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(71) Applicant: **KONINKLIJKE PHILIPS N.V.** [NL/NL]; High Tech Campus 5, 5656 AE Eindhoven (NL).

(72) Inventors: **VAIRAVAN, Srinivasan**; c/o High Tech Campus, Building 5, 5656 AE Eindhoven (NL). **CHBAT, Nicolas Wadih**; c/o High Tech Campus, Building 5, 5656 AE Eindhoven (NL). **CHIOFOLO, Caitlyn Marie**; c/o High Tech Campus, Building 5, 5656AE Eindhoven (NL).

(74) Agent: **DE HAAN, Poul Erik**; High Tech Campus Building 5, 5656 AE Eindhoven (NL).

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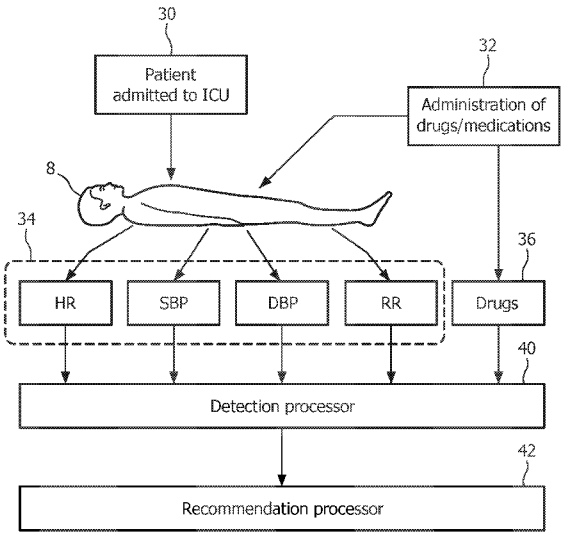

FIG. 2

(57) Abstract: Disclosed herein are approaches for monitoring a patient in real-time for ARDS development and providing a biomarker-driven ventilation therapy recommendation tool based on the correlation of various therapy patterns and an ARDS biomarker score. When the ARDS biomarker indicates that a patient has a high ARDS risk, the recommendation tool suggests possible therapy routes based on clinical practice. In response to a high score output by the ARDS detection model, the tool outputs a recommendation to initiate a lung protective ventilation strategy (Low Tidal Volume, high Positive End-Expiratory Pressure (PEEP)). A high ARDS score is recognized to be predictive of the appropriateness of such therapy up to several hours before such intervention is typically initiated under current clinical practices.

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TOOL FOR RECOMMENDATION OF VENTILATION THERAPY GUIDED BY RISK SCORE FOR ACUTE RESPIRATOR DISTRESS SYNDROME (ARDS)

BACKGROUND

The following relates to the medical monitoring arts, clinical decision support system arts, intensive care monitoring and patient assessment arts, patient mechanical ventilation arts, and so forth.

Acute Respiratory Distress Syndrome (ARDS) is a devastating complication of acute illness and one of the leading causes of multiple organ failure and mortality in the intensive care unit (ICU). Acute Respiratory Distress Syndrome (ARDS) is estimated to be prevalent in 7-10% of all ICU patients, and exhibits a high mortality of greater than 40% after hospital discharge. However, less than one-third of ARDS patients are detected by ICU physicians. Various embodiments of ARDS detection are set forth in Vairavan et al., Int'l Appl. Pub. No. WO 2013/121374 A2 published August 22, 2013 which is incorporated herein by reference in its entirety.

BRIEF SUMMARY

The following contemplates improved apparatuses and methods that overcome the aforementioned limitations and others.

According to one aspect, a therapy guidance tool for acute respiratory distress syndrome intensive care settings comprising one or more processors configured to use an ARDS score as a biomarker to recommend therapy.

According to another aspect, a method for guiding acute respiratory distress syndrome intensive care settings, comprising an ARDS score as a biomarker to recommend therapy.

According to another aspect, An apparatus for recommending ventilation strategy for a patient at risk for acute respiratory distress syndrome, comprising: a bedside monitor to monitor patient physiological variables; and one or more processors configured to: compute predictive inferences based on an ARDS score analyzed at a given time; continuously monitor a current ARDS score of a patient for the computed predictive

inferences to determine a likely expected ARDS in the future; and generate an alert after determining a likely expected ARDS.

One advantage resides in real-time alerts of ARDS risk.

Another advantage resides in continuous monitoring of an ARDS biomarker.

Another advantage resides in suggesting ventilator settings for interventional therapy.

Numerous additional advantages and benefits will become apparent to those of ordinary skill in the art upon reading the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present application may take form in various components and arrangements of components, and in various process operations and arrangements of process operations. The drawings are only for the purpose of illustrating preferred embodiments and are not to be construed as limiting the present application.

FIGURE 1 diagrammatically shows a patient in an intensive care unit (ICU) being monitored for acute respiratory distress syndrome (ARDS) at a bedside monitor and at a nurses' station, the latter along with other patients in the ICU.

FIGURE 2 illustrates an ARDS detection and ventilation recommendation approach.

FIGURE 3 illustrates a correlation of a monitored ARDS score and changes in ventilation strategy.

FIGURE 4 illustrates comparison box plots of a traditional ventilation strategy and a protective ventilation strategy on an ARDS score in view of tidal volume settings.

FIGURE 5 illustrates comparison box plots of a traditional ventilation strategy and a protective ventilation strategy on an ARDS score in view of PEEP settings.

FIGURE 6 illustrates an ARDS ventilation strategy tool.

DETAILED DESCRIPTION

Techniques disclosed herein use a continuous score of ARDS risk output by an ARDS detection model as a biomarker for ARDS development. The present application includes a biomarker-driven therapy recommendation tool based on the correlation of

various therapy patterns and the biomarker itself (ARDS score). When the biomarker indicates that a patient has a high ARDS risk, the recommendation tool suggests possible therapy routes based on clinical practice. A high score in the ARDS detection model correlates well with the lung protective ventilation strategy (Low Tidal Volume, high Positive End-Expiratory Pressure (PEEP)), thus the tool indicates that lung protective therapy should be applied to the patient. A high ARDS score also has the capacity to predict the therapy several hours before the actual intervention. Such information, when computerized, into therapy recommendations enables continuous disease monitoring and improved adoption of best clinical practices, while supporting clinicians in planning prophylactic and interventional treatments.

