(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 062 682 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
03.01.2018 Bulletin 2018/01

(21) Application number: **14780528.7**

(22) Date of filing: **03.10.2014**

(51) Int Cl.:
A61B 5/00 *(2006.01)* ***A61B 5/08*** *(2006.01)*
A61B 5/087 *(2006.01)* ***A61M 16/00*** *(2006.01)*
G01L 13/00 *(2006.01)* ***G01F 1/36*** *(2006.01)*
G01F 5/00 *(2006.01)*

(86) International application number:
PCT/EP2014/071272

(87) International publication number:
WO 2015/062811 (07.05.2015 Gazette 2015/18)

(54) **APPARATUS AND METHOD FOR DETECTING HEALTH DETERIORATION**

VORRICHTUNG UND VERFAHREN ZUR ERKENNUNG VON VERSCHLECHTERTER GESUNDHEIT

APPAREIL ET PROCÉDÉ DE DÉTECTION DE LA DÉTÉRIORATION D'UN ÉTAT DE SANTÉ

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **01.11.2013 GB 201319351**

(43) Date of publication of application:
07.09.2016 Bulletin 2016/36

(73) Proprietor: **Linde Aktiengesellschaft**
80331 München (DE)

(72) Inventors:
- **PEREZ DE ALEJO FORTUN, Rigoberto**
  Guildford
  Surrey GU2 7XY (GB)
- **FRANCO GAY, Mercedes**
  E-28033 Madrid (ES)

(74) Representative: **Christie, Gemma Louise**
The Linde Group
Intellectual Property
10 Priestley Road The Surrey Research Park
Guildford, Surrey GU2 7XY (GB)

(56) References cited:
EP-A1- 2 245 985
US-A- 4 096 746
US-A1- 2009 234 240
US-A1- 2011 247 703
US-A1- 2012 203 128
US-A1- 2012 271 372

EP 3 062 682 B1

Description

[0001] The present invention relates to a method and apparatus for detecting deterioration in the health of an individual. In particular, the present invention provides an apparatus and method for detecting the deterioration in the health of a patient receiving gas from a respiratory device.

Domiciliary oxygen therapy refers to the provision of oxygen therapy at home for patients with hypoxaemia, which is subnormal oxygenation of arterial blood. Hypoxaemia may be due to a number of chronic, mainly respiratory, conditions, such as Chronic Obstructive Pulmonary Disease (COPD). Long-term oxygen therapy (LTOT) for the treatment of chronic hypoxaemia usually prescribes that oxygen (e.g. from an oxygen cylinder and/or oxygen concentrator machine) is used for a minimum of 15 hours a day.

A large proportion of the patients receiving LTOT will at some point experience a worsening in their condition that will eventually require admission to hospital for further treatment. This exacerbation of a patient's condition not only impacts on the health and quality of life of the patient's, but is also particularly expensive for healthcare providers as most patients do not seek treatment until there has been a significant worsening of their condition that then requires admission to and a stay in hospital for treatment. It would therefore be desirable to be able to automatically detect or predict when a patient's condition is becoming exacerbated, so that examination and treatment of the patient can be initiated promptly, before the condition worsens to the point that hospital admission is a necessity.

WO2005/074361 proposes a method for predicting the onset of a clinical episode in which a pressure gauge is placed under a mattress upon which a subject sleeps to monitor the body motion of the subject during sleep. Some form of pattern analysis is then used to eliminate non-breathing related motion from the signal generated by the pressure gauge, and to extract breathing rate patterns from the remaining breathing-related motion, wherein the extracted breathing rate patterns include one or more of a slow trend breathing rate pattern, a breathing rate variability pattern, a breathing duty-cycle pattern, and interruptions in a breathing pattern. Comparison of the extracted breathing rate patterns to respective baseline patterns is then used to determine the onset of an attack.

[0002] European patent application publication EP 2245985 A1 discloses a respiratory therapy device capable of sensing respiration rate and generating a warning based on a severity change indicator.

[0003] U.S. patent application publication US 2012/203128 A1 discloses the determination of a respiration rate based on the intervals between peaks of a respiration signal.

[0004] Therefore, according to a first aspect there is provided an apparatus for detecting the deteriorating health of a patient receiving gas from a respiratory device. The apparatus comprises a sensor unit configured to monitor a flow rate or pressure of a gas that is flowing in a pipe that connects the respiratory device to a gas delivery device worn by the patient, and a processor configured to measure a respiratory rate of the patient based on variations in the flow rate or pressure of gas in the pipe and to implement a trend analysis of the measured respiratory rate. The processor is configured to generate a warning when it determines that there is an upward trend in the measured respiratory rate and that a magnitude of the trend exceeds a threshold.

[0005] The sensor unit comprises a sensor device configured to monitor the variations in the flow rate or pressure that are induced by the respiration of the patient and to output a signal that is proportional to a derivative of the flow rate or pressure with respect to time. The processor is configured to detect peaks in the monitored flow rate or pressure by implementing discrete-time integration of the output of the sensor device and to determine a measure of the respiratory rate of the patient using the separation between the detected peaks, to determine the flow rate or pressure of a flow that is induced by the respiration of the patient, and to then process the determined flow rate or pressure to detect local maxima.

[0006] The sensor device may comprise a differential pressure sensor having first and second pneumatic input ports, the first pneumatic input port being configured to receive a flow of gas from a first point in the pipe and the second pneumatic input port being configured to receive a flow of gas from a second point in the pipe, wherein the second pneumatic input port is also configured to delay the flow of gas that flows from the pipe to the differential pressure sensor.

[0007] The second pneumatic input port may comprise a porous material within a hollow centre of the second pneumatic input port. Alternatively, at least a portion of the second pneumatic input port may be formed from a resilient material.

[0008] The processor may be configured to use one or both of a threshold peak width and a threshold peak amplitude to exclude noise when measuring the respiratory rate of the patient.

[0009] The sensor unit may be configured to implement sampling phases at predefined intervals when variations in the flow rate or pressure are detected, and the flow rate or pressure is monitored for the duration of each sampling phase. The processor may then be configured to calculate a median value for the separation between the peaks detected during each sampling phase and to use the median value as a measure of the respiratory rate of the patient.

[0010] The processor may be configured to implement the trend analysis at the end of each of a plurality of daily time slots using the respiratory rate measured during the latest time slot and corresponding time slots of preceding days.

[0011] The processor may be configured to implement

a trend analysis that comprises calculating a C-statistic for the measured respiratory rate. The processor may then be configured to generate a warning when the calculated C-statistic indicates a trend and a comparison of the measured respiratory rate with a characteristic respiratory rate indicates an upward trend. The processor may be configured to determine a characteristic respiratory rate by averaging the respiratory rate measured over a reference period of at least a predefined number of days.

[0012] The processor may be configured to implement the trend analysis using the respiratory rate measured over an analysis period of a predefined number of days. The processor may be configured to determine the characteristic respiratory rate by averaging the respiratory rate measured over the days preceding the analysis period.

[0013] The apparatus may be configured to be used with a domiciliary respiratory device. The apparatus may further comprise a transceiver configured to communicate with a remote computer device. The processor may then be configured to cause a communication to be sent using the transceiver that warns a remote compute device that the patient's health is likely to be deteriorating.

[0014] The apparatus may be configured to be used with a respiratory device that is an oxygen supply device and to monitor a flow rate or pressure of oxygen provided by the oxygen supply device. Alternatively, the apparatus may be configured to be used with a respiratory device that is a ventilator and to monitor a flow rate or pressure of air provided by the ventilator.

[0015] According to a second aspect there is provided a method of detecting exacerbation of a medical condition of a patient receiving gas from a respiratory device. The method comprises using a sensor unit to monitor a flow rate or pressure of a gas that is flowing in a pipe that connects the respiratory device to a gas delivery device worn by the patient, using a processor to measure a respiratory rate of the patient based on variations in the flow rate or pressure of gas in the pipe, and using the processor to implement a trend analysis of the measured respiratory rate. The method further comprises, when the processor determines that there is an upward trend in the measured respiratory rate and that a magnitude of the trend exceeds a threshold, generating a warning.

