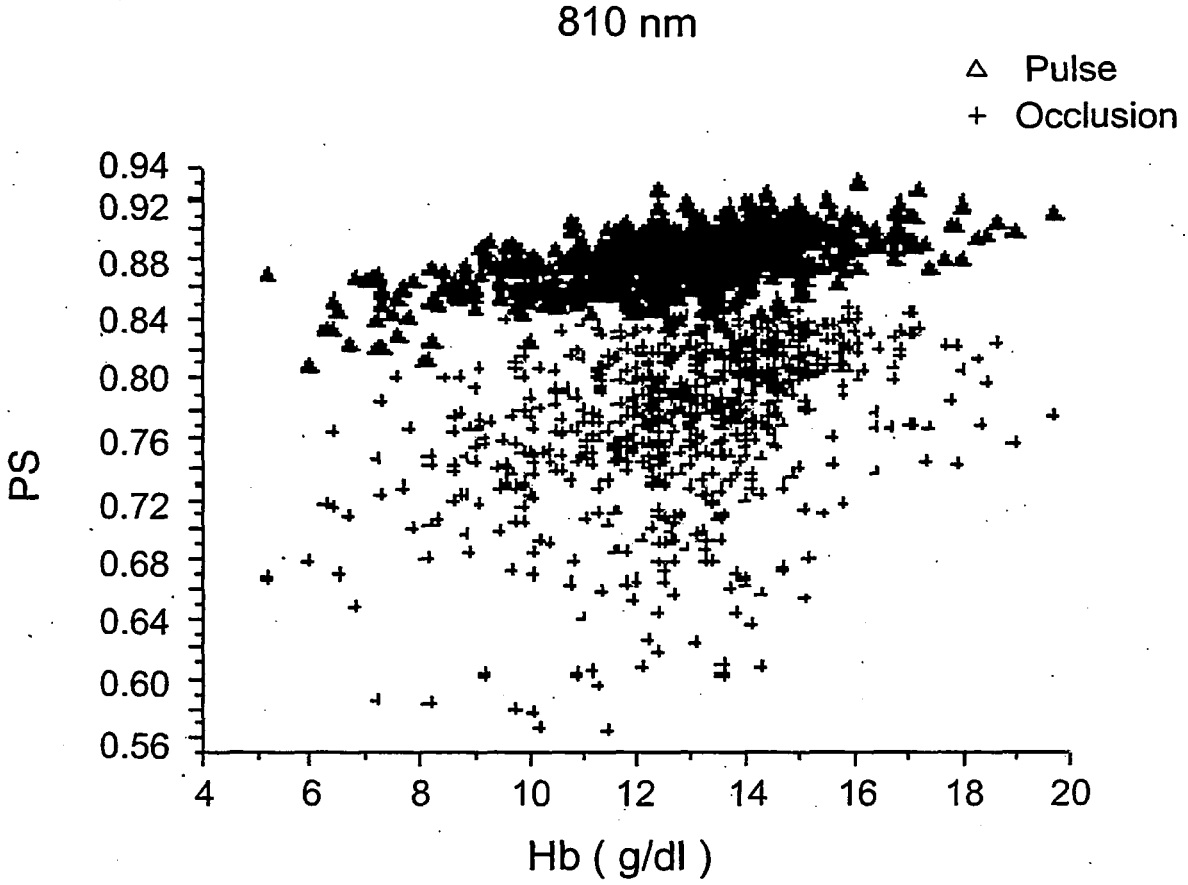
810 nm
Pulse
Occlusion
PS
0.94
0.92
0.88
0.84
0.80
0.76
0.72
0.68
0.64
0.60
0.56
4
6
8
10
12
14
16
18
20
Hb (g/dl)

FIG. 4C

REFERENCES CITED IN THE DESCRIPTION

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- **KYE JIN JEON et al.** Noninvasive total hemoglobin naeasurement. *Journal of Biomedical Optics,* January 2002, vol. 7 (1), 45-50 **[0010]**

专利名称(译)	用于受试者中的非侵入性测量的方法和装置		
公开(公告)号	EP1942790B1	公开(公告)日	2013-01-30
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发明人	FINE, ILYA		
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外部链接	Espacenet		

摘要(译)

提出了一种用于受试者（例如患者体内）的非侵入性测量的方法和系统。根据该技术，通过将外部电磁场施加到测量位置并检测测量位置的至少两个响应并且生成指示检测到的响应的数据，在对象中的测量位置上执行测量。这些至少两个响应的特征在于某个可控参数的至少两个不同值。测量包括在测量位置中的正常血流条件下执行的测量，使得能够生成指示针对至少两个参数值中的每一个的响应的第一时间变化的第一测量数据，并且包括在条件下执行的测量会话。在测量位置中的人工动力学，能够产生指示所述至少两个参数值中的每一个的响应的第二时间变化的第二测量数据。处理第一和第二测量数据以确定不同参数值的第一时间变化与所述不同参数值的第二时间变化之间的第二关系之间的第一关系。第一和第二关系用于确定至少一个血液和/或组织相关参数。