US 20150173662A1

(19) **United States**

(12) **Patent Application Publication**

Ulman et al.

(10) **Pub. No.: US 2015/0173662 A1**

(43) **Pub. Date: Jun. 25, 2015**

(54) **SYSTEMS AND METHODS FOR MINIMALLY-INVASIVE ARTERIAL BLOOD GAS MEASUREMENT**

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(21) Appl. No.: **14/414,799**

(22) PCT Filed: **Jul. 30, 2013**

(86) PCT No.: **PCT/IB2013/056264**

§ 371 (c)(1),
(2) Date: **Jan. 14, 2015**

(30) **Foreign Application Priority Data**

Aug. 8, 2012 (IN) 3256/CHE/2012

Publication Classification

(51) **Int. Cl.**

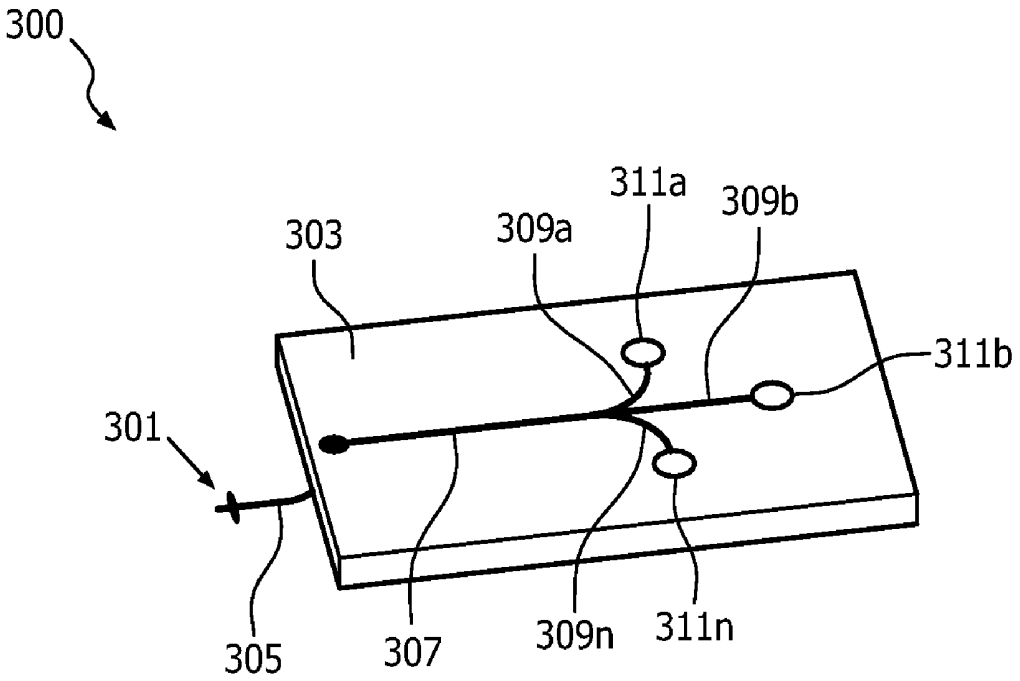
A61B 5/157	(2006.01)
A61B 5/145	(2006.01)
A61B 5/00	(2006.01)
A61B 5/15	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/157*** (2013.01); ***A61B 5/15003*** (2013.01); ***A61B 5/14542*** (2013.01); ***A61B 5/4836*** (2013.01); ***A61B 5/150251*** (2013.01)

(57) **ABSTRACT**

Provided are systems and methods for minimally invasive arterial blood gas measurements. Blood samples are collected using capillary microstructures that minimize patient discomfort and collect samples in a manner such that the samples are not exposed to an environment outside of the sample collection portion. One or more characteristics of the blood sample are then calculated and used to derive one or more arterial blood gas measurements for the sample.