With reference to FIGURE 1, a patient **8** is monitored by a bedside patient monitor **10**, which displays trend data for various physiological variables of the patient **8**. (Terms such as "physiological variables", "vital signs", or "vitals" are used interchangeably herein). For example, illustrative electrocardiograph (ECG) electrodes **12** suitably monitor heart rate and optionally full ECG traces as a function of time. Substantially any physiological variables of medical interest may be monitored, such as by way of illustrative example, one or more of the following: heart rate (HR); respiration rate (RR); systolic blood pressure (SBP); diastolic blood pressure (DBP); fraction of inspired oxygen (FiO_2); partial pressure of oxygen in arterial blood (PaO_2); positive end-expiratory pressure (PEEP); blood hemoglobin (Hgb); and so forth. Although not shown in FIGURE 1, it is contemplated for the patient **8** to be on a mechanical ventilator.

The patient monitor **10** includes a display **14**, which is preferably a graphical display, on which physiological variables and optionally other patient data are displayed using numeric representations, graphical representations, trend lines, or so forth. The patient monitor **10** further includes one or more user input devices, such as illustrative controls **16** mounted on the body of the monitor **10**, a set of soft keys **18** shown on the display **14** (which is suitably a touch-sensitive display in such a configuration), a pull-out keyboard, various combinations thereof, or so forth. The user input device(s) enable a nurse or other medical person to configure the monitor **10** (e.g. to select the physiological variables or other patient data to be monitored and/or displayed), to set alarm settings, or so forth. Although not explicitly shown, the patient monitor **10** may include other features

such as a speaker for outputting an audio alarm if appropriate, one or more LEDs or lamps of other types to output visual alarms, and so forth.

The patient monitor **10** is an "intelligent" monitor in that it includes or is operatively connected with data processing capability provided by a microprocessor, microcontroller, or the like connected with suitable memory and other ancillary electronics (details not illustrated). In some embodiments the patient monitor **10** includes internal data processing capability in the form of a built-in computer, microprocessor, or so forth, such that the patient monitor can perform autonomous processing of monitored patient data. In other embodiments the patient monitor is a "dumb terminal" that is connected with a server or other computer or data processing device that performs the processing of patient data. It is also contemplated for a portion of the data processing capability to be distributed amongst intercommunicating body-worn sensors or devices mounted on the patient **8**, e.g. in the form of a Medical Body Area Network (MBAN).

In illustrative examples, the patient **8** is disposed in a patient room of an intensive care unit (ICU), which may for example be a medical ICU (MICU), a surgical ICU (SICU), a cardiac care unit (CCU), a triage ICU (TRICU), or so forth. In such settings, the patient is typically monitored by the bedside patient monitor **10** located with the patient (e.g., in the patient's hospital room) and also by an electronic monitoring device **20** with suitable display **22** (e.g. a dedicated monitor device or a suitably configured computer) located at a nurses' station **24**. Typically, the ICU has one or more such nurses' stations, with each nurses' station assigned to a specific set of patients (which may be as few as a single patient in extreme situations). A wired or wireless communication link (indicated diagrammatically by double-arrow-headed curved line **26**) conveys patient data acquired by the bedside patient monitor **10** to the electronic monitoring device **20** at the nurses' station **24**. The communication link **26** may, for example, comprise a wired or wireless Ethernet (dedicated or part of a hospital network), a Bluetooth connection, or so forth. It is contemplated for the communication link **26** to be a two-way link – i.e., data also may be transferrable from the nurses' station **24** to the bedside monitor **10**.

The bedside patient monitor **10** is configured to detect and indicate Acute Respiratory Distress Syndrome (ARDS) by performing data processing as disclosed herein on information including at least one or more physiological variables monitored by the

patient monitor **10**. The display **14** of the bedside patient monitor **10** displays an ARDS ventilation tool **28** described in detail below. Additionally or alternatively, the electronic monitoring device **20** at the nurses' station **24** may be configured to detect and indicate ARDS by performing data processing as disclosed herein on information including at least one or more physiological variables monitored by the patient monitor **10** and display the ARDS ventilation tool **28**. Note that the terms Acute Lung Injury (ALI) and Acute Respiratory Distress Syndrome (ARDS) are used interchangeably herein. Advantageously, the ARDS detection as disclosed herein is based on physiological variables such as heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP), diastolic blood pressure (DBP), fraction of inspired oxygen (FiO_2), positive end-expiratory pressure (PEEP), or so forth, which are monitored by the patient monitor **10** and hence are available in real-time. Patient data with longer acquisition latency times, such as radiography reports and laboratory findings (e.g. PaO_2, Hgb, et cetera) are not utilized or are utilized as supplemental information for evaluating whether ARDS is indicated. In illustrative ARDS scoring examples presented herein, the data input to the ARDS model included vital signs, laboratory results and ventilator settings.

Various embodiments of continuous ARDS detection are set forth in Vairavan et al., Int'l Appl. Pub. No. WO 2013/121374 A2 published August 22, 2013 which is incorporated herein by reference in its entirety. For example, an embodiment employing Lempel-Ziv complexity-based detection of ARDS can be used. With reference to FIGURE 2, the patient **8** is admitted to the ICU (indicated by block **30**). There may be scenarios where different drugs/medications ("drugs" and "medications" are used interchangeably herein) may be administered to the patient **8** in order to stabilize the patient (indicated by block **32**). Other therapies such as mechanical ventilation may also be administered. The illustrative ARDS detection approach of FIGURE 2 utilizes illustrative vital signs data streams **34** including heart rate (HR), arterial systolic and diastolic blood pressure (SBP and DBP), and respiratory rate (RR), along with an additional patient data stream **36** comprising instances of the administration **32** of one or more different drugs to the patient **8**. The drug administration data stream **36** can take various forms, such as a binary data stream (e.g. value "0" as a function of (optionally discretized) time except during a drug administration event which is indicated by a value "1". In the case of a drug administered

over a time interval, e.g. an intravenous drip, the value may be "0" when no drip is being administered and "1" (or some other value) during the administration of the drip). Other value-time representations are also contemplated, e.g. a time-varying value modeling the expected dynamic drug concentration in the patient (or in an organ of interest) from initial administration until the drug is removed from the body by the kidneys or other mechanism.

