NEONATAL CARBON DIOXIDE MEASUREMENT SYSTEM

Cross-Reference to Related Application

[0001] This application claims the benefit of U.S. Provisional Application No. 61/872,415, filed August 30th, 2013, the content of which is incorporated herein in its entirety.

Field of the Invention

[0002] The present Disclosure applies to the field of breath measurements and monitoring and specifically to the field of measuring a constituent in the exhaled gas of a patient for the purpose of monitoring the patient's condition.

Background

[0003] In various breath parameter measurement applications, the current state-of-the-art measurement technology may not provide an accurate or reliable measurement during fast breathing patterns because the response time of the sensor employed is not fast enough to measure the breath parameter. Such measurement applications may be those in which continuous monitoring is desired, or in which intermittent monitoring is desired, or in which a one-time breath test is desired. In capnometery for example, Infra-Red sensors are used to measure the CO2 in the exhaled breath. The sensor can be in line with the patient's exhaled gas stream, or coupled to the exhaled gas stream through a gas sample scavenging tube, typically referred to as a sampling line in the case of mechanical ventilation or a nasal cannula in the case of spontaneous breathing. With fast breathing patterns the capnometry sensor is usually capable of registering a breath rate, since a waveform of some amplitude is registered for each breath, however, the sensor is not capable of registering a true peak value of CO2 for each breath. A review of the product literature available for commercial systems indicates that this limitation does indeed exist.

Brief Summary

[0004] In current capnometry systems, especially neonatal capnometry, there are two main technical limitations that prevent accurate measurements. First, the breath sample collection apparatus allows mixing of one section of gas with another section of gas, thus disturbing the homogeneity and purity of the different and discrete sections. This mixing

occurs in the patient interface components, valves, filters, water traps, the breath sensor itself, connectors and the sampling tubing. A solution to this technical problem has been described by Capnia (Reference: Capnia US Provisional Patent Application Number 61/872,270, the entire contents of which are incorporated herein). The second problem, which is addressed in the present disclosure, is the intrinsic response time of the sensor technology being employed. This response time of the sensor is not fast enough to accurately measure the CO2 in a breath when the patient is breathing fast, such as greater than 30 breaths per minute (bpm). Gas obtained from the patient travels through the sensor. When expiratory gas is flowing through the sensor, the sensor will respond to the CO2 molecules in the gas, this response known as the signal response. The amplitude of the signal response depends on and corresponds to the amount of CO2 molecules or CO2 concentration in the gas sample. However the sensor signal response is not instantaneous; it can take as long as 400 milliseconds (ms) for the sensor to finish responding to the CO2 molecules in a bolus of gas from a single expiratory cycle. Therefore, if the patient transitions from exhalation to inspiration before the sensor has finished responding to the CO2 molecules in the expiratory gas bolus, the sensor's signal response will not reach the true peak value. This technical problem is called clipping of the signal. Designers can try to extrapolate where the signal would have peaked had the sensor been fast enough, but these extrapolations are inexact, don't take into account the prevailing clinical conditions of the patient, and should not be used in a medical breath test application. An example of this response time limitation follows.

[0005] Assuming a patient is breathing at 60 bpm, with a 50/50 Inspiratory/Expiratory time ratio his or her expiratory time will be 500 ms. Assuming the lung is 50% airway deadspace, and assuming a constant expiratory flow rate, the person will expire alveolar gas for half of the expiratory time, or for 250 ms. Now, assuming the sensor has a response time of 300 milliseconds, at the end of exhalation, the sensor will have not fully responded to all of the CO2 molecules in the bolus of alveolar gas, and will have reached only 83% of the true peak value (250/300), assuming the signal response is linear. This means that the sensor signal gets truncated before it reaches the true amplitude of the gas being measured, and in this example may read for 4% CO2 instead of 5% CO2. For these above reasons, it is known in the medical community, that capnometry cannot be relied upon for neonatal CO2 monitoring, unless the patient is breathing below 40 or 50 bpm, which often does not occur

depending on the patient's age and condition. Some manufacturers of capnometry monitors often state that the device is not for neonatal use for this reason.