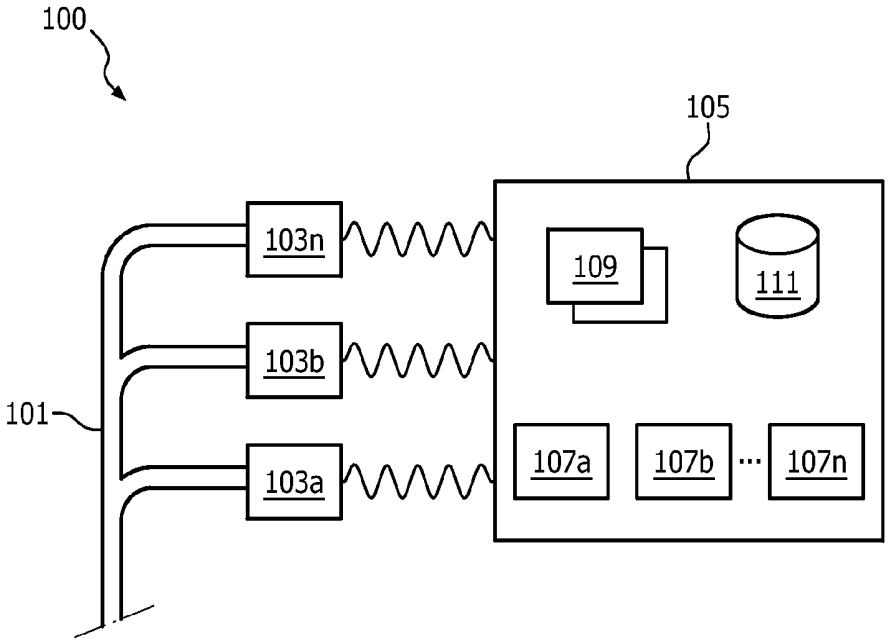

100
105
103n
103b
103a
101
109
111
107a
107b
107n

FIG. 1

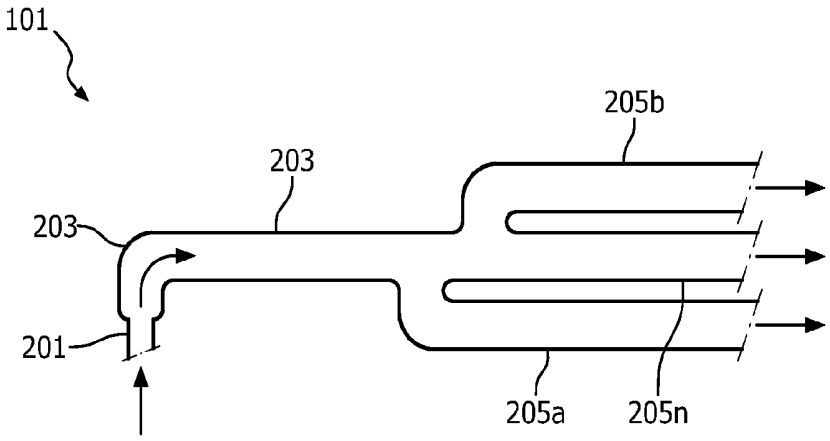

101
205b
203
203
201
205a
205n

FIG. 2

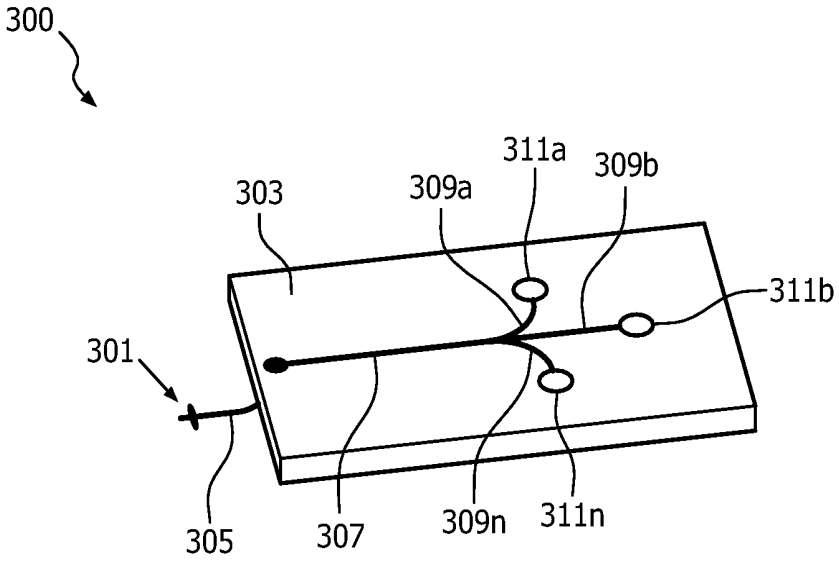

300
311a
309b
303
309a
311b
301
305
307
309n
311n

FIG. 3A

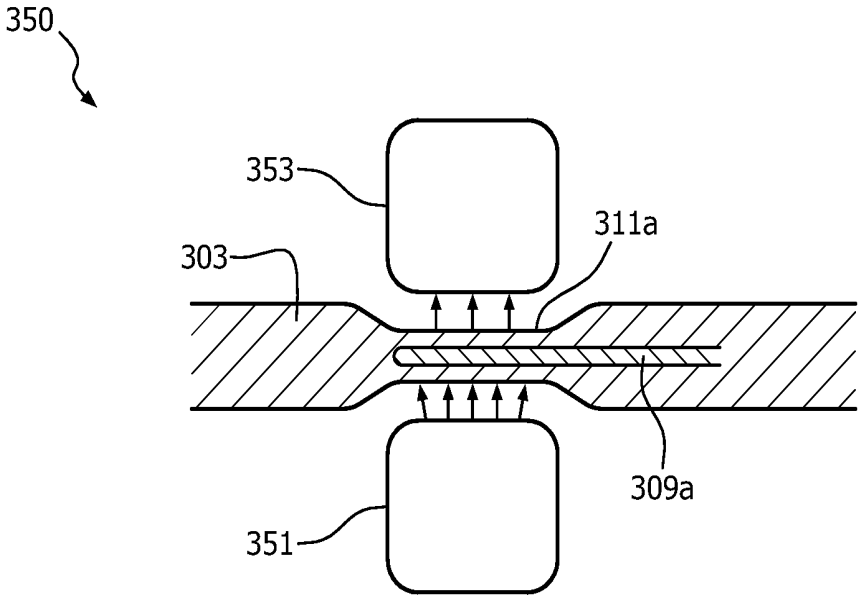

350
353
311a
303
309a
351

FIG. 3B

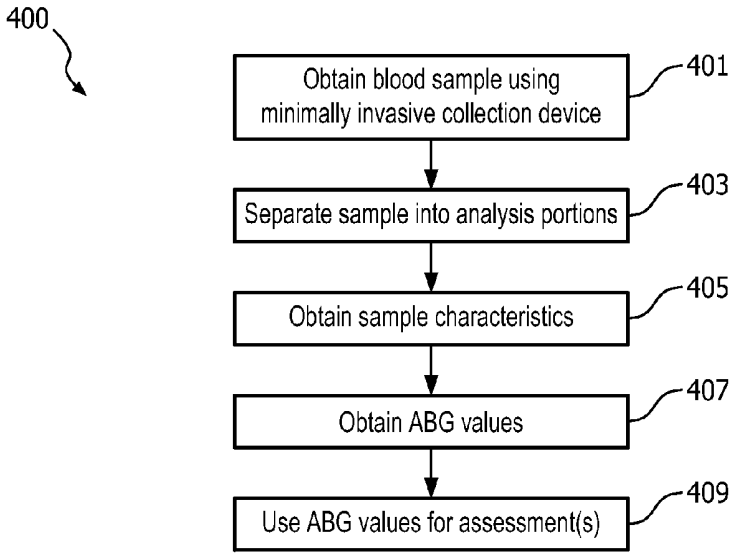

400
Obtain blood sample using minimally invasive collection device
401
Separate sample into analysis portions
403
Obtain sample characteristics
405
Obtain ABG values
407
Use ABG values for assessment(s)
409

FIG. 4

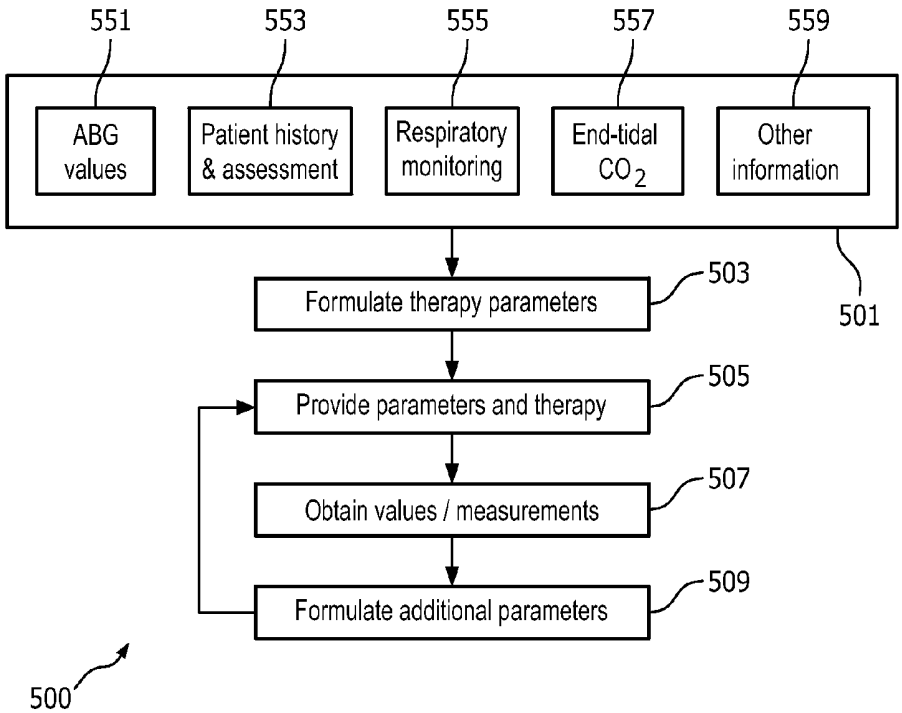

551
553
555
557
559
ABG values
Patient history & assessment
Respiratory monitoring
End-tidal CO_2
Other information
501
Formulate therapy parameters
503
Provide parameters and therapy
505
Obtain values / measurements
507
Formulate additional parameters
509
500

FIG. 5

SYSTEMS AND METHODS FOR MINIMALLY-INVASIVE ARTERIAL BLOOD GAS MEASUREMENT

[0001] The present disclosure pertains to systems and methods for minimally invasive blood gas measurement.

[0002] Arterial blood gas (ABG) measurement is often an important tool in the care of patients on ventilators in intensive care units (ICUs). Conventional methods of ABG measurement involve the puncturing of an artery and obtaining a blood sample therefrom. This can be a painful procedure, and the logistics of obtaining such a sample often result in exposing the sample to air or other environmental elements that cause errors in ABG measurements. Conventional ABG measurements are also typically sent to remote laboratories for processing, which can introduce errors in sample transport/transfer, handling of samples by multiple persons, and other reasons. Remote laboratory handling also introduces delay in the receipt of results.

[0003] Other problems may also exist with conventional methods of ABG measurement.

[0004] Accordingly, it is an object of one or more embodiments of the present invention to provide a system for providing arterial blood gas measurements comprising: a sample collection portion positioned in contact with a tissue of the patient such that a blood sample travels from the tissue of the patient into the sample collection portion without being exposed to an environment outside of the sample collection portion; one or more analysis portions in fluid communication with the sample collection portion, wherein each of the one or more analysis portions analyze one or more characteristics of the blood sample; and at least one processor configured to: receive the one or more characteristics of the blood sample and calculate one or more arterial blood gas measurements using the one or more characteristics.

