Accessible CO2 Technology Increases Caregiver Efficiency

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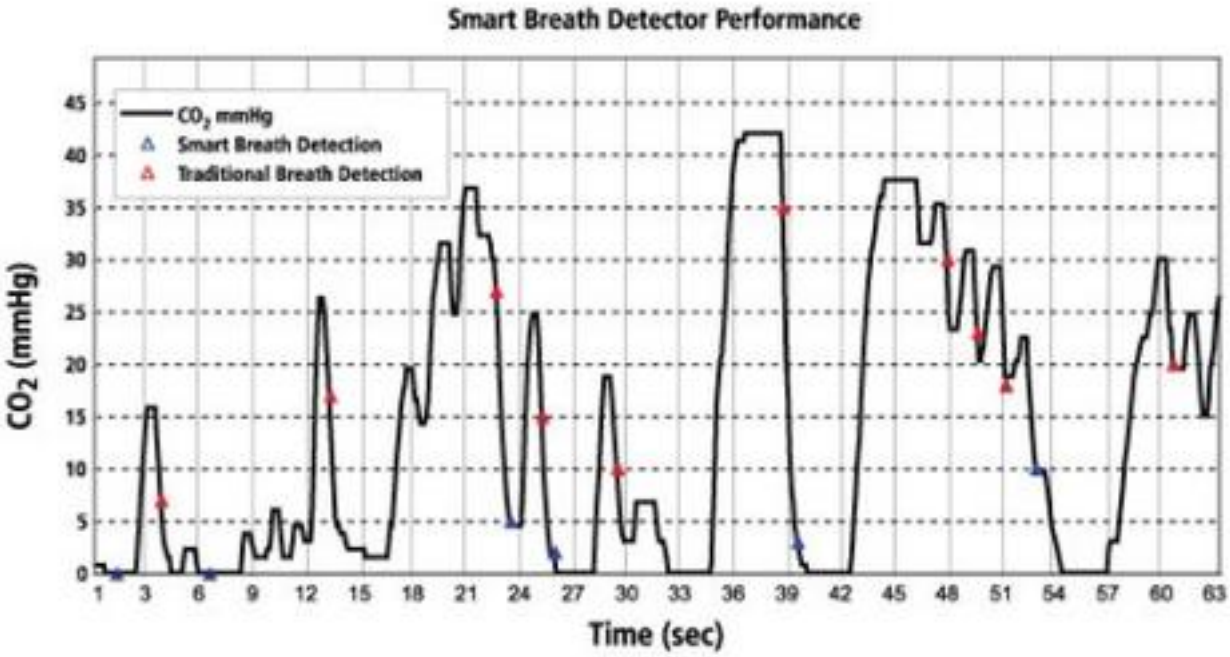
In today's medical facilities, healthcare providers face heavy workloads and care for more patients with decreased clinical staff. They need products and technologies that help them provide effective care as efficiently as possible.

At Covidien, our goal is to provide monitoring solutions that enhance patient care in a range of clinical environments. To that end, our focus is to make Covidien Microstream capnography technology, which measures end-tidal CO_2 and adequacy of ventilation, accessible through stand-alone and OEM solutions and also provide enhanced algorithms and hardware for efficient and effective patient care.

One solution is the new Micropod external module, which enables easy integration of Microstream capnography to existing platforms, and makes it quick and easy to install this technology in the factory or the field.

Improved Alarm Management

Alarms that signal clinically insignificant events are a distraction to busy caregivers, wasting their valuable time. Smart Breath Detection Algorithm (BDA) and Smart Alarm for Respiratory Analysis (SARA) together significantly reduce false or clinically insignificant respiration rate alarms by providing a more accurate respiration rate (RR) value.



Unlike traditional breath detection algorithms, the Smart BDA rejects shallow, no-breath CO_2 excursions (talking, snoring, cardiogenic artifact) from being counted as breaths. Instead, the Smart BDA suite of proprietary filter and pattern recognition techniques screen out the changes superimposed on the CO_2 waveform. This reports more accurate RR and helps avoid meaningless alarms. The waveform to the right illustrates the effect that talking—one artifact that can cause non-breath excursion—can have on the waveform.

The SARA adaptive respiratory rate averaging algorithm is an embedded alarm management technology that works with Smart BDA to increase the respiratory rate averaging time during periods of high breath-to-breath time period variability, and reduces the averaging time during periods of low breath-to-breath variability.