[0006] There are some potential options to circumvent the limitation described above. First, CO2 can be measured in the blood, however, this is invasive and therefore is not a preferred test and is not used for continuous monitoring or repeat testing. Second, CO2 can be measured transcutaneously, but these systems have not yet been proven to be reliable in all clinical situations. (See Arch Dis Child Fetal Neonatal Ed. 2006 July; 91(4): F295–F298. Are carbon dioxide detectors useful in neonates? E J Molloy and K Deakins.)

[0007] Because there is a clinical need for neonatal CO2 measurements, and because of the overwhelming desire for this measurement to be non-invasive and the desire to have the option of continuous or intermittent monitoring, there is a significant unmet need for an accurate, reliable Capnometer for this patient population and other clinical situations and populations in which breathing frequency is relatively fast compared to the sensor being employed.

[0008] It should be noted again that while the disclosure is described for the most part in terms of neonatal capnometry, the same disclosure applies to other breath markers such as O2, and clinical applications other than neonates.

Brief Description of the Figures

[0009] Figure 1 describes capnometry prior art with a CO2 value in the breath measured as a function of time.

[0010] Figure 2 describes a side view cross section of a prior art filter used for filtering gas collected from a patient.

[0011] Figure 3 describes the prior art filter of Figure 2 showing the mixing of gas sections that occurs as gas travels through the filter.

[0012] Figure 4 graphically shows the capnometry signal for a series of breaths as a function of time, in which the Capnometer is not able to measure the true peak value of the CO2 in the patient's breath, the subject of which the present disclosure solves.

[0013] Figure 5 describes a schematic of a pneumatic system of the present disclosure used to collect and measure patient gas.

[0014] Figure 6 describes the system of Figure 5 in which a desired section of gas, for example the end-tidal section, is shunted into an isolation chamber to isolate it from other gases.

[0015] Figure 7 shows the system of Figures 5-6 wherein the desired sample is fully placed in the isolation chamber and lined up precisely with the inlet to the chamber.

[0016] Figure 8 shows the system of Figures 5-7 in which desired sections of gas from three separate desired breaths are shunted into the isolation chamber to fill the chamber, without space in-between the sections.

[0017] Figure 9 shows the system of Figures 5-8 in which the gas sample bolus in the isolation chamber is diverted to a sensor for measurement.

[0018] Figure 10 shows a CO2 breath waveform diagram as a function of time for a series of breaths and threshold criteria for selection and disqualification of breaths to be chosen for analysis.

[0019] Figure 11 shows a close up view of a breath waveform from the series of breaths shown in Figure 10.

[0020] Figure 12 shows a timing diagram of the valve operation of the system in Figure 5 for the purpose of collecting and isolating the desired end-tidal samples from the desired breaths shown in Figure 10.

[0021] Figure 13 graphically shows the sensor CO2 signal of the sample bolus from the system in Figure 9 and from the breaths shown in Figure 10 when measured by the sensor, along with a valve timing diagram on the same time scale indicating the valve operation of the system in figure 9.

[0022] Figure 14 graphically shows the use of an exemplary apparatus as a function of time, with breath rate reporting interspersed by CO2 level reporting, and repeating.

[0023] Figure 15 shows a pneumatic schematic of an alternate pneumatic configuration, in which the sample bolus after collection is diverted to a sensor for measurement without changing the direction of the flow generator.

[0024] Figure 16 shows the system of Figure 15 with a first sample from a first selected breath entering a sample isolation chamber.

[0025] Figure 17 shows the system of Figures 15 and 16, with several samples from several selected breaths now occupying the sample isolation chamber.

[0026] Figure 18 shows the system of Figures 15-17 in which the sample bolus is diverted to a sensor for compositional analysis.

[0027] Figure 19 shows a pneumatic diagram of an alternate pneumatic configuration in which the flow generator direction remains constant, and shows the state in which flow from the patient is being drawn through the system.