[0005] It is yet another aspect of one or more embodiments of the present invention to provide a method for providing arterial blood gas measurements, comprising: positioning a sample collection portion in contact with a tissue of the patient such that a blood sample travels from the tissue of the patient into the sample collection portion without being exposed to an environment outside of the sample collection portion, and wherein the blood sample travels to one or more analysis portions in fluid communication with the sample collection portion, each of the one or more analysis portions analyzing one or more characteristics of the blood sample; receiving at one or more processors of a computational portion, the one or more characteristics of the blood sample; and calculating one or more arterial blood gas measurements using the one or more characteristics.

[0006] It is yet another aspect of one or more embodiments of the present invention to provide a system for providing arterial blood gas measurements, comprising: sample collection means positioned in contact with a tissue of the patient such that a blood sample travels from the tissue of the patient into the sample collection means without being exposed to an environment outside of the sample collection means; one or more analysis means in fluid communication with the sample collection means for analyzing one or more characteristics of the blood sample; processing means configured to: receive the one or more characteristics of the blood sample, and calculate one or more arterial blood gas measurements using the one or more characteristics.

[0007] These and other objects, features, and characteristics of the present invention, as well as the methods of operation and functions of the related elements of structure and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the invention.

[0008] FIG. **1** is an example of a system for minimally invasive arterial blood gas measurements, according to various embodiments of the invention.

[0009] FIG. **2** is an example of a collection portion of a system for minimally invasive arterial blood gas measurements, according to various embodiments of the invention.

[0010] FIG. **3**A is an example of a sample collection portion of a system for minimally invasive arterial blood gas measurements, according to various embodiments of the invention.

[0011] FIG. **3**B is an example of an analysis portion for a system for minimally invasive arterial blood gas measurements, according to various embodiments of the invention.

[0012] FIG. **4** is an example of a method for minimally invasive arterial blood gas measurements, according to various embodiments of the invention.

[0013] FIG. **5** is an example of a method for use of arterial blood gas measurements in a closed loop respiratory therapy, according to various embodiments of the invention.

[0014] As used herein, the singular form of "a", "an", and "the" include plural references unless the context clearly dictates otherwise. As used herein, the statement that two or more parts or components are "coupled" shall mean that the parts are joined or operate together either directly or indirectly, i.e., through one or more intermediate parts or components, so long as a link occurs. As used herein, "directly coupled" means that two elements are directly in contact with each other. As used herein, "fixedly coupled" or "fixed" means that two components are coupled so as to move as one while maintaining a constant orientation relative to each other.

[0015] As used herein, the word "unitary" means a component is created as a single piece or unit. That is, a component that includes pieces that are created separately and then coupled together as a unit is not a "unitary" component or body. As employed herein, the statement that two or more parts or components "engage" one another shall mean that the parts exert a force against one another either directly or through one or more intermediate parts or components. As employed herein, the term "number" shall mean one or an integer greater than one (i.e., a plurality).

[0016] Directional phrases used herein, such as, for example and without limitation, top, bottom, left, right, upper, lower, front, back, and derivatives thereof, relate to the orientation of the elements shown in the drawings and are not limiting upon the claims unless expressly recited therein.

[0017] The systems and methods described herein enable arterial blood gas (ABG) measurements using minimally invasive techniques. The systems and methods described herein may circumvent problems associated with conventional ABG measurement techniques. In some embodiments, the systems and methods described herein may derive or estimate ABG values from blood taken from other parts of the body. This may enable the use of minimally invasive collec-

tion techniques and collection devices that minimize or eliminate exposure of samples to the air or other foreign environments. Furthermore, in the techniques and apparatus described herein, ABG measurements may be obtained in a point of contact (POC) environment rather than transferring samples to a remote laboratory, further providing solutions to conventional techniques.

[0018] In some embodiments, systems for minimally invasive measurement of ABG values are provided. FIG. **1** illustrates a system **100**, which is an example of a system for minimally invasive measurement of ABG and/or other blood-related values. In some embodiments, system **100** may include a sample collection portion **101**, one or more analysis portions **103***a*-**103***n*, a computational system **105**, and/or other elements.

[0019] In some embodiments, sample collection portion **101** may be or include a minimally invasive collection apparatus. FIG. **2** illustrates an example of sample collection portion **101**. In some embodiments, sample collection portion **101** may be a microtubule structure having a total volume of 2-4 μl. In some embodiments, microtubules of sample collection portion **101** may have a diameter of 10 μm. Other dimensions or volumes may be used for collection portion **101**.

[0020] In some embodiments, sample collection portion **101** may include a tissue engagement portion **201** that contacts the tissue of a patient and enables blood from said tissue to flow into sample collection portion **101**. In some embodiments, tissue engagement portion may include a sharp-ended needle that is able to puncture through or "prick" a patient's skin. For example, in some instances, a needle portion of tissue engagement portion **201** may penetrate into tissue having capillaries, therefore enabling capillary blood to flow into sample collection portion **101**. In some instances, a needle of tissue engagement portion **201** may penetrate into tissue having a vein, therefore enabling venous blood to flow into sample collection portion **101**. In some embodiments, tissue engagement portion **201** may be a hollow metal needle or cannula having a diameter (e.g., 3-4 μm) that minimally damages the tissue through which it punctures (including vascular walls). Tissue engagement portion **201** and sample collection portion **101** may be sized so that a small amount of blood is collected for analysis (e.g., as low as 4 μl). This small sample size enables collection of blood for ABG measurement to be done in a less-painful manner than conventional techniques.