To evaluate the variability of the capnogram, SARA uses a Variability Index, which is the standard deviation of the last five breath intervals. RR is calculated in parallel with a Variability Index as follows:

$$\text{Variability Index (VI)} = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}}{\bar{x}}$$

N = the number of breath-to-breath time intervals.

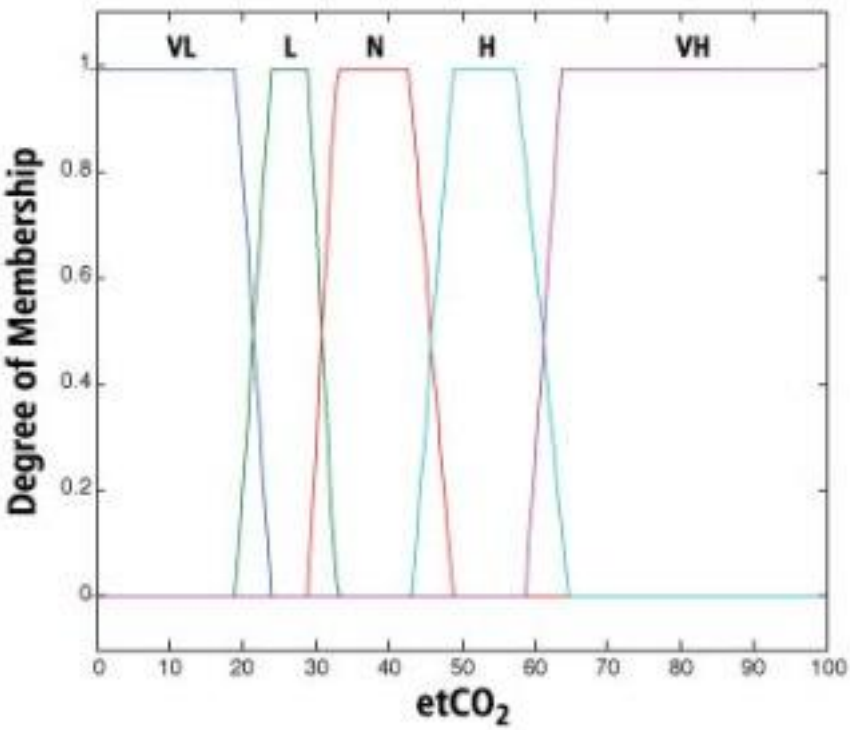
X = breath-to-breath intervals in seconds.

$\bar{X}$ = mean of breath-to-breath intervals.

By extending the averaging time during unstable periods, noise and transient fluctuations are averaged out, providing a more realistic respiratory rate.

Simplified Assessment of Overall Respiratory Status

Caregivers without strong training in respiratory conditions are sometimes hesitant to use capnography because they may not feel confident that they are correctly interpreting the numerics and waveform. Even for experienced nurses, it takes some time to evaluate all of the data available to determine the overall respiratory status of the patient.



The Integrated Pulmonary Index (IPI) provides a real-time indication of changes in the patient's respiratory status by combining the values of SpO_2, PR, $etCO_2$, and RR into an integer index that ranges from 1-10. For example, 10 indicates “normal,” 5 indicates “requires attention and may require intervention,” and 1 indicates “immediate intervention required.” IPI displays general trends in the patient's respiratory status and enables clinicians of varying backgrounds to quickly and correctly judge when the patient requires more attention. IPI empowers the clinician with actionable data, which can enhance caregiver efficiency.

IPI is a “fuzzy logic” algorithm and was built using the opinions of 30 medical experts. They evaluated the measured parameters from 235 patient cases to assign an IPI value according to a predefined scale.

IPI uses fuzzy membership functions that describe each physiological parameter by defined ranges: Very Low (VL), Low (L), Normal (N), High (H), and Very High (VH). A particular value of $etCO_2$, for example, could have a degree of membership of 60% in Normal, and a degree of membership of 40% in High. The algorithm creates IF THEN ELSE statements using the logic provided by the medical experts. For example:

