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(54) **Title**: TRAUMATIC BRAIN INJURY GUIDELINE SYSTEM AND METHOD

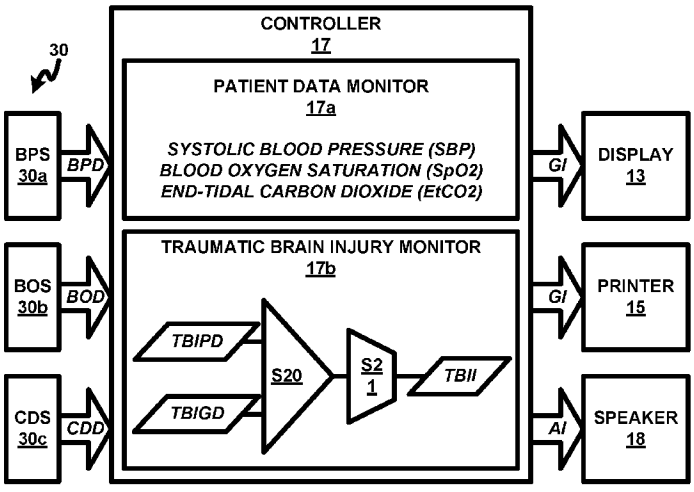

FIG. 2

(57) **Abstract**: A traumatic brain injury ("TBI") guideline system employing a patient monitoring sensor (30) and a patient monitoring device (10). In operation, the patient monitoring sensor (30) generates data for monitoring a TBI parameter of a patient (e.g., systolic blood pressure, blood oxygen saturation or carbon dioxide expiration of the patient), and the patient monitoring device (10) generates a TBI indicator derived from a comparison of the TBI parameter data to parameter guideline data associated with a potential TBI of the patient. The patient monitoring device (10) may include a patient data monitor module (17a) to monitor the TBI parameter data, and a TBI monitor module (17b) to generate the TBI indicator. The TBI indicator is informative of a TBI status of the patient (e.g., a hypotension status, a hypoxia status or a ventilation status of the patient), and/or a TBI treatment for the patient (e.g., a ventilation treatment for the patient).

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TRAUMATIC BRAIN INJURY GUIDELINE SYSTEM AND METHOD

The present disclosure generally relates to traumatic brain injury ("TBI") guidelines, such as may be implemented/used in/with medical devices (e.g., monitors/defibrillators). The present disclosure more particularly relates to novel and inventive systems and methods for using TBI guidelines in/with a medical device (e.g., a monitor/defibrillator) to treat/care for traumatic brain injury patients.

It is estimated that approximately 1.4 million victims of traumatic brain injury are seen in emergency departments each year in the United States ("U.S.") and, of those, approximately 50,000 die and 235,000 are hospitalized. It is further estimated that at least 2% of the U.S. population has a TBI-related long-term need for help to perform activities of daily living. These statistics have inspired increased research into treatment and care of TBI patients, which has gathered growing evidence that the management of TBI in the early minutes after injury profoundly impacts outcome for the patient. This has led to the promulgation of evidence-based TBI treatment guidelines by authoritative national and international scientific bodies.

More particularly, it has been demonstrated that deleterious effects of hypoxia, hypotension, hypocapnea (caused by hyperventilation) and hypercapnea (from inadequate ventilation) often occurs soon after a traumatic brain injury. Based on these findings, the Brain Trauma Foundation has promulgated evidence-based guidelines for in-hospital and pre-hospital TBI treatment.

Generally, proper management of airway, ventilation, and hemodynamics are at the core of the TBI guidelines. The negative impact of hypoxia, hypercapnea, hypocapnea and hypovolemia are so significant that, if the earliest opportunities to intervene are missed, subsequent care, even if it is optimal, will generally not recover what was lost in neurological damage.

For example, portable monitor/defibrillators are used in a pre-hospital setting by Advanced Life Support ("ALS") or Basic Life Support ("BLS") trained medical practitioners (e.g., paramedics) to care for victims of traumatic brain injury immediately after an injury has occurred (e.g., from a fall or automobile accident, prior to arrival at the hospital). These devices can be used to monitor patient data including systolic blood

pressure (SBP), blood oxygen saturation (SpO2), and expired carbon dioxide (CO2) and its derived parameter end-tidal CO2 (EtCO2).

However, many paramedics (and other medical practitioners) are not aware of the TBI guidelines, and many Emergency Medical Services ("EMS") agencies (and other medical services providers) have not formally adopted and trained their paramedics (or other medical practitioners) on the TBI guidelines. Even those paramedics (and other medical practitioners) who are trained on the TBI guidelines could still benefit from a system and method which could help them meet and maintain the TBI guidelines by providing real-time feedback and guidance. Thus, it would be beneficial to have a system and method implemented/used in/with medical devices (e.g., monitors/defibrillators) which can assist the user in maintaining monitored TBI parameters in guideline range, and can issue warnings/alerts if/when the TBI parameters fall out of guideline range.

The present disclosure recognizes that it is likely that providing TBI guideline therapy, particularly in a pre-hospital setting, will lead to dramatic improvement in outcomes for patients. From this recognition, disclosed and described herein are exemplary embodiments of the present disclosure, which, as one having ordinary skill in the art shall appreciate in view of the teachings herein, can be used together or separately to overcome the above-described needs and related challenges of the treatment and care of TBI patients.

In one exemplary embodiment of the present invention, a system is implemented in a patient monitoring device (e.g., a monitor/defibrillator) that can help the user maintain target ranges for TBI parameters based on pre-defined TBI guidelines. The system can provide warnings/alerts when the parameters fall out of a pre-defined guideline range. Such system can include software and hardware, which hardware can be used in connection with other functionality of the patient monitoring device, for example.

In one form, the system employs a patient monitoring sensor and a patient monitoring device. In operation, the patient monitoring sensor generates data for monitoring a TBI parameter of a patient (e.g., systolic blood pressure, blood oxygen saturation or carbon dioxide expiration of the patient), and the patient monitoring device generates a TBI indicator derived from a comparison of the TBI parameter data to parameter guideline data associated with monitoring a potential TBI of the patient. The patient monitoring device may include a patient data monitor to monitor the TBI parameter data, and a TBI monitor to generate the TBI indicator. The TBI indicator is

informative of a TBI status of the patient (e.g., a hypotension status, a hypoxia status or a ventilation status of the patient), and/or a TBI treatment for the patient (e.g., a ventilation treatment for the patient).

The term "patient monitoring sensors" is a specific known grouping of sensors for monitoring patients including, but not limited to, blood pressure sensors, blood oxygen sensors and carbon dioxide sensors.