[0021] Sample collection portion **101** may also include a main conduit portion **203**, which may be a microtube that receives blood from tissue engagement portion **201**. In some embodiments, main conduit **203** may be a glass or polymer microtube. In some embodiments, main conduit **203** may be of a diameter such that one of the factors contributing to the flow of blood therethrough is capillary action (other motive forces for blood through sample collection portion **101** may include, for example, the pressure of blood within the tissue of the patient). Accordingly, blood collected into main conduit may continue to flow further into sample collection portion **101**. In some embodiments, main conduit **203** may be lcm long (or longer) and may have a diameter of 10 μm. Other dimensions may be used.

[0022] In some embodiments, sample collection portion **101** may include a plurality of analyte separation portions **205***a*-**205***n*. In some embodiments, analyte separation portions **205***a*-**205***n* and main conduit **203** may be 1 cm in length (or longer) and 10 μm in diameter. Other dimensions may be used. Each analyte separation portion **205** may carry blood from main conduit **203** to a mechanism for measuring/determining a characteristic of the blood (see e.g., analysis portions **103***a*-**103***n* of FIG. **1**). For example, one analyte separation portion **205** may carry blood to components for measuring CO_2 concentration in the blood. Another analyte separation portion **205** may carry blood to components that measure the O_2 concentration in the blood. Another analyte separation portion **205** may carry blood to components that measure the pH of the blood. Other analyte separation portions **205** may be used to carry blood to other analysis components for measuring other characteristics. In some embodiments, each of analyte separation portions **205***a*-**205***n* may be or include a glass or polymer microtube. Accordingly, in some embodiments, the blood may be carried through analyte separation portions via capillary action. Use of multiple analyte separation portions **205***a*-**205***n* enables measurement of multiple characteristics using a single "prick" to the tissue of a patient, which further reduces the pain experienced by the patient when obtaining ABG values. This may be especially valuable in neonatal intensive care unit (NICU) and other intensive care units (ICU) wherein patient health can be fragile.

[0023] In some embodiments, main conduit **203** and/or other parts of sample collection portion **101** may be filled with one or more substances (e.g., nitrogen or other inert gases) so as to provide a non-reactive environment in which to collect blood (e.g., free from oxygen, air, or other reactive substances). In some embodiments, a vacuum may be created in main conduit **203** and/or other parts of sample collection portion **101** so that incoming blood samples are not exposed to oxygen, air, or other substances that may effect ABG or other blood measurements. In some embodiments, the dimensions of sample collection portion (e.g., the use of microtubes) may have such a small volume of empty space prior to collecting a sample that exposure of a blood sample to error-causing substances (e.g., oxygen, air, or other reactive substances) is de-minimis.

[0024] One or more analysis portions **103***a*-**103***n* of system **100** may each include components that measure certain characteristics of a blood sample. For example, an analysis portion **103** for measuring CO_2 concentration in the blood sample may include a spectrograph that may include a light emitter and light detection portions that are positioned so as to emit light (or other EM radiation) through the blood sample (e.g., contained in a microtubule or microchannel portion of an analysis portion **103**) and detect any light absorbed by the blood (indicating concentration of CO_2 in the blood). Similar components may be used in an analysis portion **103** for measuring O_2 concentration in the blood. One or more analysis portions **103***a*-**103***n* may also include components for measuring: a pH of a blood sample (e.g., a pH nanoelectrode), glucose-6-phosphate dehydrogenase (G6PD) deficiency (measured using, for example, a spectrograph), jaundice measurement (e.g., bilirubin levels, measured using for example, a spectrograph), and/or other measurements.

[0025] Computational system **105** may be or include one or more computing devices (e.g., specialty computing systems, desktop computers, personal computers, mobile computing devices, tablet computing devices, smartphones, or other computing devices) having one or more processors **109** (e.g., microprocessors), memory devices **111** (e.g., hard disk, RAM, eeprom, etc.), input/output components, and/or other computing components for performing the features and functions described herein (and/or other features and functions).

In some embodiments, computational system **105** may include one or more modules **107***a*-**107***n* which comprise instructions that, when executed, cause one or more processors **109** of computational system **105** to perform the various features and functions described herein. For example, in some embodiments, one or more of modules **107***a*-**107***n* may enable calculation and/or receipt of data relating to characteristics of a blood sample (CO_2 levels, O_2 levels, pH, etc.), derivation or other determination of ABG values (e.g., CO_2 levels, O_2 levels, pH, etc.) from characteristics of non-arterial blood samples, providing patient heath/pathology evaluations using ABG values and/or other information, calculation of ventilation or other respiratory therapy parameters using arterial blood values and/or other values, and/or for performing other calculations/determinations.