From the data streams, a detection processor **40** continuously computes the ARDS score. The detection processor **40** can output the ARDS score over time in the form of a plot of the score over time. The detection processor **40** may, for example, employ an ARDS (or ALI) scoring algorithm such as one disclosed in WO 2013/121374 A2 published August 22, 2013, for example in which linear discriminant analysis (LDA) or a voting system aggregates vital signs **34** and optionally other information (e.g. the illustrative drug administration information **36**, laboratory results, ventilator settings, or so forth) to generate the ARDS score. The illustrative ARDS scores presented herein were generated using the detection processor **40** embodied as the LDA aggregation model of WO 2013/121374 A2 with data input including vital signs, laboratory test results, and ventilator settings, with output in the "probability-type" range [0, 1]. More generally, the detection processor **40** can use other ARDS scoring approaches that generate a score indicative of risk that the patient has, or is developing toward, Acute Respiratory Distress Syndrome. In some embodiments, the detection processor **40** may output in a range other than [0, 1], for example the output may be a "percentage-type" value in the range 0-100. A recommendation processor **42** monitors the ARDS score in view of a predetermined threshold and recommends interventional therapy, e.g. ventilation therapy/settings, for the patient based on the monitored score. When the recommendation processor **42** detects the patient **8** to be at high risk of ARDS, the recommendation processor **42** suggests possible therapy routes based on best clinical practice. The ventilation strategies are broadly classified as Traditional and Protective. The protective ventilation strategy has been shown in clinical studies to reduce mortality in ARDS patients. The ranges of values associated with the different ventilation strategy are given as:

Mechanical Ventilation settings	Traditional	Protective
Tidal Volume (VT) (ml/kg)	**10-15**	**4-8**

Positive End Expiratory Pressure (PEEP) (cm H_2O)	**5 – 12**	**> 12**

With reference to FIGURES 3-5, ARDS patient correlation results are shown demonstrating that the ARDS score is predictive of ventilator setting change instances. Correlation of ARDS score with ventilation strategy (Traditional or Protective via vent settings as shown in the above table) was assessed by taking values of both ARDS score and vent setting change instances (T = 0 hr) across patient records. Correlation of vent strategy with ARDS score (several hours before a vent setting change) was assessed to determine the capability of ARDS score to predict a vent setting. The time periods of investigation were T = 10, 6, 5, 4, 3, 2 and 1 hours prior to vent setting change.

With reference to FIGURE 3, ARDS score **302** is compared with ventilation strategy as represented by ventilator tidal volume (VT) **304**. In FIGURE 3, Ventilator Tidal Volume (VT) setting changes are marked with black arrows. The box **306** surrounding an arrow indicates the zone corresponding to T = 0 hr (vent setting change). The box **308** represents ARDS score at T = -10 hr, or the zone corresponding to 10 hours prior to the VT settings change (at T = 0 hr).

Based on these results, the recommendation processor **42** suitably derives predictive inferences by examining values of the ARDS score. The recommendation processor **42** evaluates the ARDS score and can thereby provide a recommended ventilator setting (or setting change, if the patient is already on mechanical ventilation) up to several hours before the physician would recommend the ventilation setting change in the absence of this analysis. The recommendation processor **42** monitors the current ARDS score of the patient and uses the predictive inferences to determine whether a change in the ventilation strategy should be recommended. FIGURE 3 thus demonstrates that the ARDS score can be used as a biomarker for recommending ventilator settings for an ARDS patient. In FIGURE 3, the following notation is used: VT: Tidal Volume; P_{PLAT}: Plateau pressure; PEEP: positive end expiratory pressure; FiO2: Fraction of inspired oxygen; PaO2: Partial pressure of oxygen in blood.

FIGURES 4 and 5 show box plots of ARDS scores obtained during different time zones **306**, **308** and time zones between them, as depicted in Figure 3. In FIGURES 4 and 5, box plots provide the 25^{th}, 50^{th}, 75^{th} percentile as well as outliers for the data.

With particular reference to FIGURE 4, the correlation **400** of ARDS score **402** and tidal volume settings is depicted. The top plot **402** of FIGURE 4 shows box plots of ARDS score corresponding to protective (P) and traditional (T) tidal volume settings at different times relative to the tidal volume setting changes at T= 0 hr. The threshold **406** indicates the optimal threshold for ARDS detection as determined by Receiver Operating Characteristic curve (ROC) analysis. The middle plot **404** shows the Area under the curve (AUC) of the ROC for different prediction times. The bottom plot shows total number of patients at different time instants. In FIGURE 4, Protective Ventilation Strategy (P) has tidal volume of 4-8 ml/kg, while the Traditional Ventilation Strategy (T) has tidal volume of 10-15 ml/kg.

As shown in FIGURE 4, a statistical plot of the AUC **404** of the ROC depicts a quantification of separation between the two ventilation strategies. The time is depicted as T = 0 at the right most edge and looking back to T = -10 hours on the left hand edge of the plots. The ARDS score **402** is plotted in relation to a predetermined ARDS threshold score **406**. At T = 0 the ARDS scores corresponding to Protective and Traditional tidal volume settings are separable with an AUC for the ROC of 0.70. The threshold **406** shown in FIGURE 4 is the optimal threshold for ARDS detection based on the ROC analysis. The median values **412** in the Protective Strategy box plots are higher than this threshold **406**. This indicates that higher ARDS score is correlated with Protective Tidal volume settings.

The median values **412** of the Protective strategy box plots are consistently higher than median values **414** of the Traditional strategy box plots. This relation is observed across all time zones (T = -10….0). The threshold **406** is chosen to optimally separate the median values **412** for the protective strategy box plots from the median values **414** for the Traditional strategy box plots. As further seen in FIGURE 4, the AUC shows a good separation between the Protective and Traditional Tidal Volume Strategy across all time zones. These results indicate that the ARDS score could be used to recommend Protective tidal volume settings. Though the separation between the Protective and Traditional Tidal Volume Strategy tends to decrease for earlier time periods, the separation remains strong up until T = -2 hours (AUC = 0.69). This suggests the ARDS score **402** has a predictive capacity up until 2 hours before the ventilation intervention at T = 0 with the predictive power of the ARDS score decreasing for earlier periods of time.

Based on the results of FIGURE 4, the threshold **406** of 0.81 is suitably applied by the recommendation processor **42** in order to determine whether to recommend a tidal volume of 4-8 ml/kg as per Protective therapy (appropriate if the ARDS score is above threshold **406**). In some embodiments, in order to prevent alarm fatigue, ventilation therapy is recommended only when the ARDS score is high, in which case Protective ventilation therapy is recommended.

With reference to FIGURE 5, the correlation **500** of ARDS score **502** and PEEP settings is depicted. The top plot **502** shows box plots of ARDS score corresponding to protective and traditional ventilation settings at different time relative to the tidal volume setting changes at T= 0 hr. The threshold **506** indicates the optimal threshold for ARDS detection. The middle plot **504** shows the area under curve (AUC) **504** of the ROC curve for different prediction times. The bottom plot shows total number of patients at different time instants. In FIGURE 5, P: Protective Ventilation Strategy (PEEP>12 cm H_2O), T: Traditional Ventilation Strategy (PEEP=5-12 cm H_2O).

It can be seen in FIGURE 5 that a high ARDS score is correlative of Protective PEEP settings as opposed to Traditional PEEP settings. The median values **512** for the Protective therapy are higher than the median values **514** for the Traditional therapy. This trend is observable across different time periods starting from T = 0 hr to T = -10 hr. However, the separation between the two groups (Protective and Traditional) tends to decrease as hours before the vent setting change increases. Thus the predictive nature of ARDS score on vent setting recommendations would also decrease.

