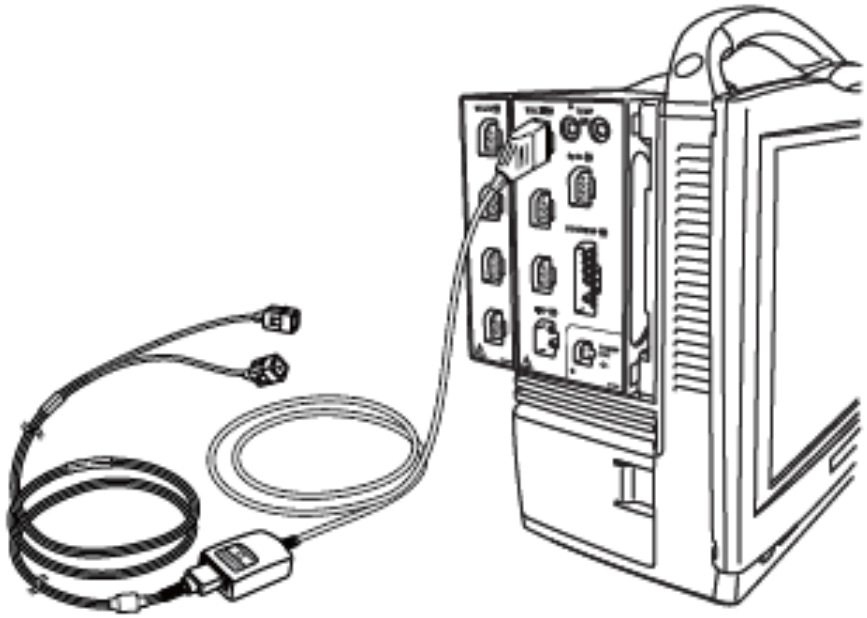
Capnography Monitoring with the CapONE CO2 Sensor

For use with the BSM 2300/4100/5100 and the BSM 6000 Series Bedside Monitors



Self Study Training Packet

August 2011

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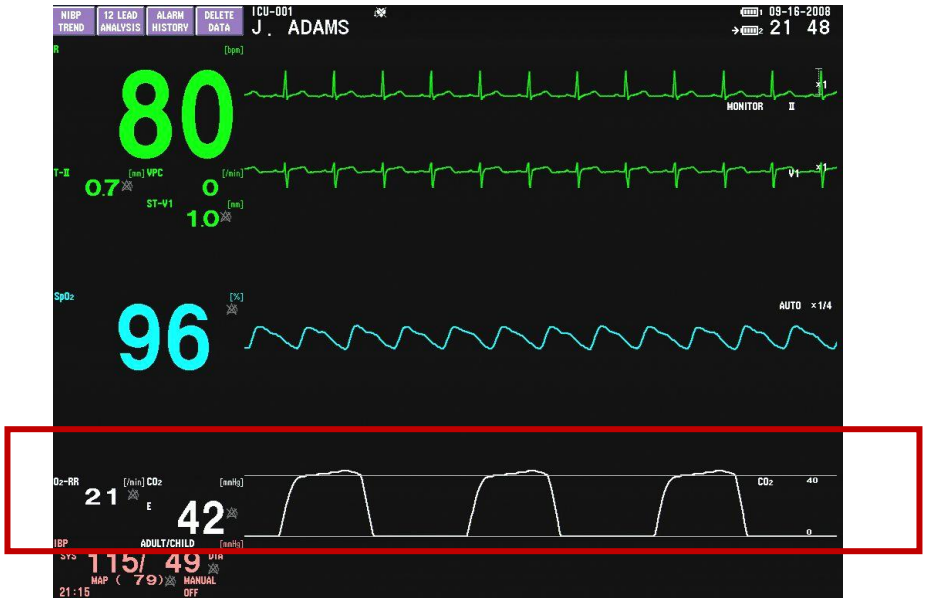
Capnography Overview

End Tidal Carbon Dioxide (EtCO2) is the measurement of expired CO2 at the end of the expiratory cycle, its point of maximum concentration. Monitoring and displaying the EtCO2 value, along with a capnogram waveform of the CO2 levels on a scale is called "capnography".