[0026] In some embodiments, sample collection and analysis portions of systems for minimally invasive measurement of ABG and/or other blood-related values may have different configurations. FIGS. **3**A and **3**B illustrate sample collection and analysis portions of an example system for minimally invasive measurement of ABG and/or other blood-related values. FIG. **3**A illustrates sample collection and analyte separation portion **300**, which includes a tissue engagement portion **301** that is connected to an analyte separation chip **303** via a connection portion **305**. Patent engagement portion may be or include a microfluidic needle or cannula that may puncture or "prick" the tissue of a patient and collect a blood sample. Connection portion **305** may be or include a microfluidic tube that transports the blood sample from tissue engagement portion **301** to analyte separation chip **303**. In some embodiments, a needle comprising tissue engagement portion **301** may be about 3-4 μm in diameter and connection portion **305** may be about 10 μm in diameter. Other dimensions may be used.

[0027] In some embodiments, analyte separation chip **303** may be or include a planar chip or other object made from silicon, glass, polymer plastic, or other material and having one or more microchannels etched or embedded therein. In some embodiments, analyte separation chip **303** may be or include a chip having dimensions of about 2 cm×4 cm. The one or more microchannels may include a main microchannel **307** that splits into one or more branch channels **309***a*-**309***n*. In some embodiments, main microchannel **307** and branch channels **309***a*-**309***n* may each be about 1 cm in length with a diameter of about 10 μm. Each of branch channels **309***a*-**309***n* may terminate at an analysis portion **311** (see e.g., **311***a*-**311***n*). In some embodiments, the diameter of analysis portions **311** may be about 50 μm. Other dimensions may be used.

[0028] A blood sample may be introduced into main microchannel **307** from connection portion **305**. Through capillary action (or other motive force), the blood sample may move into each of branch channels **309***a*-**309***n*, and into their respective analysis portions **311**. One or more characteristics of the blood sample may then be measured in each analysis portion **311**. For example, in some embodiments, an analysis portion **311** may include a window or other area that enables light to be transmitted through the blood sample therein. In some embodiments, analysis portions **311** may include one or more microtubules or microchannels (e.g., portions of branch channels **309** that are within a window or other area of an analysis portion **311** enabling light to be transmitted through a blood sample). FIG. **3**B illustrates an analysis apparatus **350**, which may include or be part of a spectrograph, wherein a light (or other EM radiation) source **351** is positioned so as to direct light (or other EM radiation) onto a blood sample at an analysis window **311***a*. A radiation detector **353** is positioned opposite light source **351** so as to detect the light that is transmitted through the blood sample in analysis window **311***a*. From the radiation that is absorbed by the blood sample in analysis window **311***a*, certain characteristics of the blood sample (e.g., O_2, CO_2, etc.) may be determined. As discussed herein, this and other determinations/calculations may be performed by a computational portion (e.g., computational portion **105**) that is in communication with light source **351**, radiation detector **353**, and/or other components. Components for determining other characteristics of a blood sample may be used at other analysis portions of chip **303**.

[0029] In some embodiments, methods for minimally invasive measurement of ABG values are provided. FIG. **4** illustrates a process **400**, which is an example of a process for obtaining and using minimally invasive measurement of ABG values. Process **400** may include an operation **401**, wherein a minimally invasive sample collection apparatus is applied or otherwise engaged with a tissue of a patient to obtain a blood sample therefrom. For example, an apparatus similar to those illustrated in FIGS. **2** and **3**A having a micro needle or cannula may be used to prick the skin of a patient and obtain a capillary (via a capillary rich tissue) or venous (via a vein) blood sample of a patient. In some embodiments, a small amount of blood (e.g., 15-20 μl) is obtained for analysis (about 5-10 μl of which may be used in each individual analysis portion).

[0030] In some embodiments, the tissue of the patient may be pre-treated before the blood sample is obtained. For example, a tissue of the patient may be warmed prior to obtaining a sample. Warming the tissue may cause vasodilation of the vessels from which blood is obtained and therefore may provide blood characteristics that more closely resemble arterial blood measurements. For example, the heel of an infant may be warmed prior to obtaining a blood sample for ABG measurements from the infant. Another example may include applying vasodilator chemicals to the heel of an infant or other patient.

[0031] In an operation **403**, the blood sample is separated into a plurality of analysis portions of the minimally invasive collection apparatus (e.g., analyte separation portions **205***a*-**205***n* of FIG. **2**; branch channels **309***a*-**309***n* and analysis portions **311***a*-**311***n* of FIG. **3**). In some implementations, only a single analysis portion maybe used (e.g., when multiple characteristics can be measured in a single analysis portion or wherein only a single characteristic is to be obtained). In some embodiments, the blood sample is obtained from the patient and separated into the plurality of analysis portions without exposing (or minimally exposing) the blood sample to oxygen, air, or other reactive substances. For example, as discussed herein, the collection apparatus may be filled with an inert gas, may have a vacuum therein, and/or may have dimensions that minimally expose the blood sample to error causing substances (e.g., oxygen, air, or other reactive substances).