In sum, as demonstrated in FIGURES 4 and 5, a high ARDS score correlates to low tidal volume settings and also correlates to high PEEP settings. These settings are the characteristic settings of lung protective ventilation. Thus, the results described with reference to FIGURES 3-5 demonstrate that ARDS score is suitable for providing a recommendation to ventilate using either the traditional or protective strategy, with this prediction being reliably made at least 2 hours in advance of when a physician would typically make such an adjustment.

With reference to FIGURE 6, the recommendation processor **42** utilizes an ARDS ventilation recommendation tool **28** that provides a graphical user interface (GUI) for suggestions of lung protective ventilation as the ARDS risk increases above the decision

threshold. The predictive nature of the ARDS score allows the ventilation recommendation tool **28** to advise users to apply low tidal volume settings and high PEEP settings up to 2-3 hours before healthcare providers would conventionally change the vent settings. It is contemplated that the above described analysis could be performed for other therapeutic interventions such as fluid administrations, and other mechanical ventilation settings such as Plateau Pressure, FiO_2, etc.

A panel, i.e. window, represents a selectable bed display **602** for each patient with current ARDS scores highlighted. Another panel represents the demographics **604** of the patient of a selected patient from the bed display **602**. The ARDS score **606** (past, current and future trajectories) is displayed in parallel with the sequential organ failure assessment (SOFA) scores **608**.

When the ARDS score **606** gets above a predetermined threshold, i.e. an optimal threshold based on retrospective analysis of the ARDS score history, an alert **610** is displayed in the screen. On clicking the alert **610**, a therapy recommendation **612** is opened with detailed recommendations of lung protective ventilation settings to reduce the risk of ARDS. In one embodiment, the alert **610** is turned off when the healthcare providers view the therapy recommendation **612**. Subsequent alerts will pop up each time the ARDS score **606** changes from a value below the threshold, e.g. 75 in this illustrative example, to a value greater than the threshold.

With returning reference to FIGURE 1, the disclosed techniques for predicting ARDS or other conditions of concern for ICU patients are suitably implemented by the built-in computer, microprocessor, or so forth of the illustrative bedside monitor **10** and/or of the illustrative nurses' station electronic monitoring device **20**. It will also be appreciated that the disclosed techniques can be embodied by a non-transitory storage medium storing instructions executable by such an electronic data processing device to perform the disclosed detection methods. The non-transitory storage medium may, for example, comprise a hard disk or other magnetic storage medium, random access memory (RAM), read-only memory (ROM), or another electronic storage medium, an optical disk or other optical storage medium, a combination of the foregoing, or so forth.

The disclosure has been set forth with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and

understanding the preceding detailed description. It is intended that the present application be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS

1. A therapy guidance tool for acute respiratory distress syndrome intensive care settings comprising:

a display device (14, ,22); and

one or more processors configured to:

compute an Acute Respiratory Distress Syndrome (ARDS) score indicative of whether a patient has Acute Respiratory Distress Syndrome based on measured physiological variables (34) of the patient;

generate a ventilation therapy recommendation based on the computed ARDS score; and

display a representation of the ventilation therapy recommendation on the display device.

2. The therapy guidance tool according to claim 1 wherein the ARDS score is computed by:

receiving values of a plurality of physiological variables (34) for the patient;

computing the ARDS score based at least on the received values of the plurality of physiological variables for the patient; and

displaying a representation of the computed ARDS score on the display (14, 22).

3. The therapy guidance tool of any one of claims 1-2, wherein the processor is further configured to:

compute an ARDS score threshold above which the patient is determined high risk of ARDS.

4. The therapy guidance tool of any one of claims 1-3, wherein the processor is configured to generate the ventilation therapy recommendation based on the computed ARDS score including a recommendation of a ventilation strategy for the patient.

5. The therapy guidance tool of claim 4 wherein the processor is configured to generate the recommendation of a ventilation strategy for the patient based on thresholding of the computed ARDS score as one of (1) the traditional ventilation strategy and (2) the protective ventilation strategy.

6. The therapy guidance tool of claim 5, wherein:

the traditional ventilation strategy includes a recommended tidal volume of between 10 ml/kg and 15 ml/kg inclusive; and

the protective ventilation strategy includes a recommended tidal volume of between 4 ml/kg and 8 ml/kg inclusive.

7. The therapy guidance tool of any one of claims 5-6, wherein:

the traditional ventilation strategy includes a recommended positive end-expiratory pressure (PEEP) of between 5 cm H_2O and 12 cm H_2O inclusive; and

the protective ventilation strategy includes a recommended PEEP of greater than 12 cm H_2O.

8. The therapy guidance tool of any one of claims 5-7 wherein the processor is configured to display the representation of the ventilation therapy recommendation on the display device (14, 22) with an indication of a time horizon for the recommendation wherein the indicated time horizon is two hours or less.

9. The therapy guidance tool of any one of claims 5-8 wherein the ARDS score is in a range [0,1] or a percentage in the range [0%,100%] and the thresholding uses a threshold of at least 0.8 or 80%.

10. The therapy guidance tool of any one of claims 1-9, wherein the processor is further configured to compute the ARDS score continuously in real time.

11. The therapy guidance tool of any one of claims 1-10, wherein the ARDS score is computed based on measured physiological variables (34) of the patient including at least heart rate, respiration rate, and a blood pressure.

12. The therapy guidance tool of any one of claims 1-11, wherein the one or more processors is configured to display the representation of the ventilation therapy recommendation on the display device using a graphical user interface (GUI).

13. A method for treating a patient comprising:

monitoring physiological variables of the patient;

using a processor:

computing an Acute Respiratory Distress Syndrome (ARDS) score for the patient based on the monitored physiological variables, and

generating a mechanical ventilation recommendation for the patient based on the computed ARDS score; and

displaying the mechanical ventilation recommendation for the patient on a display device (14, 22).

14. The method of claim 13 wherein the computing comprises computing the ARDS score in real-time based on monitored physiological variables including heart rate, respiration rate, and a blood pressure.

15. The method of any one of claims 13-14 wherein the generating comprises thresholding the computed ARDS score and generating the mechanical ventilation recommendation based on the thresholding.

16. The method of any one of claims 13-14 wherein the generating comprises thresholding the computed ARDS score and one of:

providing no recommendation if the ARDS score is below a threshold (406, 506); and

providing a recommendation to perform mechanical ventilation with protective ventilation settings if the ARDS score is above the threshold.

17. The method of claim 16 wherein:

the traditional ventilation settings include tidal volume between 10 ml/kg and 15 ml/kg inclusive; and

the protective ventilation settings include tidal volume between 4 ml/kg and 8 ml/kg inclusive.