[0028] Figure 20 shows the system of Figure 19 in which gas is diverted to a second branch for the purpose of shunting and storing a desired sample of gas from a desired breath.

[0029] Figure 21 shows the system of Figures 19 and 20 in which ambient air is drawn into the system to flush out residual unwanted patient gases.

[0030] Figure 22 shows the system of Figures 19-21 in which ambient air is drawn in to divert the sample bolus to a sensor for measurement and out another ambient port for exhausting out of the system.

Detailed Description of the Invention

[0031] Figure 1 graphically describes capnometry, when used for non-infant patients. Typically the breath period (BP), breath rate and expiratory time (TE) is slow enough for the CO2 signal 100 from the capnometry sensor to register the full amplitude of the actual CO2 102 in the breath sample, and an accurate etCO2 result is reported. The capnometry curve can be broken down into 7 parts. The inspiratory part 1 of the breathing curve, during which there is basically no signal response from the Capnometer; the beginning of exhalation 2 during which again there is basically no signal response from the Capnometer; a sensor lag time 3 which is a brief lag period or delay before the sensor responds to the first CO2 gas

molecules in the exhalation gas seen by the sensor's sensing element; an increasing signal in the middle of exhalation 4 due to the increasing percentage 5 of CO2 being expelled as gas from deeper in the lung is expelled; a plateau 6 representative of alveolar gas and when the sensor has had time to fully respond to the concentration of CO2 molecules; and the, a lag time or delay 7 from the sensor responding to a drop in the CO2 level when exhalation ends and inspiration begins; and a drop 8 in the signal corresponding to the response time of the sensor reacting to no CO2. The differences between the "Actual CO2" curve 102 and the "Capnometry Signal" curve 100 demonstrate the effects that the response time of the sensor has on the sample measurement. These effects can be subtle and unimportant in many clinical applications, but in others, such as neonatal applications, these effects can be detrimental. Below the graph the sections of gas that is being drawn from the patient, in the case of side stream monitoring, is shown graphically as inspired ambient air 110, expired airway air 112, and expired alveolar air 114.

[0032] In Figures 2 and 3, the problem of mixing of expiratory alveolar gas with non-alveolar gas is exemplified. The effect of an in-line filter is shown as an example. Such a filter is often used tp filter humidity or bacteria from the patient along a section of sampling tubing that is being used to draw the sample from the patient. In Figure 2, the different primary breath gas sections (alveolar 114, upper airway 112 and ambient 110) are shown moving in packets along the sampling pathway 122 to the inlet of a filter 120. The gases from a first breath are shown entering the filter. The filter has presumably previously been purged and filled with ambient air, or simply as ambient air inside as baseline condition, and thus is shown filled with ambient air 108, as is the conduit on the outlet side of the filter. In Figure 3, as the different gas sections from the patient's first breath, inspired ambient air 110, airway air 112 and alveolar air 114, travel through the filter, the sections mix with the ambient air in the filter to create mixed gas 130, and exit the filter diluted with the ambient air to create a contaminated airway air sample 132 and a diluted end-tidal sample 134. After a number of breaths, if the breathing pattern is steady state, the dilution reaches a steady state, but the result is that the incoming sample is diluted or contaminated in the filter and exits the filter no longer in its pure original state. The solution to this problem is described in a separate Capnia patent application number 61/872,270, the entire contents of which are incorporated herein.

[0033] Figure 4 shows the problem of sensor signal response time, and the potential inability of the sensor to measure the peak gas level. Again in this case capnometry is used as an example, but the measurement can be other analytes. The breath rate shown is 60bpm. The alveolar gas exhalation time is approximately 250-275msec. The sensor response time is > 275msec. The peak sensor signal registers 3.8%, while the actual peak percentage is 5.0%. Hence, this system is not capable of measuring CO2 under these clinical conditions. Now turning to the rest of the figures, the solution to the problem described in Figure 4 is described.