The term "blood pressure sensors broadly includes sensors known prior to and subsequent to the present invention that measure blood pressure both non-invasively (e.g., through a blood pressure cuff on the arm) or invasively (e.g., with an arterial catheter pressure line.

The term "blood oxygen sensors" broadly includes sensors known prior to and subsequent to the present invention that provide an estimation of a concentration of oxygen in the blood (e.g., peripheral capillary oxygen saturation sensor) or provides a direct measurement of the concentration of oxygen in the blood (e.g., an arterial blood gas testing sensor).

The term "carbon dioxide sensor" broadly includes sensors known prior to and subsequent to the present invention that measure expired CO2 from the lungs, or direct measurements of the partial pressure of CO2 in the arterial blood PaCO2 (e.g., via an invasive blood gas sensor)

The term "patient monitoring device" is a specific known grouping of devices for monitoring patients including, but not limited, to Advanced Life Support ("ALS") monitors/defibrillators and any Automated External Defibrillators ("AED").

In another exemplary embodiment of the present invention, a method is provided that can help the user maintain target ranges for, e.g., the TBI parameters based on pre-defined TBI guidelines. The method can include providing warnings/alerts when the parameters fall out of a pre-defined guideline range. Such method can be implemented via software and hardware to run in/with a patient monitoring device (e.g., monitor/defibrillator), for example.

In one form, the method involves a patient monitoring sensor generating data for monitoring a TBI parameter of a patient, and a patient monitoring device generating a TBI indicator derived from a comparison of the TBI parameter data to parameter guideline data associated with a potential TBI of the patient. The traumatic brain injury indicator is informative of a TBI status of the patient and/or a TBI treatment for the

patient.

According to the exemplary embodiments of the present invention, voice and/or display prompts can be provided to communicate information to "coach" (and/or guide, direct, suggest, etc.) the person providing care to help them meet the TBI guidelines.

The foregoing forms and other forms of the present invention as well as various features and advantages of the present disclosure will become further apparent from the following detailed description of various embodiments of the present disclosure read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the present invention rather than limiting, the scope of the present disclosure being defined by the appended claims and equivalents thereof.

FIGS. 1A and 1B respectively illustrate a front view and a side view of an exemplary portable monitor/defibrillator in accordance with the present disclosure.

FIG. 2 illustrates a block diagram of an exemplary controller in accordance with the present disclosure.

FIGS. 3A-3C illustrate an exemplary traumatic brain injury parameter map in accordance with the present disclosure for graphically representing an acceptable, warning, and dangerous TBI parameters, respectively.

To facilitate an understanding of the present invention, exemplary embodiments of the present invention will be provided herein directed to an integration of a TBI monitor 17b (FIG. 2) into a controller 17 (FIG. 2) of a patient monitor device 10 (FIGS. 1 and 2) in the form of a commercially available HeartStart MRx Monitor/Defibrillator. TBI monitor 17b aids a user of patient monitor device 10 in meeting and maintaining patient care guidelines for a potential traumatic brain injury to a patient. From description of the exemplary embodiments as shown in FIGS. 1-3, those having ordinary skill in the art will appreciate how to make and use the present invention for implementation by/integration into any patient monitoring device known in the art prior to or subsequent to the present invention (e.g., any ALS monitor/defibrillator and any AED).

Referring to FIGS. 1 and 2, a block diagram of patient monitoring device 10 shows a handle 11 attached to a housing 12 providing user-access to a display/display interface 13, a controller interface 14, a printer 15 and a port interface 16 as shown in FIG. 1. Housing 12 further encloses controller 17 and a speaker 18 as shown in FIG. 2.

As known in the art:

(1) display/display interface 13 displays patient monitoring data (e.g., electrocardiogram data and TBI data) as customized by a user via a display interface 13 (e.g., keys);

(2) controller interface 14 (e.g., knobs and buttons) allows the user to apply various therapies (e.g., a shock) to a patient as controlled by controller 17;

(3) printer 14 allows the user to print various patient reports, status logs and device information;

(4) port interface 16 allows for the connection by the user of one or more patient monitoring sensors 30 (FIG. 2) to controller 17 including, but not limited to, a blood pressure sensor 30a, a blood oxygen sensor 30b and a carbon dioxide sensor 30c; and

(5) controller 17 includes a patient data monitor module 17b implementing various algorithms for monitoring patient data, particularly TBI data including, but not limited to, systolic blood pressure (SBP), peripheral capillary oxygen saturation (SpO2) and end-tidal carbon dioxide (EtCO2).

This exemplary embodiment of the present invention integrates TBI monitor 17b into controller 17 for helping the user meet and maintain target ranges for TBI parameters based on pre-defined TBI guidelines. Specifically, a data flow diagram of TBI monitor 17B as shown in FIG. 2 involves a TBI parameter/guideline comparison stage S20 of a TBI parameter data *TBIP* to parameter guideline data *TBIG* associated with monitoring a potential traumatic brain injury of the patient. A TBI indicator generation stages S21 generates a TBI indicator *TBII* derived from the comparison of the TBI parameter data *TBIP* to parameter guideline data *TBIG* whereby TBI indicator *TBII* is informative of a TBI status of the patient and/or a TBI treatment for the patient. In practice, TBI indicator *TBII* may have any form suitable for communication to the user including, but not limited to, a graphically indicator *GI* for illustration by display 13 and/or for reporting by printer 15 and audio indicator *AI* for broadcast by speaker 17. TBI indicator *TBII* may also be uploaded/downloaded as required, particularly for TBI data acquisition by a laptop and for remote reporting to a hospital/care facility.

The following description is directed to non-limiting examples of a use of patient monitoring sensors 30 and patient monitoring device 10 to provide further understanding of TBI monitor 17b.

Specifically, a user initiates patient monitoring device 10 with a button press of display interface 13 and enter the patient's (approximate/estimated) age. Alternatively, the user initially can select a range for the patient's (approximate/estimated) age (e.g., "TBI age ≥ 10") and the application continues, or "TBI age < 10". If the user selects "TBI age < 10", patient monitoring device 10 prompts the user to enter a more exact (approximate/estimated) age. Based on the age, patient monitoring device 10 computes the target range for TBI parameters EtCO2, SPO2, and SBP, for example. Patient data monitor 17a monitors the three (2) exemplary TBI parameters and TBI monitor 17b provides a TBI status indicator *TBII* for each TBI parameter indicative of whether that TBI parameter is in target range or not. Additionally, TBI monitor 17b can "coach" the user who is controlling manual ventilation rate (e.g., by manually squeezing an ambu-bag) to adjust the ventilation rate based on the current EtCO2 value to reach a target EtCO2 value. Alert warnings can be provided by TBI monitor 17b when TBI parameters are approaching or have exceeded acceptable pre-defined parameter range limits.