18. The method of any one of claims 16-17, wherein:

the traditional ventilation settings include positive end-expiratory pressure (PEEP) of between 5 cm H_2O and 12 cm H_2O inclusive; and

the protective ventilation settings include PEEP of greater than 12 cm H_2O.

19. The method of any one of claims 16-18 wherein the ARDS score is in a range [0,1] or a percentage in the range [0%,100%] and the threshold (406, 506) is 0.8 or 80%.

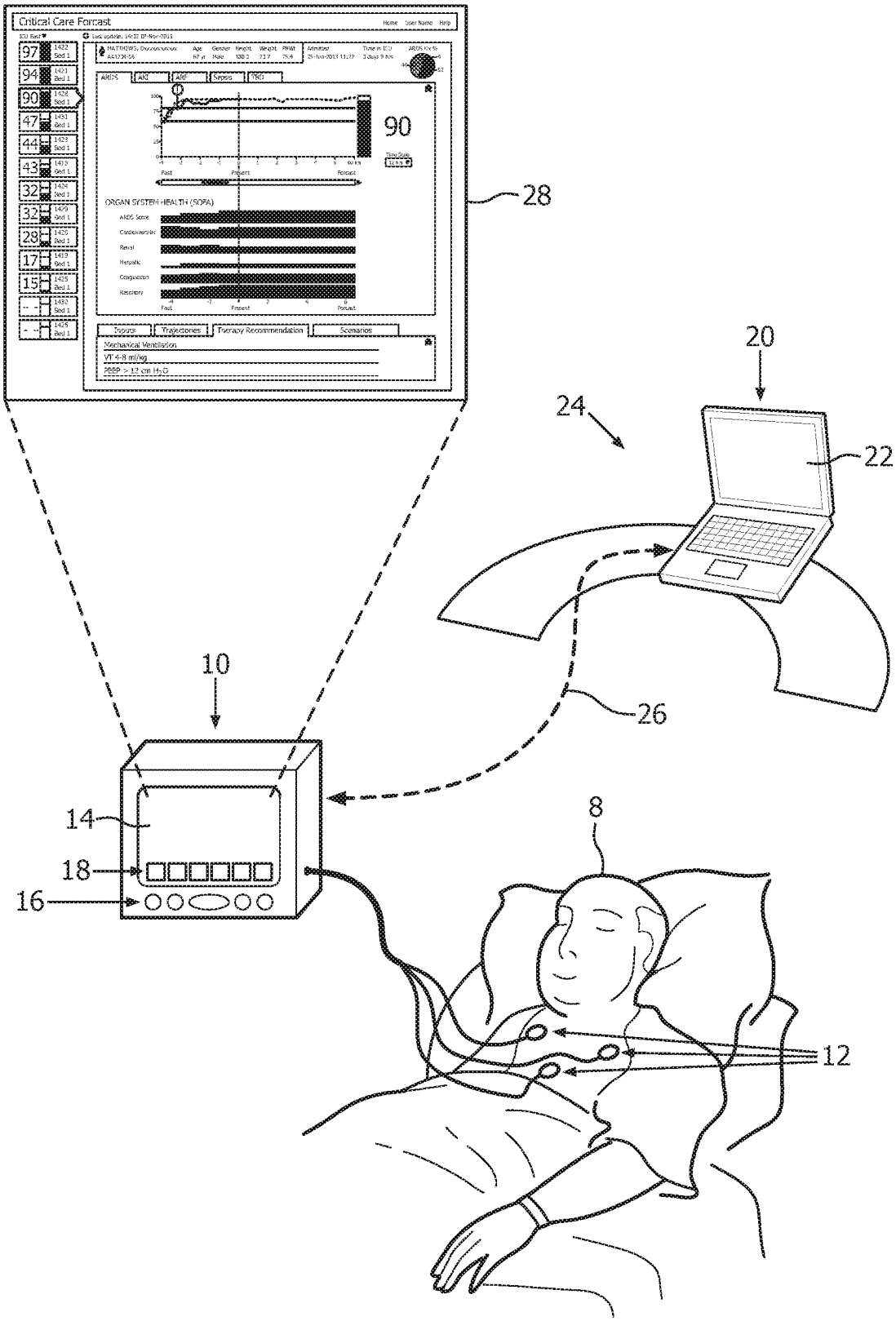
Critical Care Forcast
90
ORGAN SYSTEM HEALTH (SOFA)
Inputs
Trajectories
Therapy Recommendation
Scenarios
Mechanical Ventilation
28
20
24
22
26
10
14
18
16
8
12

FIG. 1

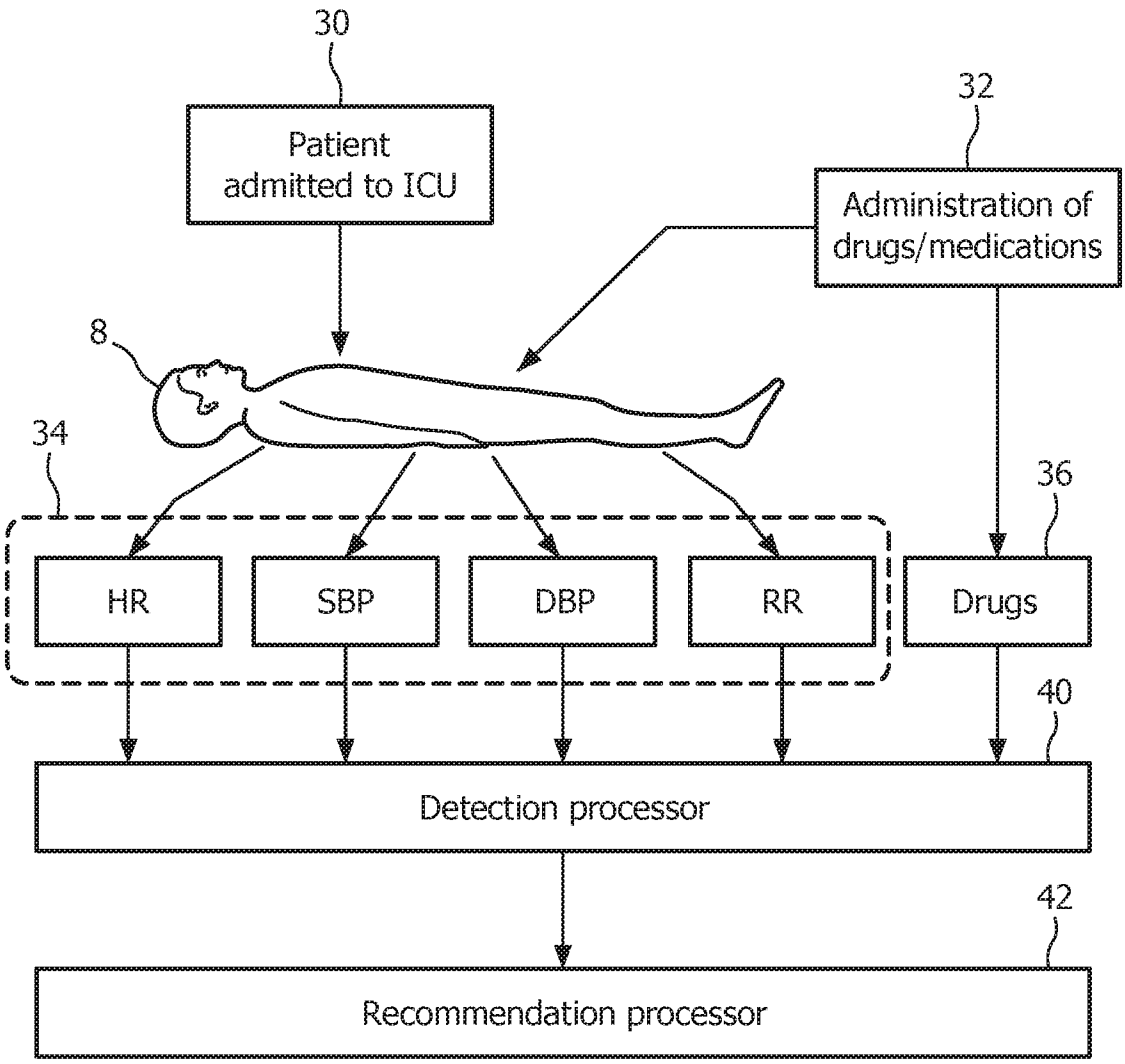
30
Patient admitted to ICU
32
Administration of drugs/medications
8
34
36
HR
SBP
DBP
RR
Drugs
40
Detection processor
42
Recommendation processor