[0016] The step of using a sensor unit to monitor a flow rate or pressure of a gas that is flowing in a pipe that connects the respiratory device to a gas delivery device worn by the patient comprises using a sensor device of the sensor unit to monitor the variations in the flow rate or pressure that are induced by the respiration of the patient and to output a signal that is proportional to a derivative of the flow rate or pressure with respect to time.

[0017] The step of using a processor to measure a respiratory rate of the patient based on variations in the flow rate or pressure of gas in the pipe comprises detecting peaks in the monitored flow rate or pressure by implementing discrete-time integration of the output of the sensor device, and determining a measure of the respiratory rate of the patient using the separation between the detected peaks to determine the flow rate or pressure of a flow that is induced by the respiration of the patient, and then processing the determined flow rate or pressure to detect local maxima.

[0018] The step of detecting peaks in the monitored flow rate or pressure may comprise using one or both of a threshold peak width and a threshold peak amplitude to exclude noise when measuring the respiratory rate of the patient.

[0019] The method may comprise implementing sampling phases at predefined intervals when variations in the flow rate or pressure are detected, and monitoring the flow rate or pressure for the duration of each sampling phase. The method may then comprise calculating a median value for the separation between the peaks detected during each sampling phase, and using the median value as a measure of the respiratory rate of the patient.

[0020] The step of using the processor to implement a trend analysis of the measured respiratory rate may comprise implementing the trend analysis at the end of each of a plurality of daily time slots using the respiratory rate measured during the latest time slot and corresponding time slots of preceding days.

[0021] The step of using the processor to implement a trend analysis of the measured respiratory rate may comprise calculating a C-statistic for the measured respiratory rate. The method may then further comprise generating a warning when the calculated C-statistic indicates a trend and a comparison of the measured respiratory rate with a characteristic respiratory rate indicates an upward trend.

[0022] The method may further comprise determining a characteristic respiratory rate by averaging the respiratory rate measured over a reference period of at least a predefined number of days. The step of using the processor to implement a trend analysis of the measured respiratory rate may comprise using the respiratory rate measured over an analysis period of a predefined number of days. The step of determining a characteristic respiratory rate may then comprise averaging the respiratory rate measured over the days preceding the analysis period.

[0023] The present invention will now be more particularly described by way of example only with reference to the accompanying drawings, in which:

Figure 1 illustrates schematically an embodiment of an apparatus for detecting exacerbation of a medical condition of a patient as described herein;

Figure 2 illustrates schematically an embodiment of a sensor unit for use in the apparatus of Figure 1; and

Figure 3 is a flow diagram illustrating an embodiment of a method for detecting exacerbation of a medical condition as described herein.

[0024] The present inventors have determined that, for patients receiving LTOT, there will typically be an increase in the respiratory rate (i.e. the number of breaths taken within a set amount of time) of a patient over a period of 4 to 5 days prior to the admission of the patient to hospital due to the exacerbation of their condition. This trend can therefore be used as a basis for detecting in advance when there is a high likelihood that a patient's condition is going to exacerbate to the extent that may require hospitalization. Being able to pre-empt the exacerbation of a patient's condition can allow action to be taken that will prevent the need for the patient to be admitted to hospital or, at the least, that will reduce the length of time that the patient will need to spend in hospital, thereby improving the health and well-being of the patient and reducing costs that arise from hospital admissions.

[0025] In addition, it is expected that for patients receiving other forms of respiratory therapy a similar trend would also be displayed when there is deterioration in their health, and that the automatic detection/prediction of the deteriorating health of a patient receiving any form of respiratory therapy would be advantageous. By way of example, continuous positive airway pressure (CPAP) is a treatment that uses a domiciliary respiratory device to provide a continuous positive flow of air to keep the airways of a patient open, and is typically a treatment for people who have breathing problems, such as sleep apnoea.

[0026] The present inventors have therefore developed a method for predicting/detecting the deteriorating health of a patient/subject receiving a supply of gas from a respiratory device that generally involves monitoring a gas in a line/pipe/hose that connects the respiratory device to a gas delivery device worn by the patient and thereby measuring the respiratory rate of the patient based on variations in the flow or pressure of gas in the pipe. A trend analysis of the measured respiratory rate can then be implemented and, when it is determined that there is an upward trend in the measured respiratory rate and that the magnitude of the trend exceeds a threshold, a warning can be generated that indicates that health of the patient is likely to be deteriorating.

[0027] Figure 1 illustrates schematically an example embodiment of an apparatus 10 suitable for predicting/detecting deterioration in the health of a patient receiving gas from a respiratory device.

[0028] The apparatus 10 comprises a sensor unit 11 and a computer device 12 connected to the sensor unit 11 via an interface 13. The computer device 12 comprises a memory 121, and a processor 122, and optionally a transmitter and a receiver 123. By way of example, the computer device 12 could be provided by a microcontroller, wherein a microcontroller is a computer device implemented on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

[0029] The sensor unit 11 is configured to monitor the variation in the flow or pressure of a gas in a pipe that connects a respiratory device to a gas delivery device worn by the patient (e.g. a mask or cannula). The sensor unit 11 then provides the captured flow/pressure data to the computer device 12. The processor 122 provided as part of the computer device 12 is configured to measure the respiratory rate of the patient based on variations in the flow/pressure of gas in the pipe (i.e. using the data provided by the sensor unit 11), and to implement a trend analysis of the respiratory rate measured over a period of time. From this trend analysis, the processor 122 is configured to determine when there is an upward trend in the measured respiratory rate and compare the magnitude of this trend with a predefined threshold. When the processor 122 determines that the magnitude of the trend exceeds the threshold, the processor 122 is configured to generate a warning that the patient's health is likely to be deteriorating. By way of example, to generate a warning the processor 122 could be configured to activate a visual and/or audio warning signal using a visual indicator and/or speaker (not shown) provided as part of the apparatus 10. Alternatively, or in addition, the processor 122 could be configured to cause a communication to be sent using the transmitter 123 that informs a remote computer device or communication device (e.g. located at a hospital, doctor's office or other medical facility) that the patient's health is likely to be deteriorating.

[0030] Figure 2 illustrates schematically an example embodiment of the sensor unit 11 of the apparatus 10 illustrated in Figure 1. In this example, the sensor unit 11 comprises a sensor device 111 that is connected to or formed with the pipe and that has an output 112 to the interface 13 with the computer device 12.

[0031] In the example of Figure 2, the sensor device 111 comprises a differential pressure sensor 1111 that has a first pneumatic input port 1112 and a second pneumatic input port 1113. The first pneumatic input port 1112 is configured to receive a flow of gas from a first point/location in the pipe and the second pneumatic input port 1113 is configured to receive a flow of gas from a second point/location in the pipe. The second pneumatic input port 1113 is also configured to delay the flow of gas that flows from the pipe to the differential pressure sensor. To do so, the second pneumatic input port 1113 includes a porous material 1113a (e.g. a sponge) within a hollow centre of the second pneumatic input port 1113. Alternatively, this delay in the flow could be achieved by forming at least a portion of the second pneumatic input port 1113 from an expandable, resilient material.

[0032] By inducing a delay in the flow of gas through the second pneumatic input port 1113 to the differential pressure sensor 1111, the differential pressure sensor 1111 effectively measures the variation in the pressure of the gas within the pipe, such that the signal generated/value measured by the differential pressure sensor 1111 is proportional to a derivative of the flow rate. In this regard, when the patient is using the respiratory device, there is a generally constant flow of gas in the pipe due

to the pressure supplied by the respiratory device. The only significant source of variation in the flow/pressure of the gas in the pipe occurs due to the respiration (i.e. inhaling and exhaling) of the patient, wherein inhalation by the patient will increase the flow rate and exhalation will decrease the flow rate. By using a differential pressure sensor that is configured to output a signal that is proportional to a derivative of the flow rate, the sensor device 111 eliminates the effect of the constant flow/pressure of gas from the respiratory device that would otherwise saturate a conventional flowmeter and that would therefore limit the detection of relatively small variations due to the respiration of the patient. Consequently, the flow rate/pressure differential monitored by the sensor device 111 is limited to the variations that are induced by the respiration of the patient.