[0034] In Figures 5 through 14, a new breath gas sampling and measurement system is described. In order to overcome the response time limitation, the system stores the appropriate section of exhaled gas from more than one breath, then the system sends the multiple-sample bolus through the sensor. For example, if the bolus may be composed of end-tidal gas samples from two breaths, each of 150msec in duration, the resultant combined sample therefore being of 300msec in duration. With this unique design and method, the sensor has enough time to register the full amplitude of the CO2 in the bolus, now that the bolus is 300msec long, rather than only 150msec long.

[0035] In Figure 5, the pneumatics of the apparatus 150 are described, comprised of a patient inlet Pt, an inlet valve V1, an ambient inlet amb, a breath analyte sensor S, a sample collection compartment 140, a bypass channel 142, a valve V2 at the inlet to the sample collection compartment, a valve V3 at the opposite end of the sample collection compartment, a pump P, and an exhaust E. The valves V1, V2 and V3 each may have three ports, a, b, and c, with c port always open, and the system toggling between ports a and b during the collection and test sequence. In Figure 5 gas from the patient is being drawn into the apparatus by a vacuum pump P, through for example a nasal cannula or sampling tube attached to the patient inlet Pt of the apparatus. The patient gas travels around the sample collection area 140 through the bypass 142 (valve V2 port b to valve V3 port b) until an end-tidal sample from a targeted breath is identified by the sensor S and arrives at valve V2. At this time, shown in Figure 6, the end-tidal sample is allowed into the sample collection area 140, and when it is properly aligned and positioned in that area, the patient gas is once again diverted around this area through the bypass, shown in Figure 7. Eventually, the sample collection area is filled with two or more end-tidal samples from two or more breaths, as shown in Figure 8. Finally, as shown in Figure 9, the pump direction is reversed, the patient

inlet is closed at Valve V1 and the ambient port amb is open, and the sample bolus is pushed back through the sensor S with ambient air stemming from the exhaust E behind it, and out the ambient port b of valve V1. The sensor S measures the CO2 in the sample bolus as it traverses through it, thus registering a etCO2 value.

[0036] Now referring to Figure 10, the breaths from which the multiple end-tidal samples are collected can be from non-consecutive breaths, in the event of non-steady-state breathing, or episodic breathing, or erratic breathing. Breath pattern algorithms are employed to target breaths that are representative of a certain breath type, for example normal tidal volume breaths, and to exclude other breaths, so as to obtain a sample bolus that is truly homogenous of the type of breath being sought for measurement. Breath measurement thresholds and other breath criteria are defined, either prospectively, in real time, or retrospectively, or combinations thereof, to establish what is normal and not normal for the particular situation. As shown in Figure 10, breaths 9, 14, and 19 pass the criteria and are deemed acceptable and are targeted for sample collection. Returning to Figure 8, the end tidal gas samples from these three targeted breaths are shown collected and stored in the sample compartment 140.

[0037] In Figure 11, breath 9 from Figure 10 is shown in more detail. It is desired in this example to acquire and measure the last 150msec of an exhaled breath from more than one breath. The last 150 msec will assure that the sample is a deep lung sample and representative of what is in the blood, even at very fast breath rates. This time can be a default value, or can be configurable automatically or manually, based on the clinical application, and/or the prevailing breathing pattern. Figure 12 describes the timing and operation of the valves V2 and V3 in Figures 5-8 in order to shunt, isolate and store these samples in the sample collection area, and to prevent mixing of these samples with other gases, in order to assure a homogeneous sample bolus of end-tidal deep alveolar gas of sufficient volume. It may be advantageous to control the valves such that the end-tidal samples of the first and last breath that are targeted overflow the sample collection area; the beginning of sample 1 extends out of the sample collection area, and the end of sample 3 does not quite enter the sample collection area. This "overfilling" technique will help assure that the sample collection area does not contain any non-end-tidal sample, which could act to contaminate the concentration of the targeted gas in sample. Figure 13 shows the valve timing and operation of the operational step shown in Figure 9, when the end-tidal sample

bolus is sent back to the sensor, as well as the sensor's corresponding signal response to the sample bolus. As can be seen, the sensor now has ample time to respond to the analyte level in the bolus, and an accurate measurement is made and can be reported. In Figures 11 through 13, 150 ms is the time duration of the desired and selected sample to be captured (the last 150 msec of exhalation), t0 is the time that the end-of-exhalation of the first good sample exits the sensor S, t1 = t2 - 150msec, t2 = t0 + Xxmsec, XXmsec is time for gas to travel from sensor S outlet to V2 inlet