Indications for capnography monitoring are for assessing ventilation during 1) moderate sedation procedures, as the sedatives can depress the depth and rate of respirations, leading to retention of carbon dioxide, 2) monitoring the effectiveness of ventilation on intubated patients in the ED or the ICU, 3) Recent AHA/ECC guidelines recommend monitoring capnography for endotracheal tube placement and 4) for the effectiveness of ambu bag ventilation continuously during CPR. The EtCO2 value approximates the alveolar level of CO2, and is represented on the monitor in mmHg. These EtCO2 values are expected to be 3-8 mmHg lower than the normal arterial blood gas values of 35-45 mmHg. When the patient is hyperventilating, the CO2 values will be low, and conversely, when they are hypoventilating, the CO2 values will increase.

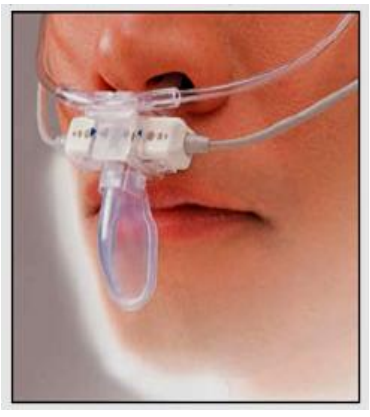
The Nihon Kohden bedside monitors use the mainstream method to monitor carbon dioxide (CO2) levels in the patient's exhaled breath, meaning that the analysis is performed at the patient and not in the monitor itself. This results in more accurate EtCO2 results and the respiratory rate is determined from the exhaled breath detection. The EtCO2 value, the respiratory rate/minute and a capnogram are displayed and trended.



The bedside monitor uses a CO2 sensor (TG0920P) called "CapONE" and a disposable airway adapter, which is placed on the endotracheal or tracheal tube or close to the patient within the airway circuit. The sensor can also be used with non-intubated patients using a different disposable adapter.

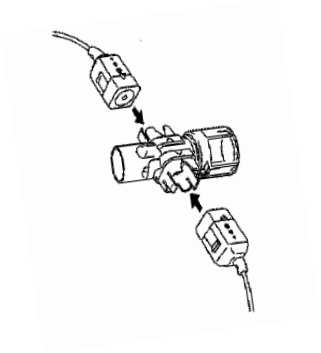
CapONE CO2 sensor kit for intubated or non-intubated patients