[0033] The flow/pressure data generated by the sensor device 111 can then be provided to the computer device 12 (i.e. using the interface 13) such that the processor 122 can measure the respiratory rate of the patient based on variations in the flow rate/pressure.

[0034] In an example embodiment, the processor 122 detects peaks in the monitored flow rate/pressure, and then determines a measure of the respiratory rate by calculating the separation between the peaks. In doing so, the processor 122 effectively determines the frequency of the variations in the flow rate/pressure, which will therefore provide an indication of the respiratory rate of the patient. To detect peaks in the monitored flow rate/pressure, the processor can be configured to implement discrete-time integration of the output of the sensor device 111 to determine the flow rate/pressure of the flow that is induced by the respiration of the patient, and to then process the monitored flow rate/pressure to detect local maxima. In an alternative configuration which is not an embodiment of the invention, the processor can be configured to detect a peak by determining when the output of the sensor device indicates that the derivative of the monitored flow rate/pressure is zero and to then determine if this relates to a local maxima.

[0035] The second pneumatic input port 1113 of the differential pressure sensor 1111 should be configured such that the delay induced in the flow of gas therethrough is in the order of, or higher than, the minimum respiratory frequency that is to be measured by the system. For example, this could be achieved by selecting a suitable porosity and length for a porous material 1113a used in the hollow centre of the second pneumatic input port 1113. Doing so ensures that the sensor device 111 acts as a high pass filter that will eliminate the constant flow/pressure (that has a frequency of zero) produced by the respiratory device and will pass the higher frequency variations produced by the respiration of the patient, such that the monitored flow rate/pressure is limited to the variations that are induced by the respiration of the patient.

[0036] Figure 3 is a flow diagram illustrating an embodiment of a process for predicting/detecting deterioration in the health of a patient receiving gas from a respiratory device. The steps performed are as follows:

A1. The sensor unit 11 monitors a flow of gas in the pipe that connects the respiratory device to a gas delivery device worn by the patient. The sensor unit 11 then provides captured flow/pressure data to the computer device 12. For example, this flow data could comprise values that are proportional to a derivative of the flow rate/pressure.

A2. The processor 122 provided as part of the computer device 12 then measures the respiratory rate of the patient based on variations in the flow/pressure of the gas in the pipe. By way of example, the processor 122 could detect peaks in the monitored flow rate/pressure, and then determine a measure of the respiratory rate by calculating the separation between the peaks.

A3. Periodically, the processor 122 implements a trend analysis of the respiratory rate measured over a period time. Typically, the processor 122 would be configured to implement a trend analysis of the respiratory rate measured over an analysis period of a predefined number of days.

A4. The processor 122 then determines if the trend analysis indicates an upward trend in the measured respiratory rate. If the processor determines that there is an upward trend in the measured respiratory rate, then the process proceeds to step A5. If the processor determines that there is not an upward trend in the measured respiratory rate, then the process returns to step A1.

A5. If the processor 122 determines that there is an upward trend in the measured respiratory rate, the processor 122 then determines if the magnitude of the trend exceeds a predefined threshold. If the processor 122 determines that the magnitude of the upward trend does exceed the threshold, then the process proceeds to step A6. If the processor determines that the trend does not exceed the threshold, then the process returns to step A1.

A6. If the processor 122 determines that the magnitude of the upward trend does exceed the threshold, then the processor 122 causes the generation of a warning that the health of the patient is likely to be deteriorating.

[0037] In a typical implementation, when the sensor unit 11 determines that the patient is receiving gas from the respiratory device (i.e. when the sensor unit 11 detects a variation in the flow/pressure of gas in the pipe), the sensor unit 11 will implement periodic sampling of the flow rate/pressure, in which the flow rate/pressure is monitored for the duration of a sampling phase/period with the sampling phase recurring at predefined intervals. For example, this periodic sampling could involve, whilst the sensor unit 11 detects a variation in the flow/pressure of the gas in the pipe, monitoring of the flow rate/pressure for the duration of a 30 second sampling phase with each

sampling phase being separated by a 20 minute interval. In this case, if the patient were to stop receiving gas from the respiratory device during the interval between sampling phases, then the sensor unit 11 would not implement a sampling phase at the end of the interval, but would initiate a further sampling phase when it determines that the patient has again started to receive gas from the respiratory device.

[0038] In addition, when monitoring the flow rate/pressure, the sensor unit 11 can be configured to take discrete measurements at a predefined sample rate. For example, if the sensor unit 11 were to implement periodic sampling, with a sampling phase duration of 30 seconds, the sensor unit 11 could be configured to take measurements at a sample rate of 100ms, such that 3000 measurements are taken during each sampling phase.

[0039] In embodiments in which the processor 122 determines a measure of the respiratory rate by calculating the separation between peaks in the monitored flow rate/pressure, the processor 122 can be configured to implement a noise elimination process to eliminate any variations in the monitored flow rate/pressure that are not caused by respiration of the patient, and that would otherwise cause the frequency determined by the peak detection process to be an inaccurate indication of the respiratory rate. To do so, the processor could be configured to use one or both of a threshold peak width and a threshold peak amplitude to exclude peaks that are too short/narrow and/or too small to have been caused by the respiration of the patient.

[0040] In addition, as it is intended that it should be possible to use this detection process with patients receiving domiciliary respiratory therapy, the detection process should be capable of accurately detecting the deterioration in the health of a patient even when the patient is not in a controlled environment (e.g. they could be walking, talking, coughing, etc.). In particular, when not in a controlled environment the behaviour of the patient could induce variations in the respiratory rate that are not part of a longer term trend. To account for such short term variability, the processor 122 could be configured to calculate a median value for the respiratory rate. These median values would then be used when implementing the trend analysis. By way of example, in a particular embodiment, the sensor unit 11 could be configured to implement periodic sampling and to take discrete measurements at a predefined sample rate during each sampling phase. The processor 122 could then determine a measure of the respiratory rate for that sampling phase by calculating the separation between any detected peaks and then determining the median value for the separation between the detected peaks.

[0041] Furthermore, to account for variations in the respiratory rate that occur due to the daily habits of a patient, the processor 122 could be configured with a plurality of daily time slots, and to implement the trend analysis at the end of each time slot using the respiratory rate data captured during the most recent/latest time slot and the corresponding time slots of preceding days. For example, when a patient is sleeping their respiratory rate is significantly slower than when the patient is awake and doing physical activity. Consequently, the processor 122 could be configured to separate each day into three time slots, 08:00 to 16:00 (day), 16:00 to 00:00 (evening), and 00:00 to 08:00 (night). The processor 122 could then be configured to implement the trend analysis at the end of each time slot, (day, evening and night) using the respiratory rate data captured during that time slot and the corresponding time slot on each of a predefined number of preceding days, such that the trend analysis is implemented three times each day.

[0042] The processor 122 could be configured to implement a trend analysis that comprises calculating a C statistic (i.e. Young's C statistic for time series analysis) for the measured respiratory rate. In this regard, time series analysis with the C statistic identifies whether a trend, defined as any systematic departure from random variation, is evident in a series of data points. The formula to calculate the C statistic is:

$$C = 1 - \frac{\sum_{i=1}^{n-1}(X_i - X_{i+1})^2}{2 \cdot \sum_{i=1}^{n}(X_i - M_x)^2}$$

Wherein X_i is the points in the data series and M_x is the average of the X values.

[0043] Depending upon the value of C, there are three different conditions:

1) $0 < C \leq$ threshold means that there is weak trend in the data series;
2) Threshold $< C \leq 1$ means that there is an strong trend in the data series;
3) And if $C \leq 0$ or $C > 1$ means there is not a trend in the data series.