[0038] In Figure 14, an example of using an exemplary embodiment is shown. For example a breath rate can be reported using the "clipped" capnometry signal. This can take place for examplefor one minute, during which time the multiple end-tidal samples from multiple targeted breaths are being collected and stored. Then, after that one minute period, breath rate reporting can be temporarily interrupted for about 3-15 seconds during which time the end-tidal sample bolus is shuttled to a CO2 sensor, and the CO2 level can be reported by the methods described earlier. Then, the above sequence is repeated, such as; breath rate reporting for one minute, 10 second period for etCO reporting, breath rate reporting for one minute, 10 second period for etCO reporting

[0039] Figures 15 through 18 describe an alternative pneumatic sampling and measurement system. In this alternative, the pump direction need not be reversed, which may be beneficial with certain types of pump technologies, and to guarantee smooth, consistent pump speed and gas flow rate operation. In Figure 15 the apparatus comprises an additional inlet valve V5 coupled to the bypass tube 142, V5 with an ambient inlet port amb2, a reverse flow valve V4, a push tube 144, and a reverse tube 146. As shown in Figure 15, gas from the patient enters the system through the patient inlet Pt, through valve V1, sensor C, valve V5, valve V3, pump P, valve V4 and out exhaust E. As shown in Figure 16, when a breath desired for sampling is identified, V2 and V3 switch to shunt the end-tidal sample into the sample collection tube 140. The identified and targeted multiple end-tidal samples are collected and properly aligned and positioned in the sample collection area similar to that describe in Figures 5-9. As shown in Figure 17, Valve V1 is then switched to the amb inlet so that the patient gases in the various sections of gas pathways other than the sample collection area are purged by ambient air being drawn in through Valve V1, through C, V5, the bypass tube 142, V3, the pump P and V4.. After purging the system, V2, V3, V4 and V5 switch as shown in Figure 18, so that ambient air is now drawn in from V5 port b, drawn through V3 port b and

the pump, and pushed through V4 port c and b into the sample collection area to push the sample bolus through V2 port c and b, and through the Sensor C, and out V1 to ambient air. It should be noted that the systems described herein can include a single sensor for performing both (a) the initial breathing pattern measurements and sample targeting, and (b) analyte measurement in the multi-sample bolus, or can include more than one sensor, for example one for (a) and a second sensor for (b).

[0040] Figures 19-22 show an additional pneumatic configuration. As shown if Figure 19 patient gas flows in through Pt, v1, S1, v5, t1, v2, v3, P, v4 and out E. As shown in Figure 20, when an end-tidal sample from a targeted breath reaches v2, the valves v2 and v3 are switched to allow the end-tidal sample into the sample collection tube, 141, then the valves are switched back to allow flow through segment 143, thus isolating the end-tidal sample. Then as shown in Figure 21, after the sample collection tube 141 is sufficiently filled with end-tidal gas from multiple samples, ambient air is drawn in through valve t1 from the ambient inlet amb3, to purge parts of the system of unwanted patient gas sections. The, in Figure 22, ambient air from amb3 is used to push the end-tidal sample bolus to v1 via v4, v3, v2 and t1, and through the sensor S1 and out the exhaust E2 via v5.

[0041] It should be noted that while different pneumatic branching structures and different combinations and locations of valves and pumps are contemplated, a common theme is that the end-tidal samples must be stored until enough end-tidal sample is collected, and that the time durations of each of the captured end-tidal samples, when added together, must add up to a time duration that is at least close to, preferably equal to, and most preferably greater than, the signal response time of the sensor that is being used to measure the gas in the sample bolus.