FIG. 2

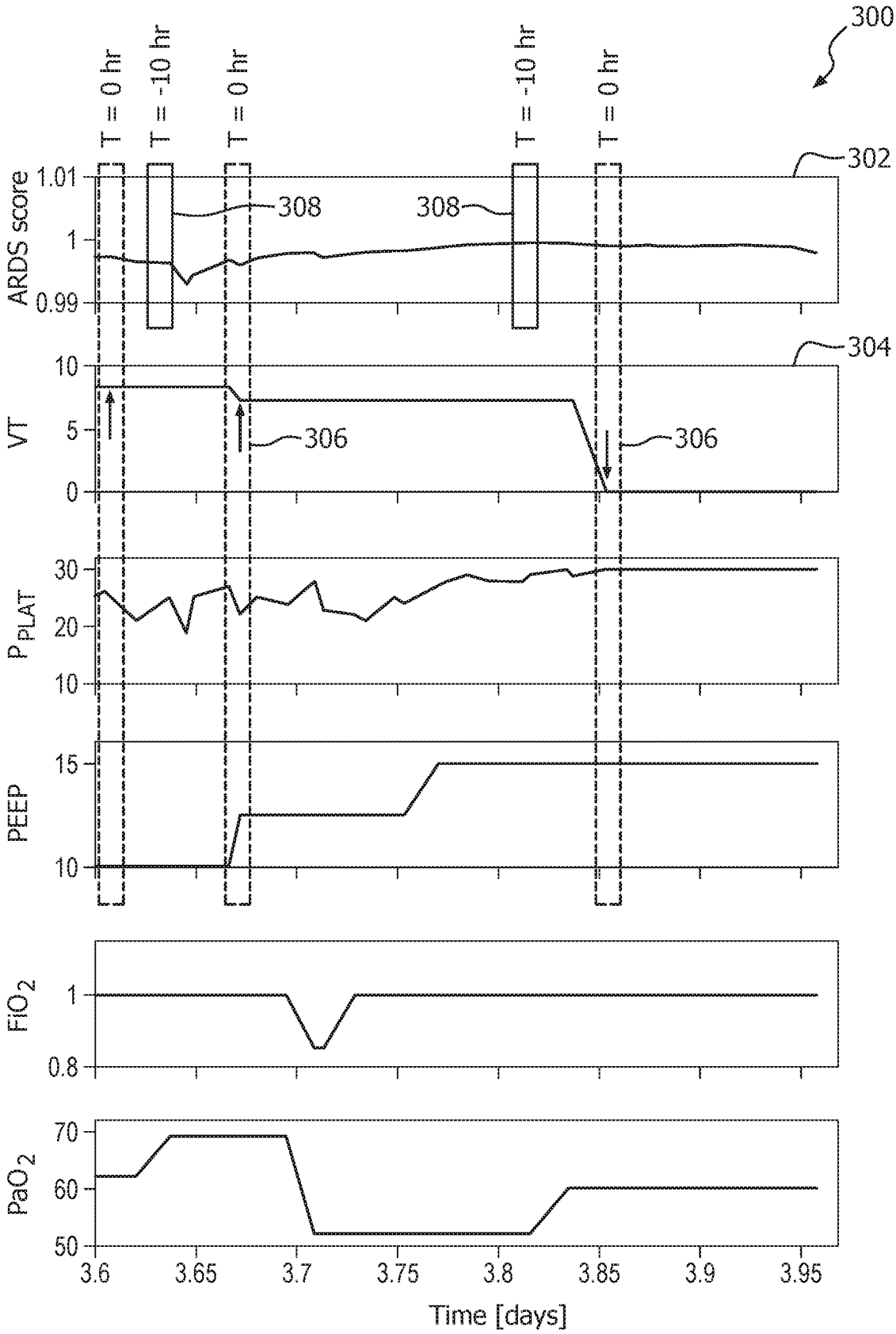
300
T = 0 hr
T = -10 hr
T = 0 hr
T = -10 hr
T = 0 hr
302
ARDS score
1.01
1
0.99
308
308
304
VT
10
5
0
306
306
P_{PLAT}
30
20
10
PEEP
15
10
FiO_2
1
0.8
PaO_2
70
60
50
3.6
3.65
3.7
3.75
3.8
3.85
3.9
3.95
Time [days]