The threshold used to determine whether there is a strong trend in the data series is configurable, and would at least initially be calibrated using test data. The configuration/calibration of the threshold could then be refined through use. In particular, usage data could indicate that the threshold value should be varied at different times of the year (e.g. to account for seasonal changes) and/or to take account of changes in environmental conditions such as temperature, humidity etc. However, the C statistic merely determines if there is a trend, and does not indicate whether that trend is upward or downward. Therefore, if the calculated value of C indicates that there is a trend, then the trend analysis implemented by the processor 122 further comprises a comparison of the measured respiratory rate with a reference/representative/characteristic respiratory rate to determine if there is an upward trend. Preferably the reference/representa-

tive/characteristic respiratory rate is patient-specific, and dynamically calibrated.

[0044] In this regard, when implementing the trend analysis the processor makes use of the respiratory rate data that has been captured over a predefined period, referred to herein as the analysis period. Therefore, in order to determine a characteristic respiratory rate, the processor can be configured to calculate an average of the respiratory rate data that was captured prior to the analysis period. For example, the processor may be configured to implement the trend analysis using the respiratory rate data captured during an analysis period that covers the last m days. Then, if the apparatus has been in use for a total of m+n days, the characteristic respiratory rate will be calculated using the respiratory rate data that was captured during a reference period that covers day_1 to day_n (i.e. the days that preceded the analysis period). In doing so, the characteristic respiratory rate calculated by the processor would be continually updated as more respiratory rate data becomes available thereby compensating for any changes in the state of the patient over time. For example, if the patient's condition were to improve over the first few days/weeks of receiving respiratory therapy, such that the patient's respiratory rate were to generally decrease over that period, then reference respiratory rate will also decrease. Consequently, the trend analysis will make use of this decreased reference respiratory rate to determine if there has been a subsequent upward trend in the patient's respiratory rate.

[0045] The comparison of the monitored respiratory rate with a reference respiratory rate to determine if there is an upward trend could comprise calculating a value that is indicative of whether the trend in the respiratory rate data captured over the analysis period is an upward trend. By way of example, this representative value (Inc) could be calculated using the following formula:

$$Inc = (X_n - baseline) \cdot \sum_{i=1}^{n-1} (X_{i+1} - X_i)$$

Wherein Xi is the points in the data series and n is the length of the reference period in days. If Inc is greater than 0, then the trend in the data is upward, and the value for the C statistic can then be compared with the predefined threshold to determine if a warning should be generated.

[0046] Unlike systems that monitor sound and/or motion to determine breathing patterns, the apparatus described herein can be provided as part of or as an accessory or peripheral to a respiratory device that is provided to a patient. The apparatus is therefore much less intrusive, more straightforward to setup, and requires less overall equipment, which is particularly important when intended for use in domiciliary environments. In addition, by monitoring a patient during the use of a respiratory device, the methods and apparatus described herein provide for greater accuracy in the measurement of the patients respiratory rate, as the patients respiration is sensed directly rather than indirectly. Moreover, the methods and apparatus described herein are not limited to the monitoring of the patient whilst asleep.

[0047] In addition, conventional methods of using breathing related measurements for predicting the onset of a medical episode that rely on comparing a monitored pattern of breathing with a comparable baseline pattern are significantly more complex than the methods described herein. In particular, to implement these conventional methods it is necessary to detect the breathing of the subject, ascertain the type of breathing pattern being displayed by the subject, and compare the breathing pattern with a baseline pattern of the same type. Each of these steps introduces potential inaccuracies that impact on the effectiveness of the prediction.

[0048] It will be appreciated that individual items described above may be used on their own or in combination with other items shown in the drawings or described in the description and that items mentioned in the same passage as each other or the same drawing as each other need not be used in combination with each other. In addition, the expression "means" may be replaced by actuator, system, unit or device as may be desirable. In addition, any reference to "comprising" or "consisting" is not intended to be limiting in any way whatsoever and the reader should interpret the description and claims accordingly.

[0049] Furthermore, although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims. By way of example, in the above described embodiments the only significant source of variation in the flow/pressure of the gas in the pipe occurs due to the respiration (i.e. inhaling and exhaling) of the patient, wherein inhalation by the patient will increase the flow rate/pressure and exhalation will decrease the flow rate/pressure. However, in an alternative embodiment the respiratory device could be provided with a demand value that automatically controls the supply of gas by opening to provide flow when the user/patient inhales and closing to shut off the supply when inhalation stops. In this alternative embodiment, the only significant source of variation in the flow/pressure of the gas in the pipe will still occur due to the respiration of the patient, as the demand value will automatically open when it detects the inspiration of the user/patient, thereby increasing the flow rate/pressure by allowing the respiratory device to supply gas into the pipe, and automatically close when inspiration has stopped, thereby reducing the flow rate/pressure in the pipe.

Claims

1. An apparatus (10) for detecting the deteriorating health of a patient receiving gas from a respiratory device, the apparatus comprising:

   a sensor unit (11) configured to monitor a flow rate or pressure of a gas that is flowing in a pipe that connects the respiratory device to a gas delivery device worn by the patient; and a processor (122) configured to measure a respiratory rate of the patient based on variations in the flow rate or pressure of gas in the pipe and to implement a trend analysis of the measured respiratory rate;
   wherein the processor (122) is configured to generate a warning when it determines that there is an upward trend in the measured respiratory rate and that a magnitude of the trend exceeds a threshold;
   wherein the sensor unit (11) comprises a sensor device (111) configured to monitor the variations in the flow rate or pressure that are induced by the respiration of the patient, and to output a signal that is proportional to a derivative of the flow rate or pressure with respect to time;
   characterized in that:

      the processor (122) is configured to detect peaks in the monitored flow rate or pressure by implementing discrete-time integration of the output of the sensor device (111) to determine the flow rate or pressure of a flow that is induced by the respiration of the patient, and to then process the determined flow rate or pressure to detect local maxima, and to determine a measure of the respiratory rate of the patient using the separation between the detected maxima.

2. The apparatus as claimed in claim 1, wherein the sensor device (111) comprises a differential pressure sensor (1111) having first and second pneumatic input ports (1112, 1113), the first pneumatic input port (1112) being configured to receive a flow of gas from a first point in the pipe and the second pneumatic input port (1113) being configured to receive a flow of gas from a second point in the pipe, wherein the second pneumatic input port (1113) is also configured to delay the flow of gas that flows from the pipe to the differential pressure sensor (1111).

3. The apparatus as claimed in claim 2, wherein the second pneumatic input port (1113) comprises a porous material (1113a) within a hollow centre of the second pneumatic input port.

4. The apparatus as claimed in claim 2, wherein at least a portion of the second pneumatic input port (1113) is formed from a resilient material.

5. The apparatus as claimed in any preceding claim, wherein the processor (122) is configured to use one or both of a threshold peak width and a threshold peak amplitude to exclude noise when measuring the respiratory rate of the patient.

6. The apparatus as claimed in any preceding claim, wherein the sensor unit (11) is configured to implement sampling phases at predefined intervals when variations in the flow rate or pressure are detected, and the flow rate or pressure is monitored for the duration of each sampling phase.

7. The apparatus as claimed in claim 6, wherein the processor (122) is configured to calculate a median value for the separation between the peaks detected during each sampling phase and to use the median value as a measure of the respiratory rate of the patient.

8. The apparatus as claimed in any preceding claim, wherein the processor (122) is configured to implement the trend analysis at the end of each of a plurality of daily time slots using the respiratory rate measured during the latest time slot and corresponding time slots of preceding days.

9. The apparatus as claimed in any preceding claim, wherein the processor (122) is configured to implement a trend analysis that comprises calculating a C-statistic for the measured respiratory rate.

10. The apparatus as claimed in claim 9, wherein the processor (122) is configured to generate a warning when the calculated C-statistic indicates a trend and a comparison of the measured respiratory rate with a characteristic respiratory rate indicates an upward trend.