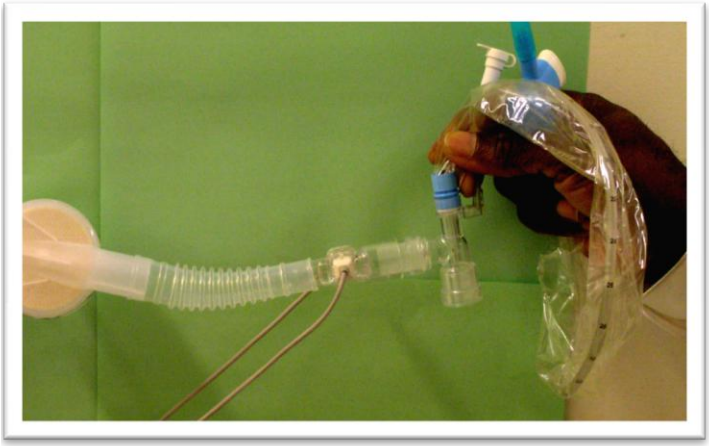
TG-920P



Using the CapONE on Intubated and Non-Intubated Patients

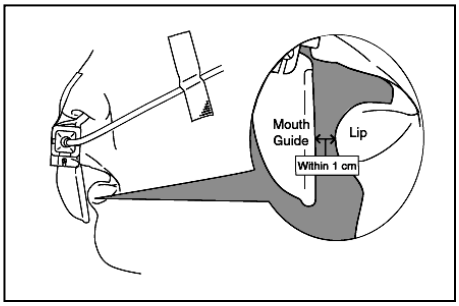
The sensor cable must be positioned so that it is parallel to the floor to keep the adapter's transparent windows upright so the exhaled breath can be analyzed. This also prevents moisture and secretions from settling and obscuring the windows. When using the CO2 sensor in a ventilator circuit with an inline suction catheter, position the disposable airway adapter to the side of the circuit so that the catheter does not go through the adapter, as this could damage the windows. Place the adapter on the patient side of the filter and as close to the airway as possible.



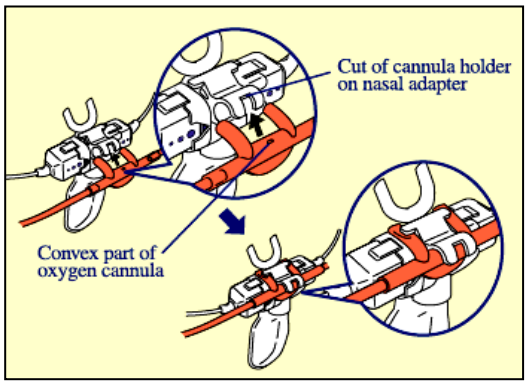


The CapONE mainstream sensor uses disposable adapters that are for single patient use only. The YG-111T is for intubated patients and the YG-122T is for non-intubated ones. The dead space volume on the YG-111T is 4ml and can only be used on children over 3 years of age who are greater than 7kg. The YG-122T is limited to use in patients over 3 years of age and 10 Kg. To maintain accuracy with the CapONE sensor when monitoring capnography continuously, change the adapter every 24 hours. (If capnography monitoring is required for a child under 3 years of age, a sidestream monitor, such as the Oridion CO2 monitor is used)

The YG-122T adapter can be used for oral and nasal monitoring. By removing the oral cup, it can be used for nasal monitoring with and without oxygen delivery. Nasal only detection would be used during oral based procedures where the oral cup would interfere with oral access. The CapONE sensor must be secured to the patients face for proper detection.

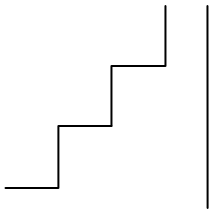


Only the Hudson RCI® oxygen cannulas #1103, 1109, 1110, 1810, 1812, 1814, 1920, and 1921 can be used with the CapONE sensor. The image below shows the positioning of the oxygen cannula onto the adapter.



Cautions:
1) Use of the CapONE sensor with BiPAP and CPAP has not been verified and is therefore not recommended.
2) With the TG-920P CO2 sensor kit (CapONE), measurements are based on the assumption of no CO2 gas being present on inspiration and uses 0 mmHG during the calibration process. Therefore, when monitoring CO2 on a patient with an oxygen mask, CO2 gas may be present on inspiration and may result in the acquired data being lower than the actual value. It is therefore not recommended to use the CapONE on patients receiving oxygen by mask.

The monitor performs an initial sensor calibration when the adapter is attached, and then periodically throughout the monitoring timeframe. The calibration is performed on the inspiratory phase of respiration and the monitor assumes a zero level of CO2 during this time, so if any CO2 is available during this calibration process, CO2 values could be higher than they are actually displayed. Please refer to the operator manual for the bedside monitor for additional information. The calibration waveform appears as a stair step from the baseline:



Gas calibration of the CapONE with the bedside monitor was completed at the factory and should be performed by qualified hospital personnel every 6 months. See the operator manual for specific recommendations.