More particularly to the examples, when the user arrives on the scene of a patient with a potential or actual TBI:

- blood pressure sensor 31 in a form of a blood pressure cuff is attached around the patient's arm and connected to port interface 16;
- blood oxygen sensor 32 in a form of a SPO2 sensor is placed on the patient's finger and connected to port interface 16; and
- if needed, the patient is intubated with an advanced airway or another type of airway such as an oropharyngeal airway device or mask from a bag-valve-mask (BVM) combination, or a nasal cannula (designed for CO2 monitoring as well as oxygen delivery) is placed in/on the patient, and carbon dioxide sensor 33 in a form of a CO2 sensor filter-line is applied between the airway tube and the ambu-bag (manual ventilation bag) or applied to the nasal cannula and connected to port interface 16.

The user begins TBI method by pressing a button (hardkey or softkey) of display interface 13 or controller interface 14 labeled with "TBI", for example. Patient monitoring device 10 then prompts the user to enter the patient's (estimated/approximate) age in years (and months for an infant < 2 years old).

TBI monitor 17b then computes the age-based systolic blood pressure (SBP) threshold, e.g.,

- Infants/Children age < 10 yrs.: [70 + (age x 2)] mmHg (using age in years or fractions);
- Age > 10 yrs.: 90 mmHg.

Examples:

Newborn Infant: 70mmHg;

Infant 6 months: 71mmHg:

5 yr. old: 80 mmHg;

>10 yrs.: 90 mmHg

TBI monitor 17b uses an SPO2 threshold of 90% for all ages.

TBI monitor 17b uses an EtCO2 target range of 35-45 mmHg for all ages.

These threshold and targets are current TBI guidelines. Nonetheless, in practice, TBI monitor 17b may be configured with different values in the monitor/defibrillator configuration. It is possible that this configuration can be configurable by a user, and/or manufacturer, supplier, etc.

According to exemplary embodiments of the present invention, TBI monitor 17b may provide the TBI indicator *TBII* in the form of the following hypotension warnings using the current value of SBP as follows:

- at threshold + 10: "NOTICE: Approaching Hypotension"
- at threshold + 5 : "WARNING: Marginal Hypotension"
- at or below threshold: "ALERT !! HYPOTENSION !!"

According to exemplary embodiments of the present invention, TBI monitor 17b may provide the TBI indicator *TBII* in the form of the following hypoxia warnings using the current value of SPO2 as follows:

- 93-96% : "Insure High-Flow O2"
- 90-92% : "WARNING: Marginal O2 Sat"
- < 90% : "ALERT: !! DANGEROUS HYPOXIA !!"

One having ordinary skill in the art shall appreciate in view of teachings herein that these warnings as shown are examples. The present invention is not limited to these examples, as it has been contemplated by the inventors that the present invention can include different warnings and/or different ways that warnings are displayed and/or

otherwise communicated to a user and/or recorded, stored and/or transmitted to a hospital, for example.

Further, according to exemplary embodiments of the present invention, TBI monitor 17b may guide ventilation rate by use of a metronome. For example, TBI monitor 17b may control a flashing light and/or an audio prompt to "ventilate" according to an algorithm/method that compares the current EtCO2 value to the target EtCO2 range (e.g., proportional-integral-derivative for minimizing any differential between the current EtCO2 value and the target EtCO2 range).

TBI monitor 17b start with initial ventilation rates (bpm: breaths-per-minute) according to the following patient ages, for example:

- Infants (age 0-2 years) : 25 bpm
- Children (age 2-14 yrs.) : 20 bpm
- Adolescents/Adults (age 15+): 10 bpm

When the current EtCO2 is above the target range (e.g., > 45 mmHg), TBI monitor 17b can, e.g., display the message:

- "Gently Increase Ventilation Rate"

...and the metronome gradually increases the rate until the target range is reached.

When the current EtCO2 is below the target range (e.g., < 35 mmHg), TBI monitor 17b can, e.g., display the message:

- "Gently Decrease Ventilation Rate"

...and the metronome gradually decreases the rate until the target range is reached.

As one having ordinary skill in the art shall appreciate in view of the teachings herein, there is usually an inverse relationship with ventilation rate and EtCO2, particularly when perfusion remains constant.

Further, exemplary embodiments of TBI monitor 17b may control a graphic display whether the three exemplary TBI parameters (SBP, SPO2, and EtCO2) are in target ranges, or close to or above/below thresholds. This can be an advantageous feature/functionality of patient monitoring device 10 in accordance with exemplary embodiments of the present invention.

For example, exemplary embodiments of TBI monitor 17b can use "Horizon Trends", similar to that which is used in some existing in-hospital patient monitors as known in the art.

Additionally, in accordance with exemplary embodiments of the present invention, it is possible to use another display modality disclosed and described herein, such as that of the novel and inventive exemplary "TBI Map" illustrated in FIG. 3.

Specifically, FIG. 3A illustrates a graphic representation of a TBI map 40 of a current value of the three (3) TBI parameters on a three axes labeled 41a-41c. In this example case, the three parameters are all in acceptable guideline range as illustrated by a TBI indicator 41 as as circle at the center which crosses the axes 41a-41c at the current values of the TBI parameters. In practice, TBI indicator circle 42 at the center and parameter labels 41a-41c may be colored green to represent that all parameters are in TBI guideline range.

FIG. 3B illustrates a graphic representation of TBI map 40 whereby TBI parameters SpO2 and SBP are both approaching thresholds as indicated by a downward shift of TBI indicator 42 into an elliptical shape. In practice, as a warning, TBI indicator 42 and parameter labels 41b and 41c may be colored yellow to provide the warning that TBI parameters SpO2 and SBP are both approaching thresholds of the TBI guidelines, and parameter label 41a may remain green to represent TBI parameter EtCO2 is still within the guideline range.

FIG. 3C illustrates a graphic representation of TBI map 40 whereby TBI parameters SpO2 and SBP are out of range as indicated by a further downward shift by TBI indicator 42 in a larger elliptical shape. In practice, as an alert, TBI indicator 42 and parameter labels 41b and 41c may be colored red to provide the alert that TBI parameters SpO2 and SBP are out of TBI guideline range, and parameter label 41a may remain green to represent TBI parameter EtCO2 is still within the guideline range.

The description and example of an exemplary indicator as shown in FIG. 1-3, for example, is in accordance with an exemplary embodiment of a TBI indicator that represents current parameter values against the guideline range. One having ordinary skill in the art shall appreciate in view of the teachings provided herein that the above approach may be further refined, and that alternate embodiments of TBI indicators, including the information and manner in which the information is displayed or otherwise communicated, is within the scope of the present invention.