11. The apparatus as claimed in claim 10, wherein the processor (122) is configured to determine a characteristic respiratory rate by averaging the respiratory rate measured over a reference period of at least a predefined number of days.

12. A method of detecting exacerbation of a medical condition of a patient receiving gas from a respiratory device, the method comprising:

   using a sensor unit to monitor a flow rate or pressure of a gas that is flowing in a pipe that connects the respiratory device to a gas delivery device worn by the patient (A1);
   using a processor to measure a respiratory rate

of the patient based on variations in the flow rate or pressure of gas in the pipe (A2);
using the processor to implement a trend analysis of the measured respiratory rate (A3); and
when the processor determines that there is an upward trend in the measured respiratory rate (A4) and that a magnitude of the trend exceeds a threshold (A5), generating a warning (A6);
wherein the step of using a sensor unit to monitor a flow rate or pressure of a gas that is flowing in a pipe that connects the respiratory device to a gas delivery device worn by the patient comprises using a sensor device of the sensor unit to monitor the variations in the flow rate or pressure that are induced by the respiration of the patient and to output a signal that is proportional to a derivative of the flow rate or pressure with respect to time;
characterized in that:

the step of using a processor to measure a respiratory rate of the patient based on variations in the flow rate or pressure of gas in the pipe comprises detecting peaks in the monitored flow rate or pressure by implementing discrete-time integration of the output of the sensor device to determine the flow rate or pressure of a flow that is induced by the respiration of the patient, and then processing the determined flow rate or pressure to detect local maxima, and determining a measure of the respiratory rate of the patient using the separation between the detected maxima.

13. The method as claimed in claim 12, wherein the step of detecting peaks in the monitored flow rate or pressure comprises using one or both of a threshold peak width and a threshold peak amplitude to exclude noise when measuring the respiratory rate of the patient.

14. The method as claimed in any of claims 12 to 13, and comprising implement sampling phases at predefined intervals when variations in the flow rate or pressure are detected, and monitoring the flow rate or pressure for the duration of each sampling phase.

15. The method as claimed in claim 14, wherein a median value for the separation between the peaks detected during each sampling phase is calculated, and the median value is used as a measure of the respiratory rate of the patient.

16. The method as claimed in any of claims 12 to 15, wherein the step of using the processor to implement a trend analysis of the measured respiratory rate comprises implementing the trend analysis at the end of each of a plurality of daily time slots using the respiratory rate measured during the latest time slot and corresponding time slots of preceding days.

17. The method as claimed in any of claims 12 to 16, wherein the step of using the processor to implement a trend analysis of the measured respiratory rate comprises calculating a C-statistic for the measured respiratory rate.

Patentansprüche

1. Vorrichtung (10) für den Nachweis der Verschlechterung der Gesundheit eines Patienten, der Gas von einem Atemgerät erhält, wobei die Vorrichtung Folgendes umfasst:

eine Sensoreinheit (11), die zur Überwachung einer Durchflussmenge oder eines Drucks eines strömenden Gases in einer Leitung, die das Atemgerät mit einer vom Patienten getragenen Gasabgabevorrichtung verbindet, ausgelegt ist; und einen Prozessor (122), der zur Messung einer Atemfrequenz des Patienten auf Basis von Schwankungen in der Durchflussmenge oder im Druck des Gases in der Leitung und zur Implementierung einer Trendanalyse der gemessenen Atemfrequenz ausgelegt ist;
wobei der Prozessor (122) ausgelegt ist, eine Warnmeldung zu erzeugen, wenn er feststellt, dass ein Aufwärtstrend in der gemessenen Atemfrequenz vorliegt und dass eine Größe des Trends einen Schwellenwert überschreitet;
wobei die Sensoreinheit (11) eine Sensorvorrichtung (111) umfasst, die zur Überwachung der Schwankungen in der Durchflussmenge oder im Druck, die durch die Atmung des Patienten ausgelöst werden, und zur Ausgabe eines Signals, das zu einer Ableitung der Durchflussmenge oder des Drucks in Bezug auf die Zeit proportional ist, ausgelegt ist;
dadurch gekennzeichnet, dass:

der Prozessor (122) zum Nachweisen von Peaks in der überwachten Durchflussmenge oder im überwachten Druck durch Implementierung einer diskreten Zeitintegration der Ausgabe der Sensorvorrichtung (111), zur Bestimmung der Durchflussmenge oder des Drucks einer Strömung, die durch die Atmung des Patienten ausgelöst wird, und zur anschließenden Verarbeitung der bestimmten Durchflussmenge oder des Drucks zum Nachweisen von örtlichen Maxima und zur Bestimmung eines Maßes der Atemfrequenz des Patienten unter Verwendung des Abstands zwischen den nachge-

wiesenen Maxima ausgelegt ist.

2. Vorrichtung nach Anspruch 1, wobei die Sensorvorrichtung (111) einen Differenzdrucksensor (1111) mit ersten und zweiten pneumatischen Eingangsöffnungen (1112, 1113) umfasst, wobei die erste pneumatische Eingangsöffnung (1112) zum Erhalten einer Gasströmung von einem ersten Punkt in der Leitung ausgelegt ist und die zweite pneumatische Eingangsöffnung (1113) zum Erhalten einer Gasströmung von einem zweiten Punkt in der Leitung ausgelegt ist, wobei die zweite pneumatische Eingangsöffnung (1113) auch zur Verzögerung der Gasströmung von der Leitung zum Differenzdrucksensor (1111) ausgelegt ist.

3. Vorrichtung nach Anspruch 2, wobei die zweite pneumatische Eingangsöffnung (1113) ein poröses Material (1113a) in einer hohlen Mitte der zweiten pneumatischen Eingangsöffnung umfasst.

4. Vorrichtung nach Anspruch 2, wobei zumindest ein Teil der zweiten pneumatischen Eingangsöffnung (1113) aus einem nachgiebigen Material besteht.

5. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der Prozessor (122) ausgelegt ist, eine Schwellenpeakbreite und/oder eine Schwellenspitzenamplitude zum Ausschluss von Rauschen bei der Messung der Atemfrequenz des Patienten zu verwenden.

6. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Sensoreinheit (11) ausgelegt ist, Abtastphasen in vorbestimmten Intervallen zu implementieren, wenn Schwankungen in der Durchflussmenge oder im Druck nachgewiesen werden, und wobei die Durchflussmenge oder der Druck für die Dauer jeder Abtastphase überwacht wird.

7. Vorrichtung nach Anspruch 6, wobei der Prozessor (122) ausgelegt ist, einen Medianwert für den Abstand zwischen den Peaks, die während jeder Abtastphase nachgewiesen wurden, zu berechnen und den Medianwert als Maß für die Atemfrequenz des Patienten zu verwenden.

8. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der Prozessor (122) ausgelegt ist, die Trendanalyse am Ende jedes einer Vielzahl von täglichen Zeitfenstern unter Verwendung der Atemfrequenz, die während des letzten Zeitfensters und entsprechenden Zeitfenstern der vorhergehenden Tage gemessen wurde, zu implementieren.

9. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der Prozessor (122) zur Implementierung einer Trendanalyse ausgelegt ist, die die Berechnung einer C-Statistik für die gemessene Atemfrequenz umfasst.

10. Vorrichtung nach Anspruch 9, wobei der Prozessor (122) ausgelegt ist, eine Warnmeldung zu erzeugen, wenn die berechnete C-Statistik auf einen Trend hinweist und ein Vergleich der gemessenen Atemfrequenz mit einer charakteristischen Atemfrequenz auf einen Aufwärtstrend hinweist.

11. Vorrichtung nach Anspruch 10, wobei der Prozessor (122) ausgelegt ist, eine charakteristische Atemfrequenz durch Mittelung der Atemfrequenz, die über einen Bezugszeitraum von mindestens einer vorbestimmten Anzahl von Tagen gemessen wurde, zu bestimmen.