[0042] The system described herein can be useful for collecting and measuring end-tidal gas samples, as well as samples from other sections of the breath. It can be used for measuring for example CO2 in the breath, or other gases, such as CO, H2, NO, and others. It can be used for measuring other non-gaseous substances in the breath as well as gaseous markers. The system disclosed can be used for period, intermittent, semi-continuous, or continuous measurements and monitoring. While overcoming fast breathing patterns is used throughout the foregoing descriptions, the disclosure can be applied to overcome other breathing pattern challenges.

Claims

What is claimed is:

1. A method of measuring a breath analyte comprising:

monitoring a series of breaths with a first sensor;

determining a plurality of breath segments of the series of breaths to capture, wherein each of the plurality of breath segments comprises a duration in the first sensor shorter than an analyte response time of the first sensor;

collecting the plurality of breath segments together; and

measuring an analyte concentration of the collection of breath segments using a second sensor, wherein the collection of breath segments comprises a duration longer than a response time of the second sensor.

2. The method of claim 1, wherein the first sensor and the second sensor are the same sensor.

3. The method of claim 1, wherein the first sensor and the second sensor are both capable of measuring the analyte.

4. The method of claim 1, wherein monitoring the series of breaths comprises monitoring each breath's breath rate.

5. The method of claim 1, wherein monitoring the series of breath comprises monitoring each breath's capnometry signal.

6. The method of claim 1, wherein determining a plurality of breath segments of the series of breaths to capture comprises identifying breaths with a normal end-tidal profile.

7. The method of claim 1, wherein determining a plurality of breath segments of the series of breaths to capture comprises excluding one or more of a non-steady state breath, an episodic breath, and an erratic breath.

8. The method of claim 1, wherein the analyte is CO_2.

9. The method of claim 1, wherein the first sensor is an infrared CO_2 sensor.

10. The method of claim 1, wherein each of the plurality of breath segments comprises substantially all of the last 150 msec of the respective breath.

11. The method of claim 1, wherein collecting the plurality of breath segments together comprises drawing the plurality of breath segments into a collection chamber using a pump, and wherein

measuring an analyte concentration of the collection of breath segments using a second sensor comprises reversing the pump to send the collection of breath segments to the second sensor.

12. The method of claim 1, wherein collecting the plurality of breath segments together comprises drawing the plurality of breath segments into a collection chamber using a pump, and wherein

measuring an analyte concentration of the collection of breath segments using a second sensor comprises not reversing the pump to send the collection of breath segments to the second sensor.

13. A system for measuring a breath analyte comprising:

a first sensor that generates data from a series of breaths;

a processor that receives the data and determines a plurality of breath segments of the series of breaths to capture based on the data, wherein each of the plurality of breath segments comprises a duration in the first sensor shorter than an analyte response time of the first sensor;

a chamber that collects the plurality of breath segments together; and

a second sensor that measures an analyte concentration of the collection of breath segments, wherein the collection of breath segments comprises a duration longer than a response time of the first sensor.

14. The apparatus of claim 13, wherein the first sensor and the second sensor are the same sensor.

15. The apparatus of claim 13, wherein the first sensor and the second sensor are both capable of measuring the analyte.

16. The apparatus of claim 13, wherein the first sensor generates data on a breath rate of each breath of the series of breaths.

17. The apparatus of claim 13, wherein the first sensor generates data on a capnometry signal of each breath of the series of breaths.

18. The apparatus of claim 13, wherein the processor determines the plurality of breath segments of the series of breaths to capture by identifying breaths with a normal end-tidal profile.

19. The apparatus of claim 13, wherein the processor determines the plurality of breath segments of the series of breaths to capture by excluding one or more of a non-steady state breath, an episodic breath, and an erratic breath.

20. The apparatus of claim 13, wherein the analyte is CO_2.

21. The apparatus of claim 13, wherein the first sensor is an infrared CO_2 sensor.

22. The apparatus of claim 13, wherein each of the plurality of breath segments comprises substantially all of the last 150 msec of the respective breath.