While the present invention has been described primarily with respect to monitors/defibrillator, such as pre-hospital monitors/defibrillators (e.g., used by paramedics/EMS personnel), one having ordinary skill in the art shall appreciate in view

of the teaching provided herein that exemplary embodiments of the present invention can be implemented in other medical devices, including, but not limited to, patient monitors (e.g., ECG monitors), automatic external defibrillators (AEDs) and/or other defibrillators coupled to or receiving data from the necessary sensors. Indeed, exemplary embodiments of the present invention implemented in these other types of device are specifically contemplated and considered to be within the scope of the present invention.

Further, as one having ordinary skill in the art will appreciate in view of the teachings provided herein, features, elements, components, etc. described in the present disclosure/specification and/or depicted in the Figures may be implemented in various combinations of hardware and software, and provide functions which may be combined in a single element or multiple elements. For example, the functions of the various features, elements, components, etc. shown/illustrated/depicted in the Figures can be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions can be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which can be shared and/or multiplexed. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and can implicitly include, without limitation, digital signal processor ("DSP") hardware, memory (e.g., read only memory ("ROM") for storing software, random access memory ("RAM"), non-volatile storage, etc.) and virtually any means and/or machine (including hardware, software, firmware, combinations thereof, etc.) which is capable of (and/or configurable) to perform and/or control a process.

Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future (e.g., any elements developed that can perform the same or substantially similar function, regardless of structure). Thus, for example, it will be appreciated by one having ordinary skill in the art in view of the teachings provided herein that any block diagrams presented herein can represent conceptual views of illustrative system components and/or circuitry embodying the principles of the invention. Similarly, one having ordinary skill in the art should appreciate in view of the teachings provided herein that any flow charts,

flow diagrams and the like can represent various processes which can be substantially represented in computer readable storage media and so executed by a computer, processor or other device with processing capabilities, whether or not such computer or processor is explicitly shown.

Furthermore, exemplary embodiments of the present invention can take the form of a computer program product accessible from a computer-usable and/or computer-readable storage medium providing program code and/or instructions for use by or in connection with, e.g., a computer or any instruction execution system. In accordance with the present disclosure, a computer-usable or computer readable storage medium can be any apparatus that can, e.g., include, store, communicate, propagate or transport the program for use by or in connection with the instruction execution system, apparatus or device. Such exemplary medium can be, e.g., an electronic, magnetic, optical, electromagnetic, infrared or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include, e.g., a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), flash (drive), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk – read only memory (CD-ROM), compact disk – read/write (CD-R/W) and DVD. Further, it should be understood that any new computer-readable medium which may hereafter be developed should also be considered as computer-readable medium as may be used or referred to in accordance with exemplary embodiments of the present invention and disclosure.

Having described preferred and exemplary embodiments of novel and inventive system and method for using traumatic brain injury guidelines in/with a monitor/defibrillator to care for traumatic brain injury patients, (which embodiments are intended to be illustrative and not limiting), it is noted that modifications and variations can be made by persons having ordinary skill in the art in light of the teachings provided herein, including the Figures. It is therefore to be understood that changes can be made in/to the preferred and exemplary embodiments of the present disclosure which are within the scope of the embodiments disclosed herein.

Moreover, it is contemplated that corresponding and/or related systems incorporating and/or implementing the device or such as may be used/implemented in a device in accordance with the present disclosure are also contemplated and considered to

be within the scope of the present invention. Further, corresponding and/or related method for manufacturing and/or using a device and/or system in accordance with the present disclosure are also contemplated and considered to be within the scope of the present invention.

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Claims

1. A traumatic brain injury guideline system, comprising:

a patient monitoring sensor (30) operable to generate data for monitoring a traumatic brain injury parameter of a patient; and

a patient monitoring device (10) operable in communication with the patient monitoring sensor (30) to generate, responsive to the traumatic brain injury parameter data, a traumatic brain injury indicator derived from a comparison of the traumatic brain injury parameter data to parameter guideline data associated with monitoring a potential traumatic brain injury of the patient,

wherein the traumatic brain injury indicator is informative of at least one of a traumatic brain injury status of the patient and a traumatic brain injury treatment for the patient.

2. The traumatic brain injury guideline system of claim 1,

wherein the patient monitoring sensor (30) is a blood pressure sensor operable to generate data indicative of a systolic blood pressure of the patient; and

wherein, responsive to the systolic blood pressure data, the patient monitoring device (10) is operable to generate the traumatic brain injury indicator informative of a hypotension status of the patient derived from a comparison of the systolic blood pressure data to blood pressure guideline data associated with the potential traumatic brain injury of the patient.

3. The traumatic brain injury guideline system of claim 1,

wherein the patient monitoring sensor (30) is a blood oxygen sensor operable to generate data indicative of a saturation of a blood oxygen of the patient; and

wherein, responsive to the blood oxygen data, the patient monitoring device (10) is operable to generate the traumatic brain injury indicator informative of a hypoxia status of the patient derived from a comparison of the blood oxygen saturation data to a blood oxygen saturation guideline data associated with the potential traumatic brain injury of the patient.

4. The traumatic brain injury guideline system of claim 1,

wherein the patient monitoring sensor (30) is a carbon dioxide sensor operable to generate data indicative of an expiration level of carbon dioxide by the patient; and

wherein, responsive to the carbon dioxide data, the patient monitoring device (10) is operable to generate the traumatic brain injury indicator informative of a carbon dioxide ventilation status of the patient derived from a comparison of an expiration of end-tidal carbon dioxide by the patient to an end-tidal carbon dioxide guideline data associated with the potential traumatic brain injury of the patient.

5. The traumatic brain injury guideline system of claim 1,

wherein the patient monitoring sensor (30) is a carbon dioxide sensor operable to generate data indicative of an expiration level of carbon dioxide by the patient; and

wherein, responsive to the carbon dioxide data, the patient monitoring device (10) is operable to generate the traumatic brain injury indicator informative of a ventilation treatment for the patient derived from a comparison of an expiration of end-tidal carbon dioxide by the patient to an end-tidal carbon dioxide guideline data associated with the potential traumatic brain injury of the patient.

6. The traumatic brain injury guideline system of claim 1, wherein the patient monitoring device (10) is operable to graphically display the traumatic brain injury indicator relative to a map of the parameter guideline data associated with monitoring the potential traumatic brain injury of the patient.

7. The traumatic brain injury guideline system of claim 1, wherein the patient monitoring device (10) is operable to graphically display the traumatic brain injury indicator relative to a map of the parameter guideline data associated with monitoring the potential traumatic brain injury of the patient and of at least one additional parameter guideline data associated with monitoring the potential traumatic brain injury of the patient.