[0032] In an operation **405**, one or more characteristics of the blood sample are obtained (e.g., using measurement components as described herein with respect to FIGS. **1**, **2** and **3**B). For example, in some embodiments, one or more of a CO_2 measurement, an O_2 measurement, and/or a pH measurement. Other measurements may also be obtained such as, for example, glucose-6-phosphate dehydrogenase (G6PD) defi-

ciency measurements, jaundice measurements (e.g., bilirubin levels), and/or other measurements. In some embodiments, the one or more characteristics may be calculated/determined/derived at a computational portion (e.g., computational portion **105** and/or one or more modules **107***a*-**107***n* thereof) from signals sent by analysis components. In some embodiments, the one or more characteristics may be calculated/determined/derived (e.g. using processors and logic integrated with a spectrograph/radiation detectors or other analysis components) and sent to a computational portion (e.g., computational portion **105** and/or one or more modules **107***a*-**107***n* thereof).

[0033] In an operation **407**, the one or more characteristics of the blood sample may be used to derive ABG measurements. The ABG measurements may include O_2 concentration, CO_2 concentration, blood pH, and/or other characteristics. In some embodiments, a function or correlation graph may be used to convert the measured sample characteristics (e.g., O_2, CO_2, pH, etc.) into ABG values. In some embodiments, additional information may be used with determined sample characteristics to derive ABG values. For example, in some embodiments, the type of blood or location of blood draw may be used with sample characteristics to derive ABG values. For instance, capillary blood may be sampled (i.e., from a patient's capillaries) and a function or correlation graph specifically intended for use in converting capillary blood samples to ABG values may be used. According to many studies, the arterialization of capillary blood is linearly related with arterial blood gas values. In another example, a function or correlation graph specifically intended for use in converting venous blood samples into ABG values may be used when venous blood is used for a blood sample. Other types of information may also be used to select functions or correlation graphs for converting sample values to ABG values such as, for example, patient age, physical condition of a patient (e.g., healthy, hypothermic, etc.), pathology information relating to a patient (e.g., hypoxemia, metabolic acidosis, respiratory alkylosis, etc.), and/or other information. In some embodiments, a function or correlation graph used to convert sampled non-arterial blood into arterial values may be constructed by plotting a calibration curve between a spectrogram of sampled blood characteristics (e.g., O_2, CO_2, etc.) and arterial blood gas values using a gold standard such as, for example, arterial blood samples obtained using oxygen and carbon dioxide electrodes. This calibration curve may be stored as a look up table (e.g., in computational system **105**) and used to derive ABG values from sampled characteristics.

[0034] In an operation **409**, the derived ABG measurements may be used, alone or with other data, to assess the condition of a patient, to assess the results or effectiveness of a therapy, and/or otherwise used. For example, arterial O_2, CO_2, and/or pH values may be useful in assessing the health of a patient. In another example, the ABG values may be used to assess whether ventilation or other respiratory therapy is effective in achieving predetermined goals (e.g., a specific arterial O_2 concentration, etc.).

[0035] In some implementations, the ABG values may be used as part of closed-loop respiratory therapy (e.g., fraction of inspired oxygen (FiO_2) management). Using the minimally invasive devices and methods provided herein, clinicians can arrive at ABG values using a very small volume of blood (obtained with minimal invasive interaction with the patient). These ABG values can, in turn, be used to help clinicians in choosing ventilation strategies and other courses of action (FiO_2 management is one of those strategies). FIG. **5** illustrates a method **500**, which is an example of a method for closed loop integration of ABG values into respiratory therapy management. In an operation **501**, ABG values **551**, patient history and assessment data **553**, respiratory monitoring values **555** (e.g., saturation of peripheral oxygen—SpO_2), end-tidal CO_2 values **557**, and/or other information **559** may be received/determined In some embodiments, these parameters may be received and/or calculated by a CDS engine (a rule-based clinical decision support engine) which may be one of the one or more modules **107***a*-**107***n* discussed herein.

[0036] In an operation **503**, the information from operation **501** may be used to formulate ventilation or other respiratory therapy parameters for a patient. For example, the information may be used to determine whether a patient is adequately ventilated or not. If the patient is not adequately ventilated, a ventilator setting can be changed or other actions can be taken. In an operation **505**, these parameters may be communicated to a respirator or other apparatus for providing respiratory therapy such that the respiratory therapy is provided to a patient by the apparatus in accordance with the apparatus.

[0037] In an operation **507**, one or more values/measurements may be determined/made after or during delivery of treatment. In some embodiments, these values may include ABG values, patient assessment data, respiratory monitoring values (e.g., saturation of peripheral oxygen—SpO_2), end-tidal CO_2 values, and/or other information. In an operation **509**, the values/measurements may be used to formulate additional respiratory therapy parameters for further treatment. Process **500** may then return to operation **505**, wherein respiratory therapy is provided to the patient based on the parameters. In this manner, a closed-loop system is provided.

[0038] In some embodiments, tangible computer-readable media comprising computer-executable instructions for causing one or more computer processors (e.g., processors **109**) to perform one or more of the features and functions set forth herein, including the operations of the methods described herein, may be provided.

[0039] The systems described herein are exemplary system configurations. Other configurations may exist. Those having skill in the art will appreciate that the invention described herein may work with various configurations. Accordingly, more or less of the aforementioned system components may be used and/or combined in various embodiments. It should also be understood that various software modules that are utilized to accomplish the functionalities described herein may be maintained on different components than computational system **105**, as desired or necessary. In other embodiments, as would be appreciated, the functionalities described herein may be implemented in various combinations of hardware and/or firmware, in addition to, or instead of, software. Furthermore, various operations of the methods described herein, while described in a particular order, may be performed in different orders as would be appreciated by those having skill in the art. In some embodiments, more of less of the described operations may be used.