FIG. 3

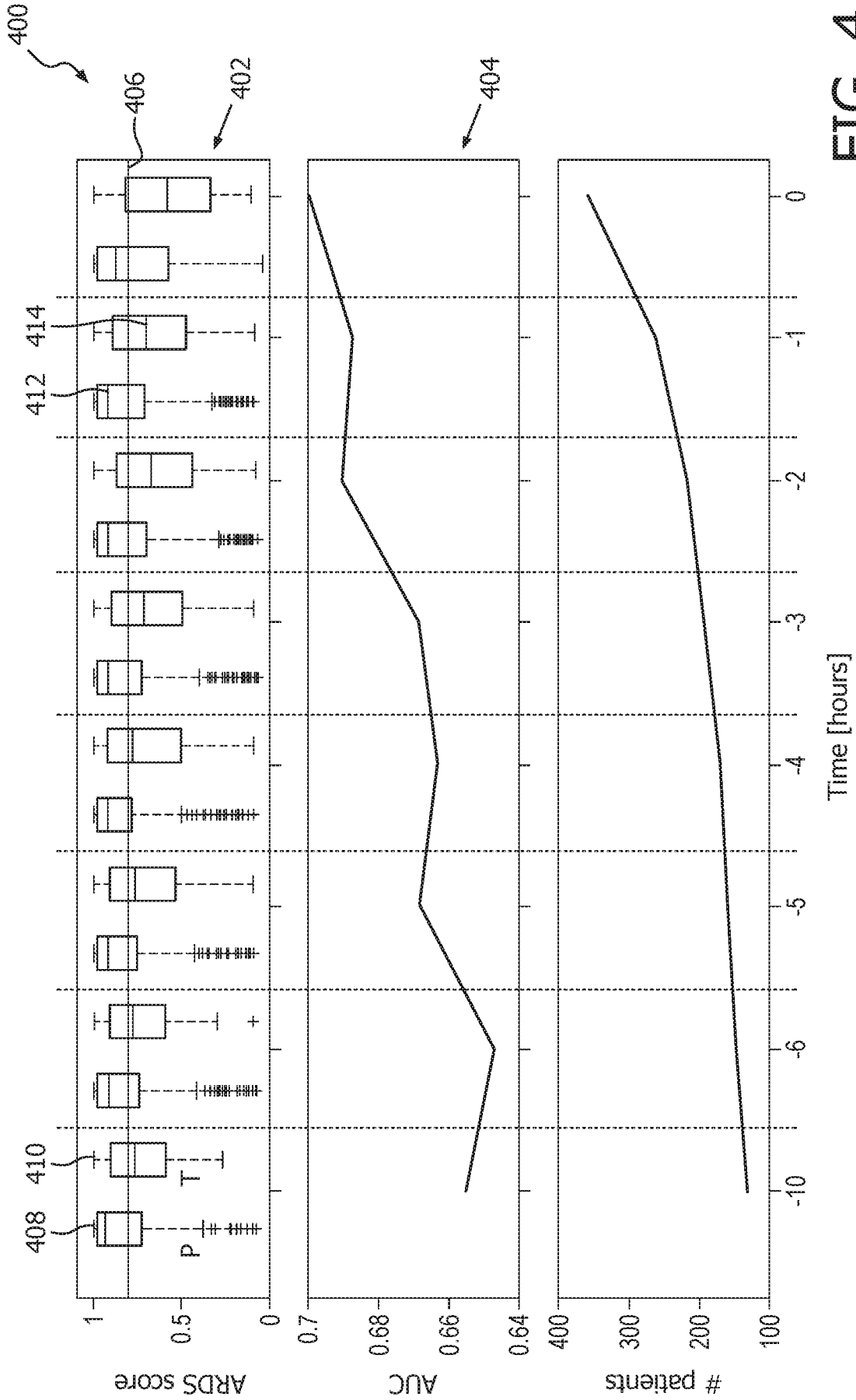
400
406
402
404
414
412
410
408
P
T
ARDS score
AUC
patients
Time [hours]
1
0.5
0
0.7
0.68
0.66
0.64
400
300
200
100
0
-1
-2
-3
-4
-5
-6
-10

FIG. 4

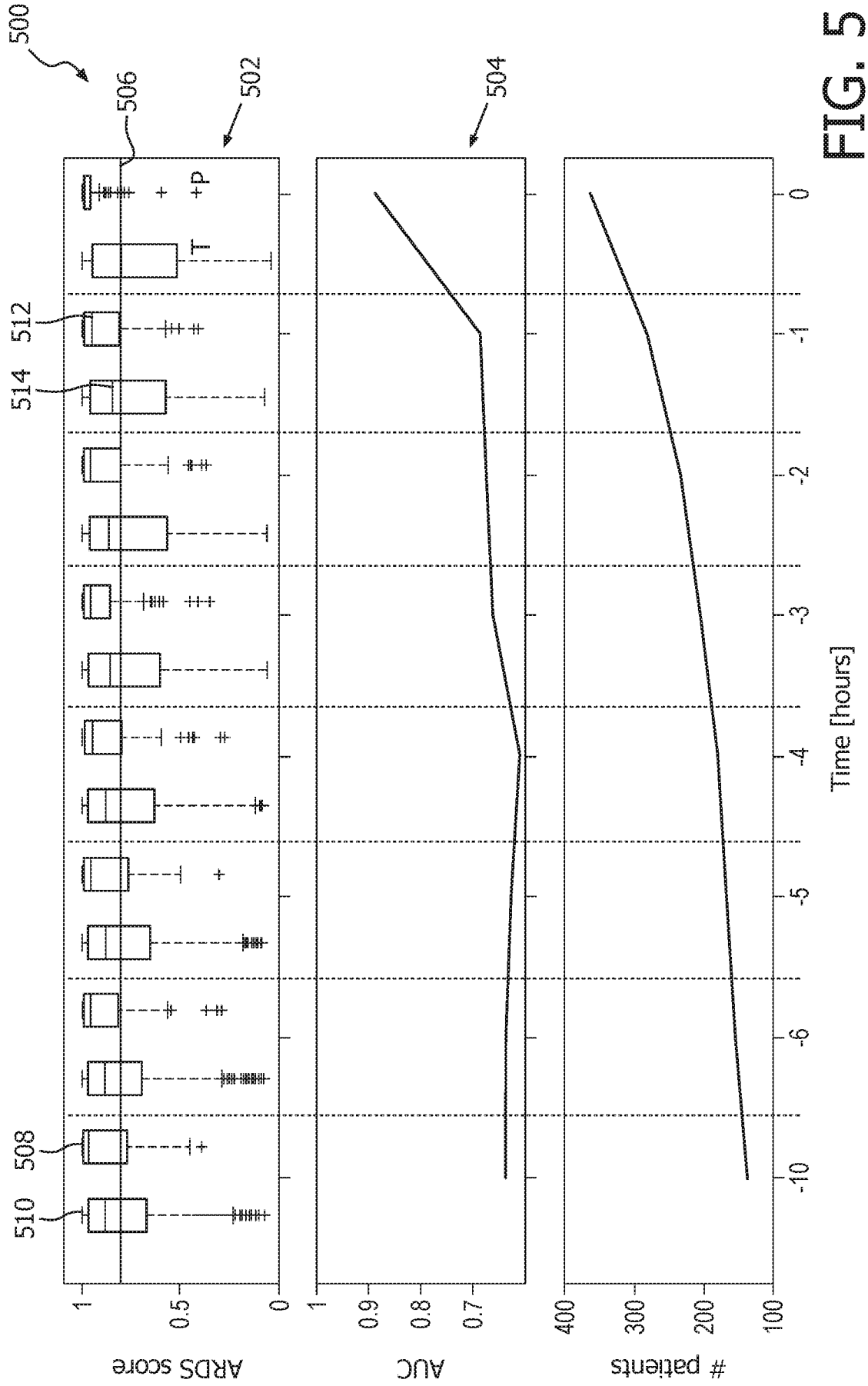
500
506
502
504
512
514
508
510
P
T
ARDS score
AUC
patients
Time [hours]
1
0.5
0
1
0.9
0.8
0.7
400
300
200
100
0
-1
-2
-3
-4
-5
-6
-10