8. The traumatic brain injury guideline system of claim 1, wherein the patient monitoring device (10) is operable at least one of report and broadcast the traumatic brain injury indicator.

9. A patient monitoring device (10), comprising:

a patient data monitor module (17a) operable to monitor data indicative of a traumatic brain injury parameter of a patient; and

a traumatic brain injury monitor module (17b) operable in communication with the patient data monitor module (17a) to generate, responsive to a monitoring of the traumatic brain injury parameter data, a traumatic brain injury indicator derived from a comparison of the traumatic brain injury parameter data to parameter guideline data associated with monitoring a potential traumatic brain injury of the patient,

wherein the traumatic brain injury indicator is informative of at least one of a traumatic brain injury status of the patient and a traumatic brain injury treatment for the patient.

10. The patient monitoring device (10) of claim 9,

wherein the patient data monitor module (17a) is operable to monitor data indicative of a systolic blood pressure of the patient; and

wherein, responsive to a monitoring of the systolic blood pressure data by the patient data monitor module (17a), the traumatic brain injury monitor module (17b) is operable to generate the traumatic brain injury indicator informative of a hypotension status of the patient derived from a comparison of the systolic blood pressure data to blood pressure guideline data associated with the potential traumatic brain injury of the patient.

11. The patient monitoring device (10) of claim 9,

wherein the patient data monitor module (17a) is operable to monitor data indicative of a saturation of a blood oxygen of the patient; and

wherein, responsive to a monitoring of the blood oxygen level data by the patient data monitor module (17a), the traumatic brain injury monitor module (17b) is operable to generate the traumatic brain injury indicator informative of a hypoxia status of the patient derived from a comparison of the blood oxygen saturation data to a blood oxygen saturation guideline data associated with the potential traumatic brain injury of the patient.

12. The patient monitoring device (10) of claim 9,

wherein the patient data monitor module (17a) is operable to monitor data indicative of an expiration level of carbon dioxide by the patient; and

wherein, responsive to a monitoring of the expired carbon dioxide data by the patient data monitor module (17a), the traumatic brain injury monitor module (17b) is operable to generate the traumatic brain injury indicator informative of a carbon dioxide ventilation status of the patient derived from a comparison of an expiration of end-tidal carbon dioxide by the patient to an end-tidal carbon dioxide guideline data associated with the potential traumatic brain injury of the patient.

13. The patient monitoring device (10) of claim 9,

wherein the patient data monitor module (17a) is operable to monitor data indicative of an expiration level of carbon dioxide by the patient; and

wherein, responsive to a monitoring of the expired carbon dioxide data by the patient data monitor module (17a), the traumatic brain injury monitor module (17b) is operable to generate the traumatic brain injury indicator informative of a ventilation treatment for the patient derived from a comparison of an expiration of end-tidal carbon dioxide by the patient to an end-tidal carbon dioxide guideline data associated with the potential traumatic brain injury of the patient.

14. The patient monitoring device (10) of claim 9, wherein the traumatic brain injury monitor module (17b) is operable to graphically display the traumatic brain injury indicator relative to a map of the parameter guideline data associated with monitoring the potential traumatic brain injury of the patient.

15. The patient monitoring device (10) of claim 9, wherein traumatic brain injury monitor module (17b) is operable to graphically display the traumatic brain injury indicator relative to a map of the parameter guideline data associated with monitoring the potential traumatic brain injury of the patient and of at least one additional parameter guideline data associated with monitoring the potential traumatic brain injury of the patient.

16. A traumatic brain injury guideline method, comprising:

a patent monitoring sensor (30) generating data for monitoring a traumatic brain injury parameter of a patient; and

a patient monitoring device (10), responsive to the traumatic brain injury parameter data, generating a traumatic brain injury indicator derived from a comparison of the traumatic brain injury parameter data to parameter guideline data associated with a potential traumatic brain injury of the patient,

wherein the traumatic brain injury indicator is informative of at least one of a traumatic brain injury status of the patient and a traumatic brain injury treatment for the patient.

17. The traumatic brain injury guideline method of claim 16,

wherein the patient monitoring sensor (30) is a blood pressure sensor generating data indicative of a systolic blood pressure of the patient; and

wherein, responsive to the systolic blood pressure data, the patient monitoring device (10) generates the traumatic brain injury indicator informative of a hypotension status of the patient derived from a comparison of the systolic blood pressure data to blood pressure guideline data associated with the traumatic brain injury.

18. The traumatic brain injury guideline method of claim 16,

wherein the patient monitoring sensor (30) is a blood oxygen sensor generating data indicative of a saturation of a blood oxygen of the patient; and

wherein, responsive to the blood oxygen data, the patient monitoring device (10) generates the traumatic brain injury indicator informative of a hypoxia status of the patient derived from a comparison of the blood oxygen saturation data to a blood oxygen saturation guideline data associated with the traumatic brain injury.

19. The traumatic brain injury guideline method of claim 16,

wherein the patient monitoring sensor (30) is a carbon dioxide sensor generating data indicative of an expiration level of carbon dioxide by the patient; and

wherein, responsive to the carbon dioxide data, the patient monitoring device (10) generates the traumatic brain injury indicator informative of a carbon dioxide ventilation status of the patient derived from a comparison of an expiration of end-tidal carbon

dioxide by the patient to an end-tidal carbon dioxide guideline data associated with the traumatic brain injury.

20. The traumatic brain injury guideline method of claim 16,

wherein the patient monitoring sensor (30) is a carbon dioxide sensor generating data indicative of an expiration level of carbon dioxide by the patient; and

wherein, responsive to the carbon dioxide data, the patient monitoring device (10) generates the traumatic brain injury indicator informative of a ventilation treatment for the patient derived from a comparison of an expiration of end-tidal carbon dioxide by the patient to an end-tidal carbon dioxide guideline data associated with the traumatic brain injury.