[0040] In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" or "including" does not exclude the presence of elements or steps other than those listed in a claim. In a device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. In any

device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain elements are recited in mutually different dependent claims does not indicate that these elements cannot be used in combination.

[0041] Although the invention has been described in detail for the purpose of illustration based on what is currently considered to be the most practical and preferred embodiments, it is to be understood that such detail is solely for that purpose and that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover modifications and equivalent arrangements that are within the spirit and scope of the appended claims For example, it is to be understood that the present invention contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment.

1. A system for providing arterial blood gas measurements, comprising:

a sample collection portion positioned in contact with a tissue of the patient such that a blood sample travels from the tissue of the patient into the sample collection portion without being exposed to an environment outside of the sample collection portion;

one or more analysis portions in fluid communication with the sample collection portion, wherein each of the one or more analysis portions analyze one or more characteristics of the blood sample; and

at least one processor configured to:

receive the one or more characteristics of the blood sample, and

calculate one or more arterial blood gas measurements using the one or more characteristics.

2. The system of claim **1**, wherein the at least one processor is further configured to receive information relating to the circumstances surrounding collection of the blood sample, and wherein calculating one or more arterial blood gas measurements further uses the information relating to the circumstances surrounding the collection of the blood sample.

3. The system of claim **2**, wherein the one or more circumstances surrounding collection of the blood sample include a type of blood sample, and wherein calculation of one or more arterial blood gas measurements further includes selecting a function configured for analyzing blood samples of the received type, the calculation of the one or more arterial blood gas measurements using the selected function.

4. The system of claim **1**, wherein one or more arterial blood gas measurements are input into a closed loop system for providing respiratory therapy to the patient.

5. The system of claim **1**, wherein one or more of the sample collection portion or the one or more analysis portions include one or more microtubules or microchannels.

6. A method for providing arterial blood gas measurements, comprising:

positioning a sample collection portion in contact with a tissue of the patient such that a blood sample travels from the tissue of the patient into the sample collection portion without being exposed to an environment outside of the sample collection portion, and wherein the blood sample travels to one or more analysis portions in fluid communication with the sample collection portion, each of the one or more analysis portions analyzing one or more characteristics of the blood sample;

receiving at one or more processors of a computational portion the one or more characteristics of the blood sample; and

calculating one or more arterial blood gas measurements using the one or more characteristics.

7. The method of claim **6**, further comprising receiving information relating to the circumstances surrounding collection of the blood sample, and wherein calculating one or more arterial blood gas measurements further uses the information relating to the circumstances surrounding the collection of the blood sample.

8. The method of claim **7**, wherein the one or more circumstances surrounding collection of the blood sample include a type of blood sample, and wherein calculating one or more arterial blood gas measurements further includes selecting a function configured for analyzing blood samples of the received type, the calculation of the one or more arterial blood gas measurements using the selected function.

9. The method of claim **6**, further comprising, inputting the one or more arterial blood gas measurements into a closed loop system for providing respiratory therapy to the patient.

10. The method of claim **6**, wherein one or more of the sample collection portion or the one or more analysis portions include one or more microtubules or microchannels.

11. A system for providing arterial blood gas measurements, comprising:

sample collection means positioned in contact with a tissue of the patient such that a blood sample travels from the tissue of the patient into the sample collection means without being exposed to an environment outside of the sample collection means;

one or more analysis means in fluid communication with the sample collection means for analyzing one or more characteristics of the blood sample; and

processing means configured to:

receive the one or more characteristics of the blood sample, and

calculate one or more arterial blood gas measurements using the one or more characteristics.

12. The system of claim **11**, the processing means being further configured to receive information relating to the circumstances surrounding collection of the blood sample, and wherein calculating one or more arterial blood gas measurements further uses the information relating to the circumstances surrounding the collection of the blood sample.

13. The system of claim **12**, wherein the one or more circumstances surrounding collection of the blood sample include a type of blood sample, and wherein calculation of one or more arterial blood gas measurements further includes selecting a function configured for analyzing blood samples of the received type, the calculation of the one or more arterial blood gas measurements using the selected function.

14. The system of claim **11**, wherein one or more arterial blood gas measurements are input into a closed loop system for providing respiratory therapy to the patient.

15. The system of claim **11**, wherein one or more of the sample collection means or the one or more analysis means include one or more microtubules or microchannels.

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专利名称(译)	用于微创动脉血气测量的系统和方法		
公开(公告)号	US20150173662A1	公开(公告)日	2015-06-25
申请号	US14/414799	申请日	2013-07-30
[标]申请(专利权)人(译)	飞利浦灯具控股公司		
申请(专利权)人(译)	koninklijkie飞利浦公司		
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发明人	ULMAN, SHRUTIN JAYAVANTH, SANJAY		
IPC分类号	A61B5/157 A61B5/145 A61B5/00 A61B5/15		
CPC分类号	A61B5/157 A61B5/15003 A61B5/150251 A61B5/4836 A61B5/14542 A61B5/14514 A61B5/685		
优先权	3256CHE2012 2012-08-08 IN		
外部链接	Espacenet USPTO		

摘要(译)

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