23. The apparatus of claim 13, further comprising a pump to draw the plurality of breath segments into the chamber, and wherein the pump routes the collection of breath segments to the second sensor.

24. The apparatus of claim 23, wherein the pump is not reversed to route the collection of breath segments to the second sensor.

Claims

What is claimed is:

1. A method of measuring a breath analyte comprising:

monitoring a series of breaths with a first sensor;

determining a plurality of breath segments of the series of breaths to capture, wherein each of the plurality of breath segments comprises a duration in the first sensor shorter than an analyte response time of the first sensor;

collecting the plurality of breath segments together; and

measuring an analyte concentration of the collection of breath segments using a second sensor, wherein the collection of breath segments comprises a duration longer than a response time of the second sensor.

2. The method of claim 1, wherein the first sensor and the second sensor are the same sensor.

3. The method of claim 1, wherein the first sensor and the second sensor are both capable of measuring the analyte.

4. The method of claim 1, wherein monitoring the series of breaths comprises monitoring each breath's breath rate.

5. The method of claim 1, wherein monitoring the series of breath comprises monitoring each breath's capnometry signal.

6. The method of claim 1, wherein determining a plurality of breath segments of the series of breaths to capture comprises identifying breaths with a normal end-tidal profile.

7. The method of claim 1, wherein determining a plurality of breath segments of the series of breaths to capture comprises excluding one or more of a non-steady state breath, an episodic breath, and an erratic breath.

8. The method of claim 1, wherein the analyte is CO_2.

9. The method of claim 1, wherein the first sensor is an infrared CO_2 sensor.

10. The method of claim 1, wherein each of the plurality of breath segments comprises substantially all of the last 150 msec of the respective breath.

11. The method of claim 1, wherein collecting the plurality of breath segments together comprises drawing the plurality of breath segments into a collection chamber using a pump, and wherein

measuring an analyte concentration of the collection of breath segments using a second sensor comprises reversing the pump to send the collection of breath segments to the second sensor.

12. The method of claim 1, wherein collecting the plurality of breath segments together comprises drawing the plurality of breath segments into a collection chamber using a pump, and wherein

measuring an analyte concentration of the collection of breath segments using a second sensor comprises not reversing the pump to send the collection of breath segments to the second sensor.

13. A system for measuring a breath analyte comprising:

a first sensor that generates data from a series of breaths;

a processor that receives the data and determines a plurality of breath segments of the series of breaths to capture based on the data, wherein each of the plurality of breath segments comprises a duration in the first sensor shorter than an analyte response time of the first sensor;

a chamber that collects the plurality of breath segments together; and

a second sensor that measures an analyte concentration of the collection of breath segments, wherein the collection of breath segments comprises a duration longer than a response time of the first sensor.

14. The apparatus of claim 13, wherein the first sensor and the second sensor are the same sensor.

15. The apparatus of claim 13, wherein the first sensor and the second sensor are both capable of measuring the analyte.

16. The apparatus of claim 13, wherein the first sensor generates data on a breath rate of each breath of the series of breaths.

17. The apparatus of claim 13, wherein the first sensor generates data on a capnometry signal of each breath of the series of breaths.

18. The apparatus of claim 13, wherein the processor determines the plurality of breath segments of the series of breaths to capture by identifying breaths with a normal end-tidal profile.

19. The apparatus of claim 13, wherein the processor determines the plurality of breath segments of the series of breaths to capture by excluding one or more of a non-steady state breath, an episodic breath, and an erratic breath.

20. The apparatus of claim 13, wherein the analyte is CO_2.

21. The apparatus of claim 13, wherein the first sensor is an infrared CO_2 sensor.

22. The apparatus of claim 13, wherein each of the plurality of breath segments comprises substantially all of the last 150 msec of the respective breath.

23. The apparatus of claim 13, further comprising a pump to draw the plurality of breath segments into the chamber, and wherein the pump routes the collection of breath segments to the second sensor.

24. The apparatus of claim 23, wherein the pump is not reversed to route the collection of breath segments to the second sensor.