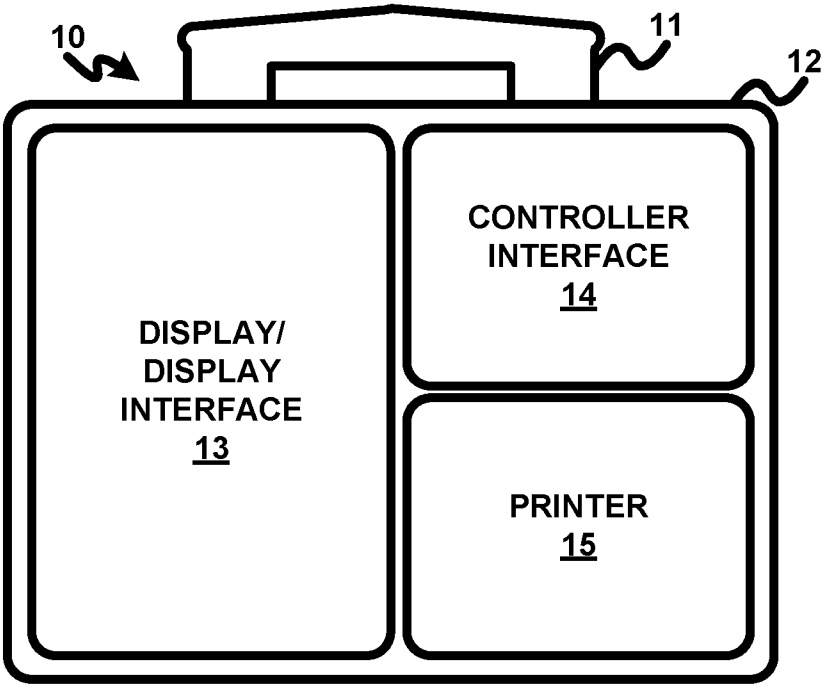

FIG. 1A

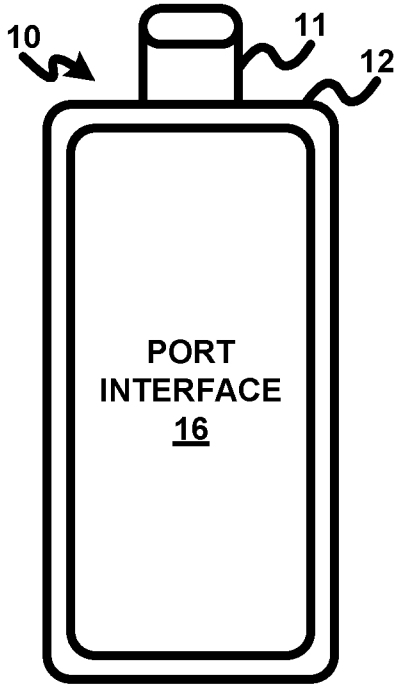

FIG. 1B

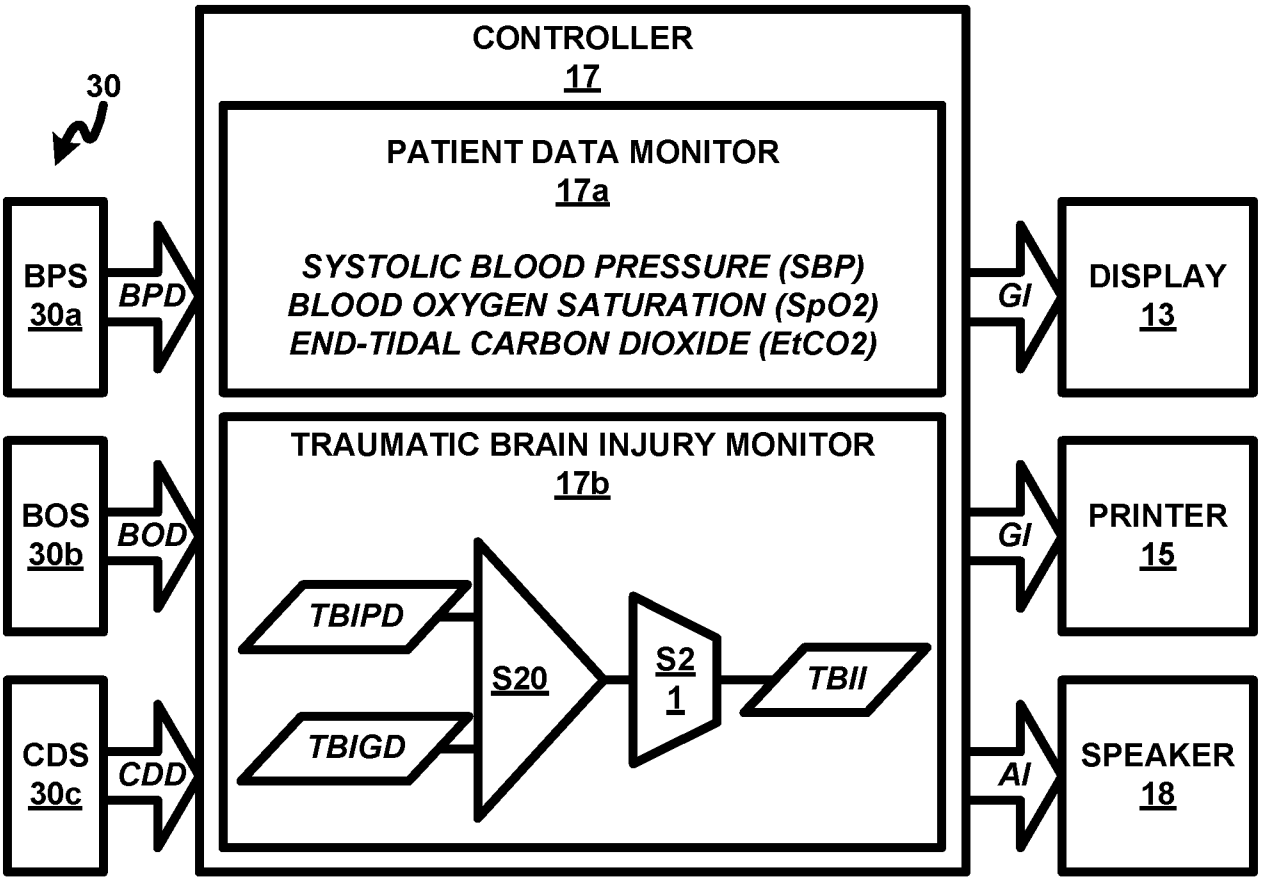

FIG. 2

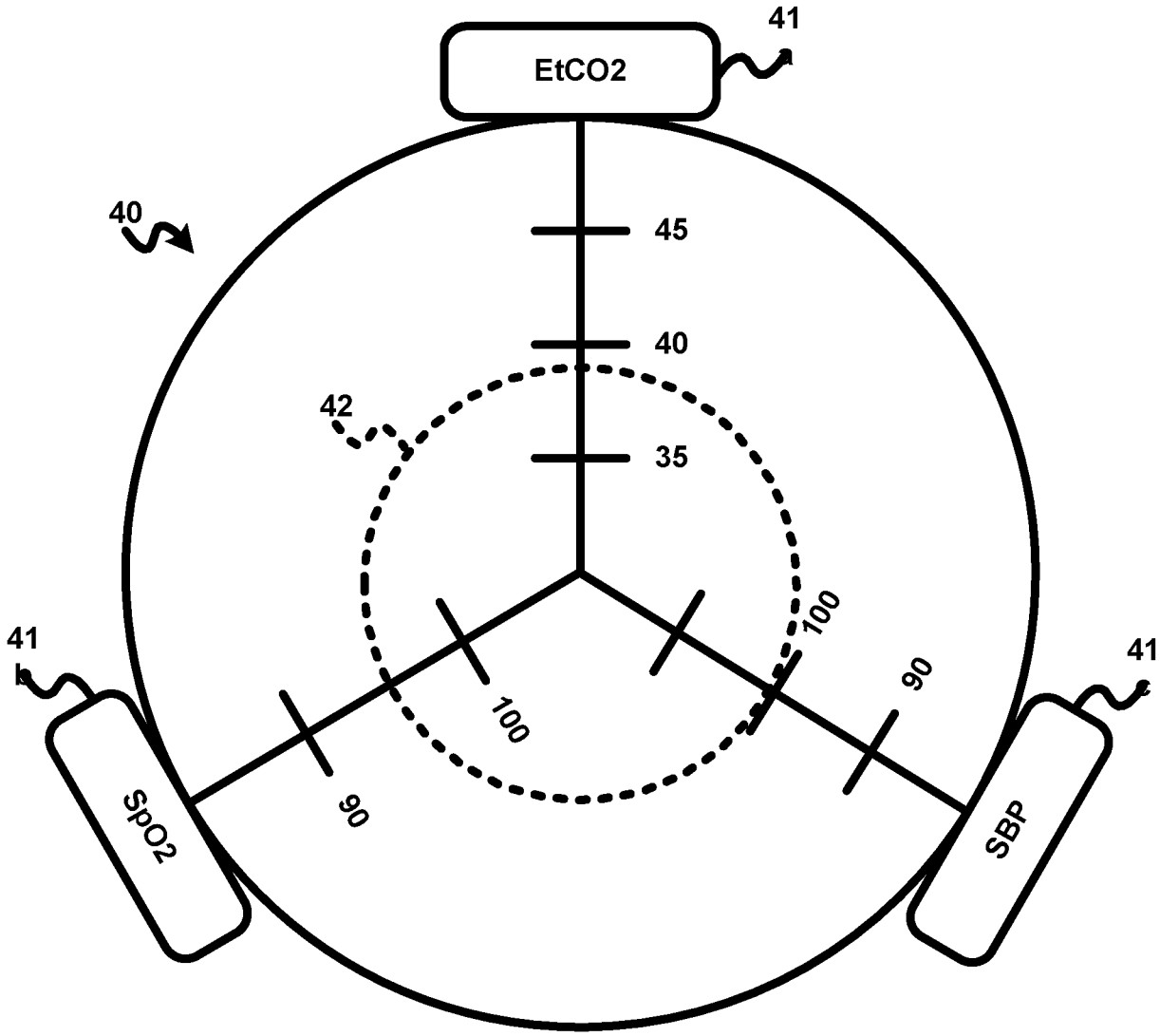

FIG. 3A

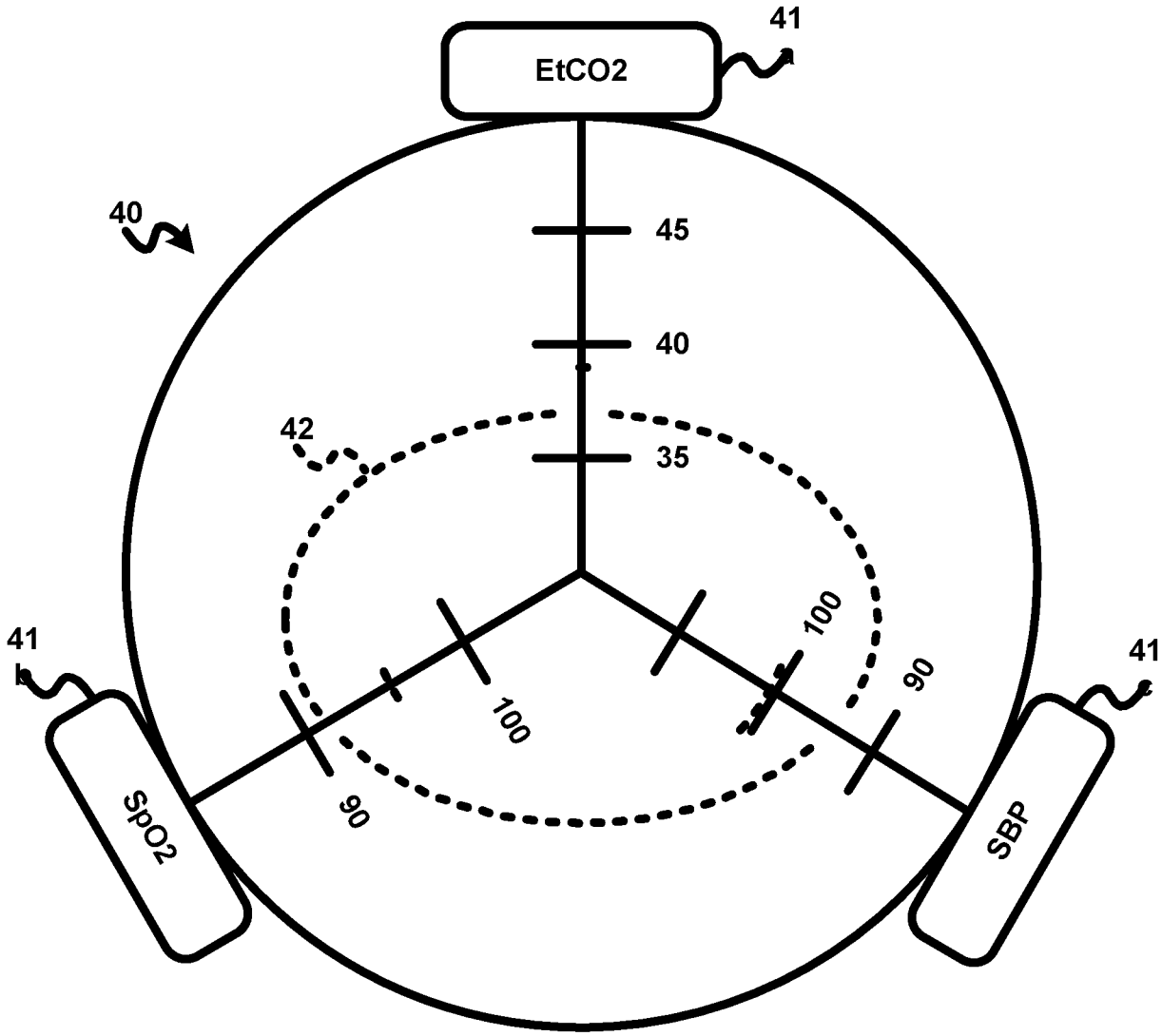

FIG. 3B

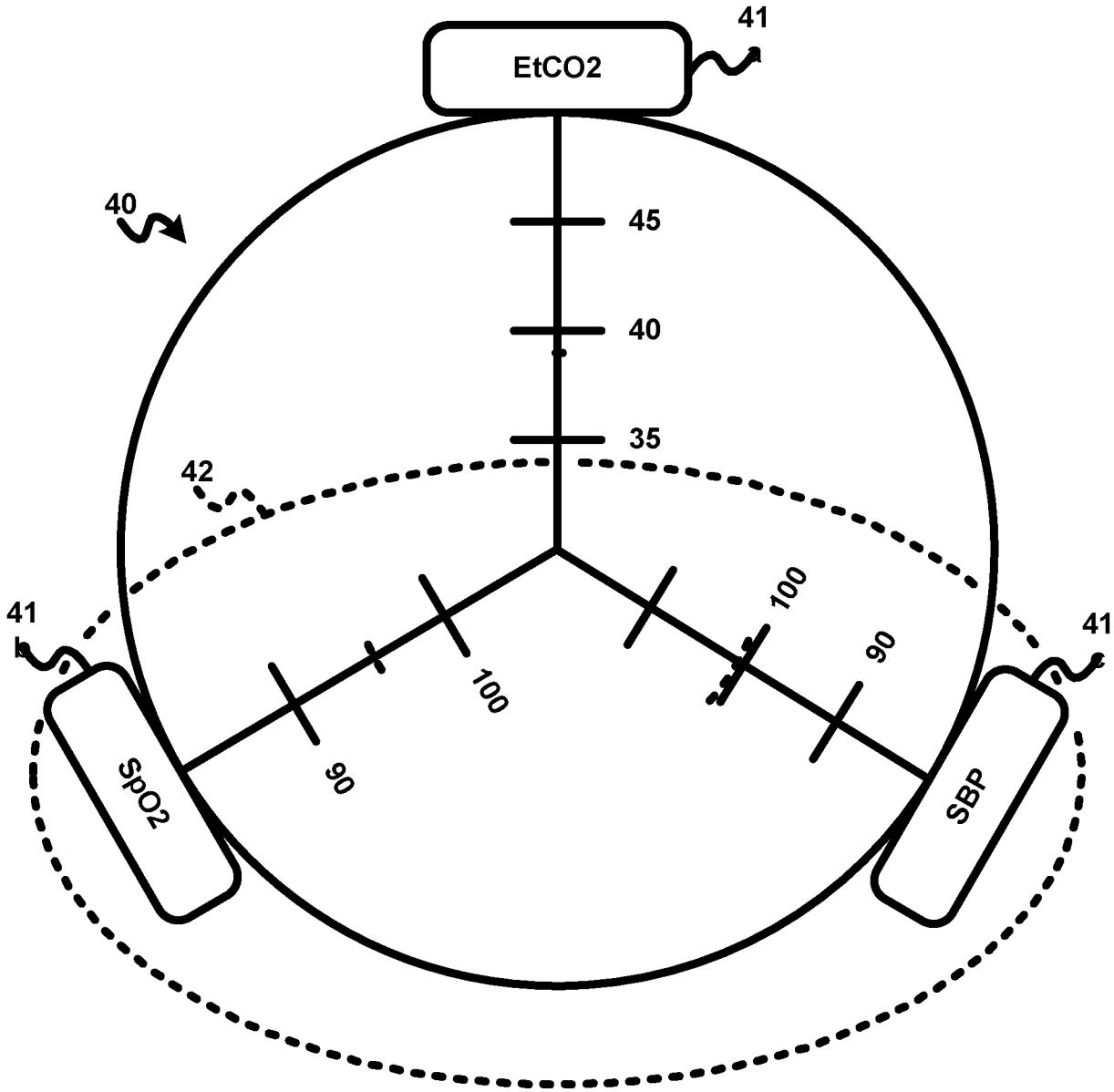

FIG. 3C

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/066113

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/087 A61B5/1455 A61B5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/155206 A1 (LYNN LAWRENCE A [US]) 13 July 2006 (2006-07-13) paragraphs [0034], [0063], [0064], [0088], [0092] - [0094], [0118], [0145], [0210], [0223], [0332], [0333]; figures 2, 6, 7, 18	1-20