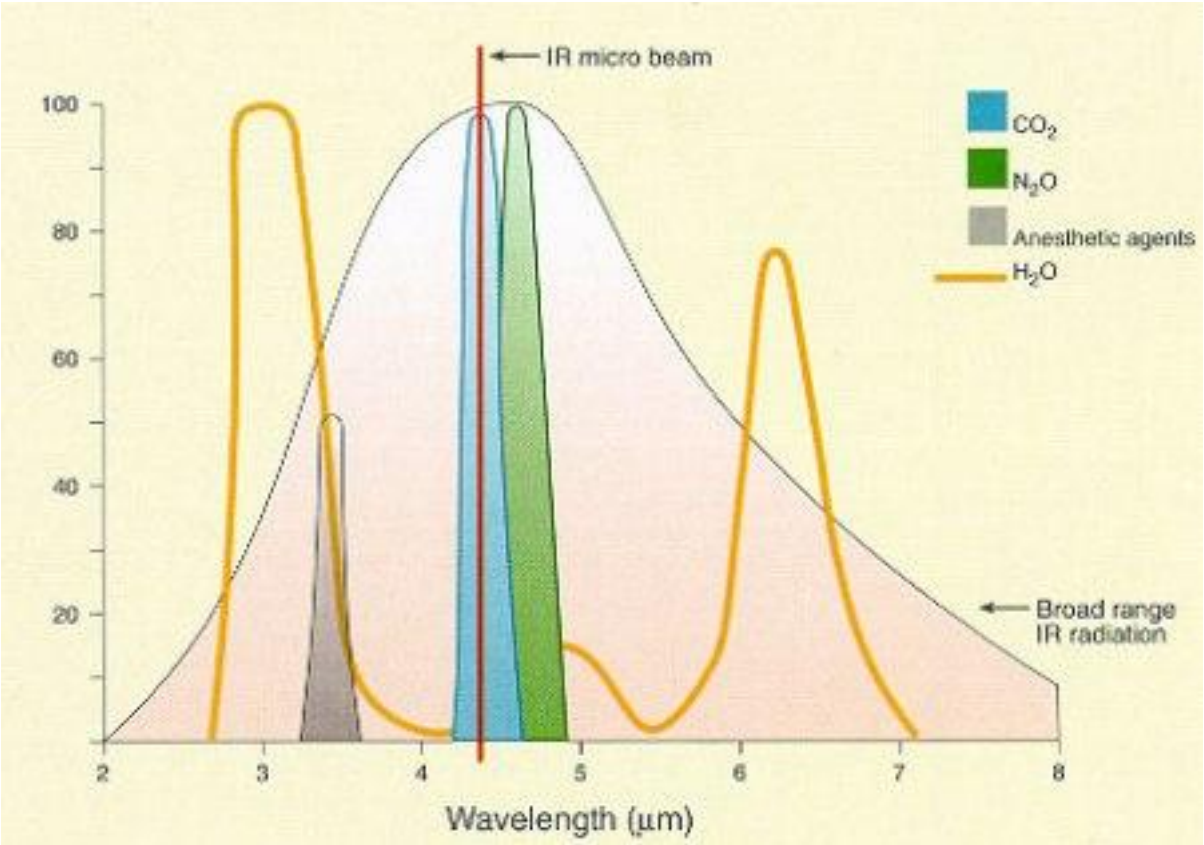
If $etCO_2$ is VH, and RR is VH, and SpO_2 is N, and PR is H, then IPI = 2 (Patient

requires immediate intervention)

Hardware That Takes Care of Itself

Automatic Zeroing

The MicroMediCO$_2$, the engine inside the new MicroPod OEM module, does not require calibration or zeroing every time there is a new consumable or patient; it automatically zeros at turn on, and then senses changes in the environment that would require re-zeroing. This is accomplished by having two separate internal airflow paths: one for the patient's breath sample and one for this “auto zero” purpose. A solenoid will automatically switch between the paths as required. This also allows accuracy to be maintained during shifts in environment, such as the temperature changes in transport and the barometric pressure changes in helicopter evacuations.



Innate Accuracy with Anesthetic Gases

The MicroPod module uses non-dispersive infrared (IR) spectroscopy to measure CO$_2$. This is done by shining a proprietary IR light source, which radiates in the frequency of CO$_2$ through the gas sample, and then measuring how much light is received on the opposite side of the measurement chamber. The light that did not make it through was absorbed by the gas, and is proportional to the CO$_2$ content.

This differs from many CO$_2$ technologies where "black body" sources, which produce light in a broad spectrum of frequencies, are used. Their CO$_2$ measurement is distorted by the presence of other gases, requiring the caregiver to interact with the monitor to initiate compensation routines. Instead, the MicroMediCO$_2$ simplifies the workflow and increases patient safety.

The Future

The MicroPod solution has a powerful microcomputer, for which exciting new features are already under development. As they are available, existing hardware can be updated with the latest software, enabling the monitoring system to continue to offer the latest algorithms and features.

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