12. Verfahren zum Nachweisen einer Verschlimmerung eines medizinischen Zustands eines Patienten, der Gas von einem Atemgerät erhält, wobei das Verfahren Folgendes umfasst:

Verwendung einer Sensoreinheit zur Überwachung einer Durchflussmenge oder eines Drucks eines strömenden Gases in einer Leitung, die das Atemgerät mit einer vom Patienten getragenen Gasabgabevorrichtung verbindet (A1);
Verwendung eines Prozessors zur Messung einer Atemfrequenz des Patienten auf Basis von Schwankungen in der Durchflussmenge oder im Druck des Gases in der Leitung (A2);
Verwendung des Prozessors zur Implementierung einer Trendanalyse der gemessenen Atemfrequenz (A3); und,
wenn der Prozessor feststellt, dass ein Aufwärtstrend in der gemessenen Atemfrequenz vorliegt (A4) und dass eine Größe des Trends einen Schwellenwert überschreitet (A5), Erzeugen einer Warnmeldung (A6);
wobei der Schritt der Verwendung der Sensoreinheit zur Überwachung einer Durchflussmenge oder eines Drucks eines strömenden Gases in einer Leitung, die das Atemgerät mit einer vom Patienten getragenen Gasabgabevorrichtung verbindet, die Verwendung einer Sensorvorrichtung der Sensoreinheit zur Überwachung der Schwankungen in der Durchflussmenge oder im Druck, die durch die Atmung des Patienten ausgelöst werden, und zur Ausgabe eines Signals, das zu einer Ableitung der Durchflussmenge oder des Drucks in Bezug auf die Zeit proportional ist, umfasst;
dadurch gekennzeichnet, dass:

der Schritt der Verwendung des Prozessors zur Messung der Atemfrequenz des Patienten auf Basis von Schwankungen in der

Durchflussmenge oder im Druck des Gases in der Leitung den Nachweis von Peaks in der überwachten Durchflussmenge oder im überwachten Druck durch Implementierung einer diskreten Zeitintegration der Ausgabe der Sensorvorrichtung, die Bestimmung der Durchflussmenge oder des Drucks einer Strömung, die durch die Atmung des Patienten ausgelöst wird, und die anschließende Verarbeitung der bestimmten Durchflussmenge oder des Drucks zum Nachweisen von örtlichen Maxima und die Bestimmung eines Maßes der Atemfrequenz des Patienten unter Verwendung des Abstands zwischen den nachgewiesenen Maxima umfasst.

13. Verfahren nach Anspruch 12, wobei der Schritt des Nachweises von Peaks in der überwachten Durchflussmenge oder im überwachten Druck die Verwendung einer Schwellenpeakbreite und/oder einer Schwellenspitzenamplitude zum Ausschluss von Rauschen bei der Messung der Atemfrequenz des Patienten umfasst.

14. Verfahren nach einem der Ansprüche 12 bis 13, und umfassend die Implementierung von Abtastphasen in vorbestimmten Intervallen, wenn Schwankungen in der Durchflussmenge oder im Druck nachgewiesen werden, und die Überwachung der Durchflussmenge oder des Drucks für die Dauer jeder Abtastphase.

15. Verfahren nach Anspruch 14, wobei ein Medianwert für den Abstand zwischen den Peaks, die während jeder Abtastphase nachgewiesen wurden, berechnet wird und der Medianwert als Maß für die Atemfrequenz des Patienten verwendet wird.

16. Verfahren nach einem der Ansprüche 12 bis 15, wobei der Schritt der Verwendung des Prozessors zur Implementierung einer Trendanalyse der gemessenen Atemfrequenz die Implementierung der Trendanalyse am Ende jedes einer Vielzahl von täglichen Zeitfenstern unter Verwendung der Atemfrequenz, die während des letzten Zeitfensters und entsprechenden Zeitfenstern der vorhergehenden Tage gemessen wurde, umfasst.

17. Verfahren nach einem der Ansprüche 12 bis 16, wobei der Schritt der Verwendung des Prozessors zur Implementierung einer Trendanalyse der gemessenen Atemfrequenz die Berechnung einer C-Statistik für die gemessene Atemfrequenz umfasst.

Revendications

1. Appareil (10) pour détecter la détérioration de l'état de santé d'un patient recevant un gaz d'un dispositif respiratoire, l'appareil comprenant :

une unité de capteur (11) configurée pour contrôler un débit, ou une pression, d'un gaz qui s'écoule dans un tuyau qui raccorde le dispositif respiratoire à un dispositif de distribution de gaz porté par le patient ; et un processeur (122) configuré pour mesurer une fréquence respiratoire du patient en se basant sur des variations du débit, ou de la pression, du gaz dans le tuyau et pour mettre en oeuvre une analyse des tendances de la fréquence respiratoire mesurée ;
dans lequel le processeur (122) est configuré pour générer un avertissement lorsqu'il détermine qu'il y a une tendance à la hausse de la fréquence respiratoire mesurée et que l'importance de la tendance dépasse un seuil ;
dans lequel l'unité de capteur (11) comprend un dispositif de capteur (111) configuré pour contrôler les variations du débit, ou de la pression, qui sont induites par la respiration du patient et pour transmettre un signal qui est proportionnel à une dérivée du débit ou de la pression par rapport au temps ;
caractérisé en ce que :

le processeur (122) est configuré pour détecter des pics dans le débit contrôlé, ou dans la pression contrôlée, en mettant en oeuvre une intégration à temps discret de la sortie du dispositif de capteur (111) afin de déterminer le débit, ou la pression, d'un flux qui est induit par la respiration du patient et pour traiter ensuite le débit déterminé, ou la pression déterminée, afin de détecter des maxima locaux et pour déterminer une mesure de la fréquence respiratoire du patient à l'aide de la séparation entre les maxima détectés.

2. Appareil selon la revendication 1, dans lequel le dispositif de capteur (111) comprend un capteur de pression différentielle (1111) ayant des premier et second orifices d'entrée pneumatiques (1112, 1113), le premier orifice d'entrée pneumatique (1112) étant configuré pour recevoir un écoulement de gaz en provenance d'un premier point dans le tuyau et le second orifice d'entrée pneumatique (1113) étant configuré pour recevoir un écoulement de gaz en provenance d'un second point dans le tuyau, dans lequel le second orifice d'entrée pneumatique (1113) est également configuré pour retarder l'écoulement du gaz qui s'écoule depuis le tuyau vers le capteur de pression différentielle (1111).

3. Appareil selon la revendication 2, dans lequel le second orifice d'entrée pneumatique (1113) comprend un matériau poreux (1113a) dans un centre creux du second orifice d'entrée pneumatique.

4. Appareil selon la revendication 2, dans lequel au moins une partie du second orifice d'entrée pneumatique (1113) est composée d'un matériau élastique.

5. Appareil selon l'une quelconque des revendications précédentes, dans lequel le processeur (122) est configuré pour utiliser une largeur de pic de seuil et/ou une amplitude de pic de seuil pour exclure du bruit lors de la mesure de la fréquence respiratoire du patient.

6. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'unité de capteur (11) est configurée pour mettre en oeuvre des phases d'échantillonnage à des intervalles prédéfinis lorsque des variations du débit ou de la pression sont détectées, et le débit est surveillé, ou la pression est surveillée, pendant la durée de chaque phase d'échantillonnage.

7. Appareil selon la revendication 6, dans lequel le processeur (122) est configuré pour calculer une valeur médiane pour la séparation entre les pics détectés pendant chaque phase d'échantillonnage et pour utiliser la valeur médiane comme mesure de la fréquence respiratoire du patient.

8. Appareil selon l'une quelconque des revendications précédentes, dans lequel le processeur (122) est configuré pour mettre en oeuvre l'analyse des tendances à la fin de chaque intervalle de temps journalier d'une pluralité d'intervalles de temps journaliers à l'aide de la fréquence respiratoire mesurée pendant le dernier intervalle de temps et des intervalles de temps correspondants des jours précédents.