FIG. 5

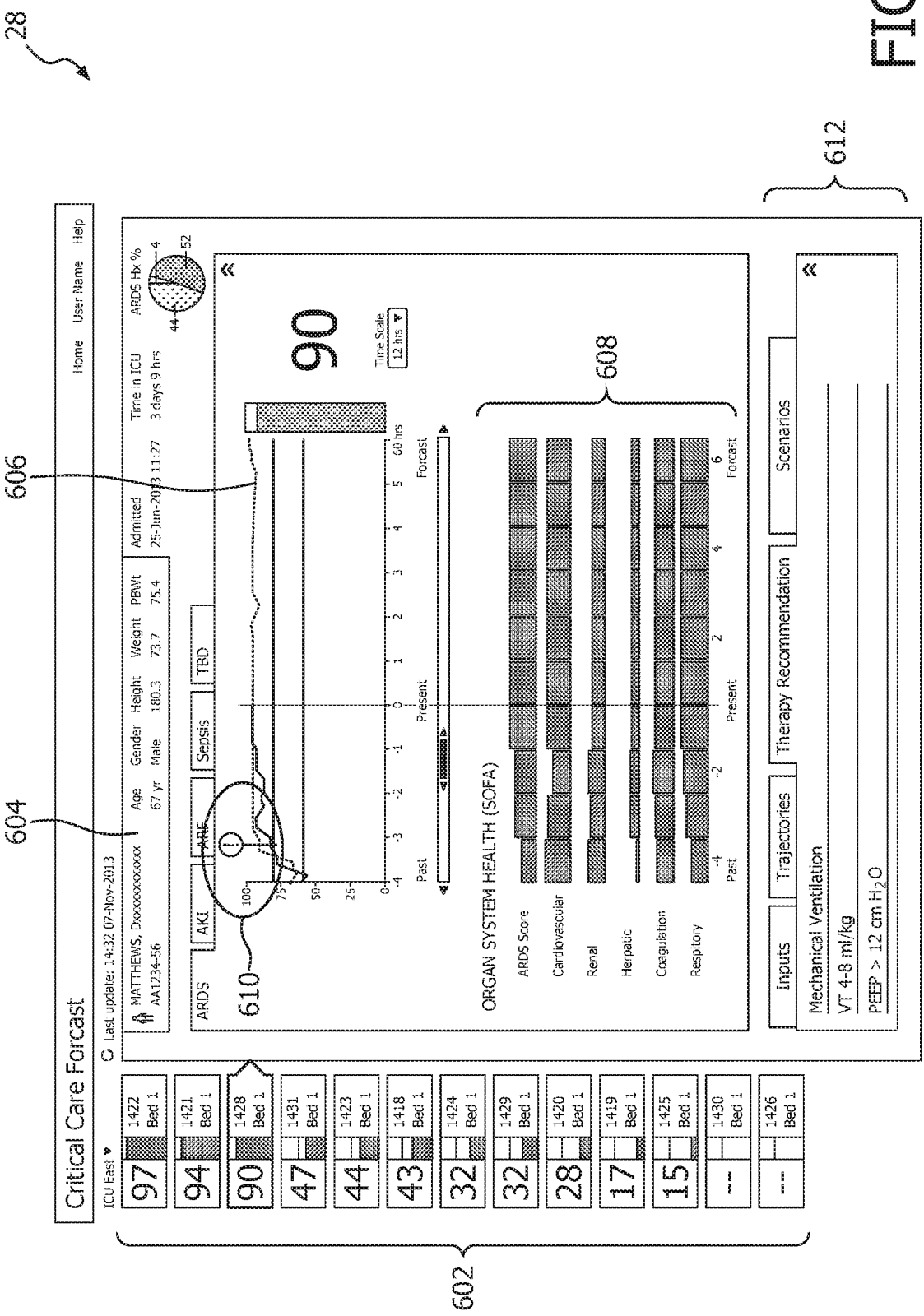
28
Critical Care Forcast
Home
User Name
Help
ICU East
Last update: 14:32 07-Nov-2013
602
604
606
608
610
612
97 1422 Bed 1
94 1421 Bed 1
90 1428 Bed 1
47 1431 Bed 1
44 1423 Bed 1
43 1418 Bed 1
32 1424 Bed 1
32 1429 Bed 1
28 1420 Bed 1
17 1419 Bed 1
15 1425 Bed 1
-- 1430 Bed 1
-- 1426 Bed 1
MATTHEWS, Dxxxxxxxxxxx
AA1234-56
Age 67 yr
Gender Male
Height 180.3
Weight 73.7
PBWt 75.4
Admitted 25-Jun-2013 11:27
Time in ICU 3 days 9 hrs
ARDS Hx %
ARDS
AKI
ARF
Sepsis
TBD
90
Time Scale 12 hrs
Past
Present
Forcast
ORGAN SYSTEM HEALTH (SOFA)
ARDS Score
Cardiovascular
Renal
Herpatic
Coagulation
Respitory
Inputs
Trajectories
Therapy Recommendation
Scenarios
Mechanical Ventilation
VT 4-8 ml/kg
PEEP > 12 cm H_2O

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/051525

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F19/00
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)
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, BIOSIS, Sequence Search, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/121374 A2 (KONINKL PHILIPS NV [NL]) 22 August 2013 (2013-08-22) cited in the application pgs. 1-2, 15, claims 1, 20, 22	1-19
A	WO 2009/098627 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; SAEED MOHAMMED [US]; LEE KWOK PUN) 13 August 2009 (2009-08-13) the whole document	1-19
A	US 2012/216809 A1 (MILNE GARY [US] ET AL) 30 August 2012 (2012-08-30) the whole document	1-19

☐ 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
11 May 2016	30/05/2016

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	Wimmer, Georg

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2016/051525

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		WO 2012116133 A1	30-08-2012