X	US 2009/005703 A1 (FASCIANO ROBERT W [US]) 1 January 2009 (2009-01-01) paragraphs [0002], [0004], [0010], [0027]; figures 2, 3	1,3,6,7
A	US 2003/083582 A1 (HIRSH ROBERT [US]) 1 May 2003 (2003-05-01) figure 32	1
A	US 2013/261472 A1 (PARKIN WILLIAM GEOFFREY [AU] ET AL) 3 October 2013 (2013-10-03) figure 9	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 February 2015	18/02/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Visser, Robert

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/066113

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2013261472 A1	03-10-2013
		WO 2009094700 A1	06-08-2009

专利名称(译)	创伤性脑损伤指南系统和方法		
公开(公告)号	EP3071105A1	公开(公告)日	2016-09-28
申请号	EP2014812298	申请日	2014-11-18
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
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发明人	HELFENBEIN, ERIC BABAEIZADEH, SAEED		
IPC分类号	A61B5/087 A61B5/1455 A61B5/00		
CPC分类号	A61B5/087 A61B5/14551 A61B5/7275 G16H20/40 G16H40/60 A61B5/021 A61B5/082 A61B5/14542 A61B5/4064 A61B5/7246 A61B5/742 A61M16/0078 A61M2205/58		
代理机构(译)	STEFFEN，THOMAS		
优先权	61/906841 2013-11-20 US		
外部链接	Espacenet		

摘要(译)

一种创伤性脑损伤（“TBI”）指南系统，其采用患者监测传感器（30）和患者监测装置（10）。在操作中，患者监测传感器（30）产生用于监测患者的TBI参数的数据（例如，患者的收缩压，血氧饱和度或二氧化碳呼气），并且患者监测设备（10）产生TBI从TBI参数数据与与患者的潜在TBI相关的参数指南数据的比较得出的指标。患者监测设备（10）可以包括用于监测TBI参数数据的患者数据监测模块（17a），以及用于产生TBI指标的TBI监测模块（17b）。 TBI指标提供患者的TBI状态（例如，低血压状态，缺氧状态或患者的通气状态）和/或患者的TBI治疗（例如，患者的通气治疗）的信息。 。