9. Appareil selon l'une quelconque des revendications précédentes, dans lequel le processeur (122) est configuré pour mettre en oeuvre une analyse des tendances qui comprend le calcul d'une statistique C pour la fréquence respiratoire mesurée.

10. Appareil selon la revendication 9, dans lequel le processeur (122) est configuré pour générer un avertissement lorsque la statistique C calculée indique une tendance et une comparaison de la fréquence respiratoire mesurée avec une fréquence respiratoire caractéristique indique une tendance à la hausse.

11. Appareil selon la revendication 10, dans lequel le processeur (122) est configuré pour déterminer une fréquence respiratoire caractéristique en faisant la moyenne de la fréquence respiratoire mesurée sur une période de référence d'au moins un nombre prédéfini de jours.

12. Procédé de détection d'une aggravation d'un état médical d'un patient recevant un gaz d'un dispositif respiratoire, le procédé consistant :

à utiliser une unité de capteur pour contrôler un débit, ou une pression, d'un gaz qui s'écoule dans un tuyau qui raccorde le dispositif respiratoire à un dispositif de distribution de gaz porté par le patient (A1) ;
à utiliser un processeur pour mesurer une fréquence respiratoire du patient en se basant sur des variations du débit, ou de la pression, du gaz dans le tuyau (A2) ;
à utiliser le processeur pour mettre en oeuvre une analyse des tendances de la fréquence respiratoire mesurée (A3) ; et
lorsque le processeur détermine qu'il y a une tendance à la hausse de la fréquence respiratoire mesurée (A4) et qu'une importance de la tendance dépasse un seuil (A5), à générer un avertissement (A6) ;
dans lequel l'étape d'utilisation d'une unité de capteur pour contrôler un débit, ou une pression, d'un gaz qui s'écoule dans un tuyau qui raccorde le dispositif respiratoire à un dispositif de distribution de gaz porté par le patient comprend l'utilisation d'un dispositif de capteur de l'unité de capteur pour contrôler les variations du débit, ou de la pression, qui sont induites par la respiration du patient et pour transmettre un signal qui est proportionnel à une dérivée du débit ou de la pression par rapport au temps ;
caractérisé en ce que :

l'étape d'utilisation d'un processeur pour mesurer une fréquence respiratoire du patient en se basant sur des variations du débit, ou de la pression, du gaz dans le tuyau comprend la détection de pics dans le débit contrôlé, ou dans la pression contrôlée, en mettant en oeuvre une intégration à temps discret de la sortie du dispositif de capteur afin de déterminer le débit, ou la pression, d'un flux qui est induit par la respiration du patient, puis le traitement du débit déterminé, ou de la pression déterminée, afin de détecter des maxima locaux et la détermination d'une mesure de la fréquence respiratoire du patient à l'aide de la séparation entre les maxima détectés.

13. Procédé selon la revendication 12, dans lequel l'étape de détection de pics dans le débit contrôlé, ou

dans la pression contrôlée, comprend l'utilisation d'une largeur de pic de seuil et/ou d'une amplitude de pic de seuil pour exclure du bruit lors de la mesure de la fréquence respiratoire du patient.

14. Procédé selon l'une quelconque des revendication 12 à 13, et comprenant la mise en oeuvre des phases d'échantillonnage à des intervalles prédéfinis lorsque des variations du débit ou de la pression sont détectées, et la surveillance du débit, ou de la pression, pendant la durée de chaque phase d'échantillonnage.

15. Procédé selon la revendication 14, dans lequel une valeur médiane pour la séparation entre les pics détectés pendant chaque phase d'échantillonnage est calculée et la valeur médiane est utilisée comme mesure de la fréquence respiratoire du patient.

16. Procédé selon l'une quelconque des revendication 12 à 15, dans lequel l'étape d'utilisation du processeur pour mettre en oeuvre une analyse des tendances de la fréquence respiratoire mesurée comprend la mise en oeuvre de l'analyse des tendances à la fin de chaque intervalle de temps journalier d'une pluralité d'intervalles de temps journaliers à l'aide de la fréquence respiratoire mesurée pendant le dernier intervalle de temps et des intervalles de temps correspondants des jours précédents.

17. Procédé selon l'une quelconque des revendication 12 à 16, dans lequel l'étape d'utilisation du processeur pour mettre en oeuvre une analyse des tendances de la fréquence respiratoire mesurée consiste à calculer une statistique C pour la fréquence respiratoire mesurée.

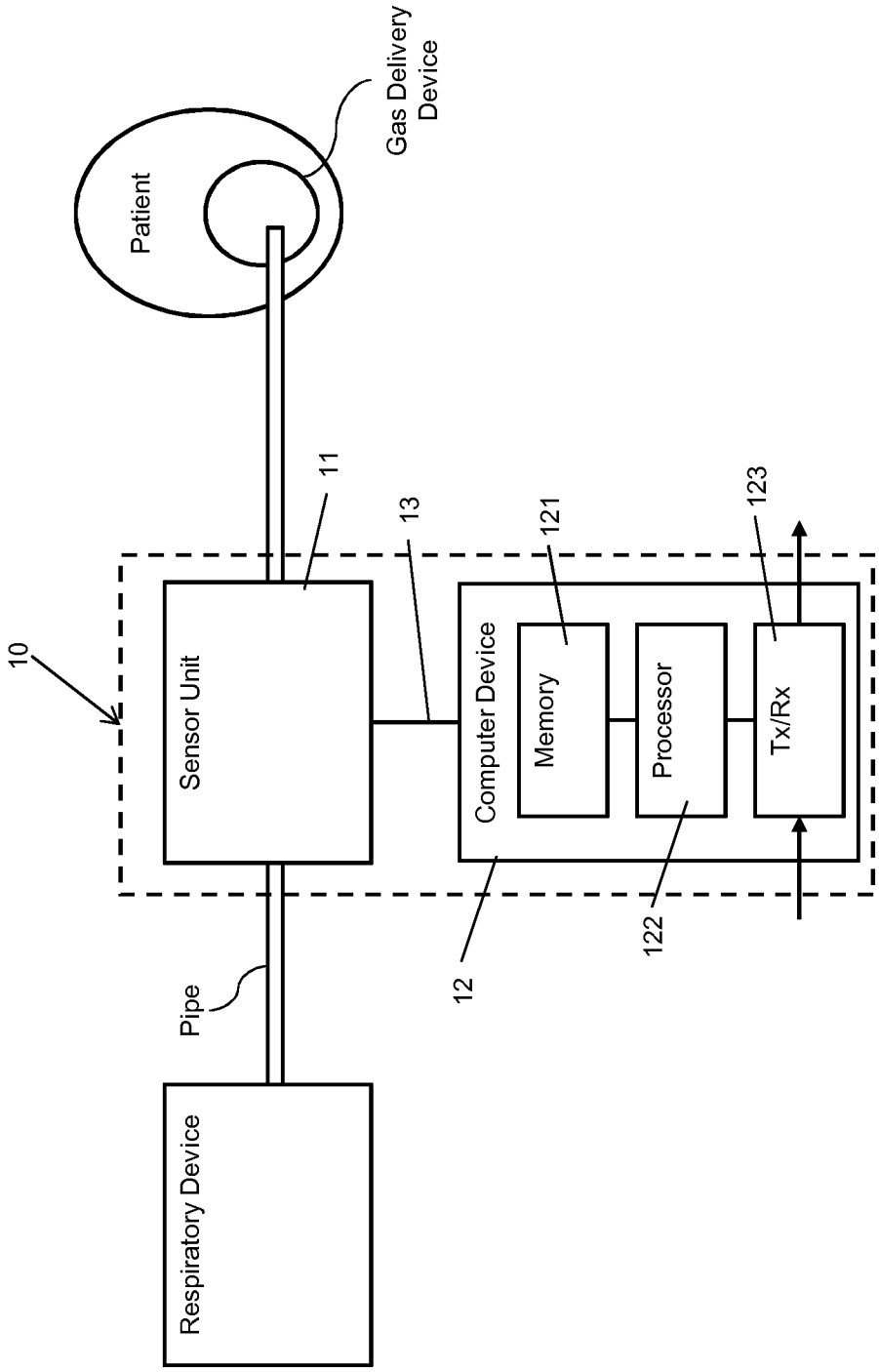
Patient
Gas Delivery Device
10
11
13
121
123
Sensor Unit
Computer Device
Memory
Processor
Tx/Rx
12
122
Pipe
Respiratory Device

Figure 1

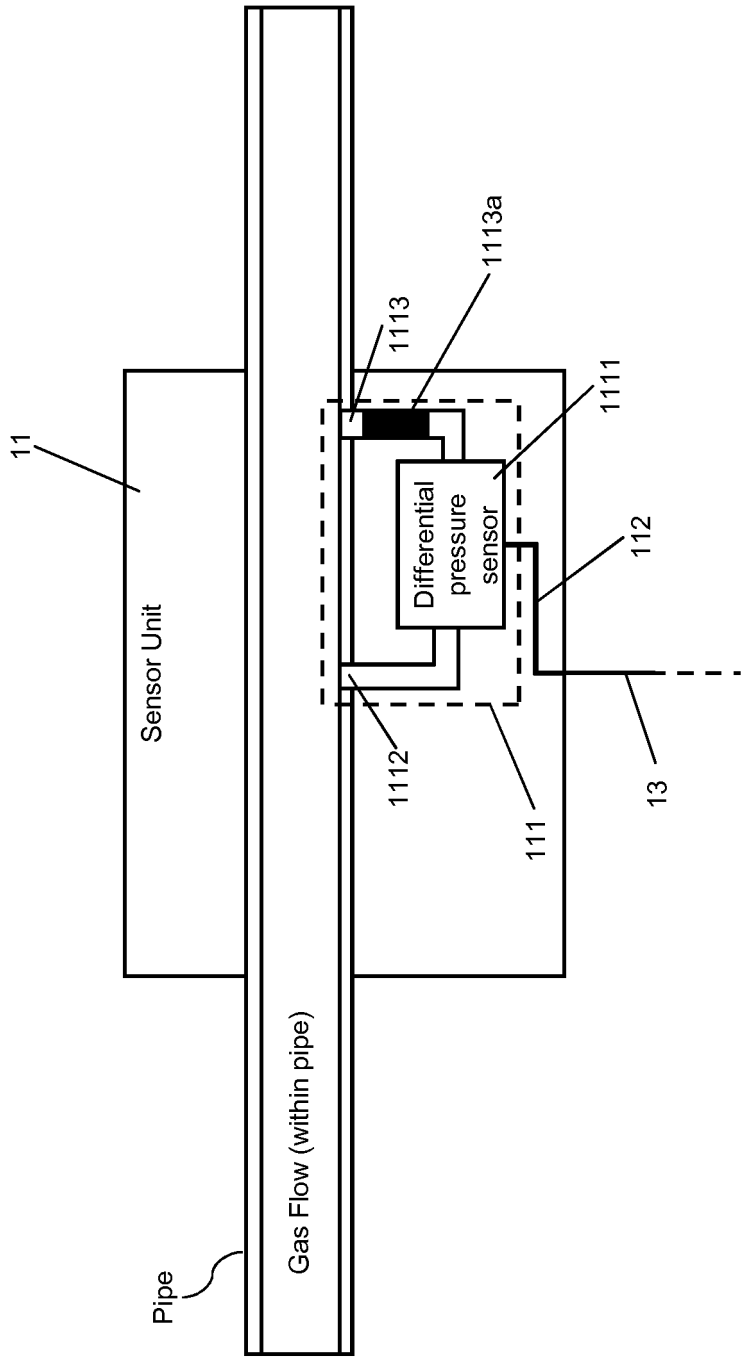
11
Sensor Unit
1113a
1113
1111
Differential pressure sensor
112
1112
111
13
Gas Flow (within pipe)
Pipe

Figure 2

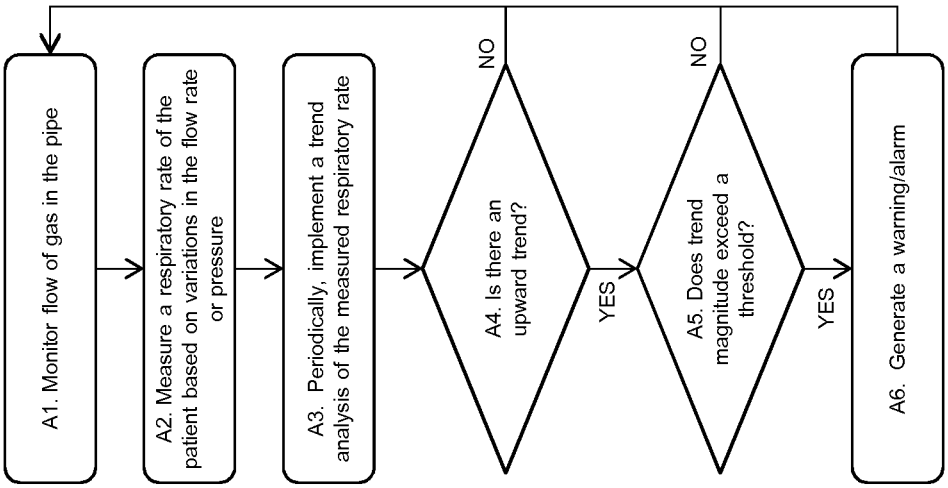
A1. Monitor flow of gas in the pipe
A2. Measure a respiratory rate of the patient based on variations in the flow rate or pressure
A3. Periodically, implement a trend analysis of the measured respiratory rate
A4. Is there an upward trend?
NO
YES
A5. Does trend magnitude exceed a threshold?
NO
YES
A6. Generate a warning/alarm

Figure 3

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2005074361 A **[0001]**
- EP 2245985 A1 **[0002]**
- US 2012203128 A1 **[0003]**

专利名称(译)	用于检测健康恶化的装置和方法		
公开(公告)号	EP3062682A1	公开(公告)日	2016-09-07
申请号	EP2014780528	申请日	2014-10-03
[标]申请(专利权)人(译)	林德股份公司		
申请(专利权)人(译)	LINDE AKTIENGESELLSCHAFT		
当前申请(专利权)人(译)	LINDE AKTIENGESELLSCHAFT		
[标]发明人	PEREZ DE ALEJO FORTUN RIGOBERTO FRANCO GAY MERCEDES		
发明人	PEREZ DE ALEJO FORTUN, RIGOBERTO FRANCO GAY, MERCEDES		
IPC分类号	A61B5/00 A61B5/08 A61M16/00 G01L13/00 G01F1/36		
CPC分类号	A61B5/024 A61B5/0816 A61B5/087 A61B5/4842 A61B5/4848 A61B5/7217 A61B5/7239 A61B5/7242 A61B5/7275 A61B5/7278 A61B5/746 A61M2202/0208 A61M2230/42 G01F1/36 G01F5/005 G16H20/40 G16H40/60 A61M2202/0007 A61M16/0051 A61M16/0858 A61M2016/0027 A61M2016/003 A61M2205/0216		
优先权	2013019351 2013-11-01 GB		
其他公开文献	EP3062682B1		
外部链接	Espacenet		

摘要(译)

提供了一种用于检测从呼吸装置接收气体的患者的健康状况恶化的装置。该装置包括传感器单元和处理器，该传感器单元被配置为监测在将呼吸装置连接到患者所穿的气体输送装置的管道中流动的气体的流速或压力，以及处理器，其被配置为测量患者的呼吸速率。基于管道中气体的流速或压力的变化并实施测量的呼吸速率的趋势分析。处理器被配置为当其确定测量的呼吸速率存在上升趋势并且趋势的大小超过阈值时生成警告。