CO2 Parameter Operations on the Bedside Monitor

To access the CO2 parameter menu, touch the CO2 value on the Home Screen ***OR***

1. Press **MENU** key
2. Touch **RESP/CO2** button in the PARAMETER SETUP section

CO2 Tab menu options:

Scale 0-20, 0-40, 0-80

Controls for adjusting the scale for the waveform on the HOME screen. Set to display the waveform within the high and low scale parameters - Higher values require a higher scale. Touch the desired scale option to select it.

Vital Alarm – Resp/Apnea/CO2 Alarm Limits

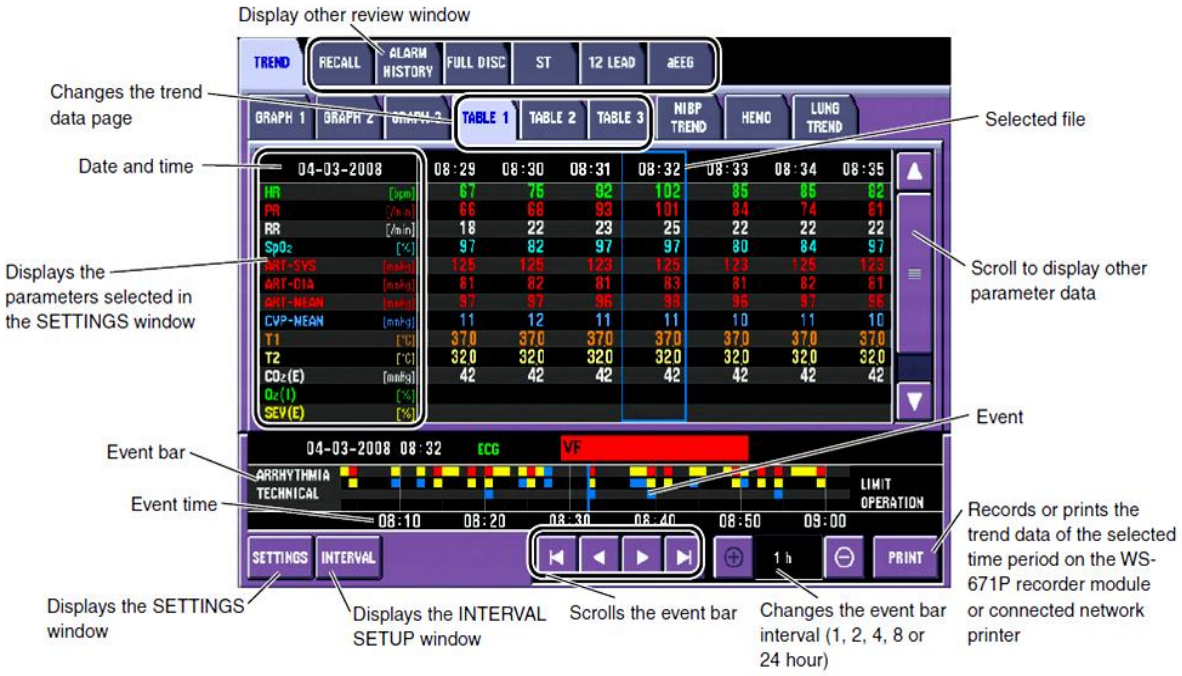
Touch the desired limit then the appropriate arrow to increase or decrease limits

Note: Set the value to ABOVE MAXIMUM or BELOW MINIMUM to turn the limit to OFF

Scale and Limits

Review the CO2 Trends

The capnography data is stored with the other vital sign information in the Review window on the bedside monitor. To access this information, touch the TREND DATA function key on the HOME screen, or press the MENU key and then the TREND or LIST key on the menu. The parameters are displayed to the left and the results are displayed according to the selected time frames. On the BSM 6000 bedside monitor, the SETTINGS key opens a menu to select the parameter if CO2 is not displayed. Other models have a similar key for this purpose.



Cleaning and Disinfecting the CapONE Sensor

To clean the CapONE sensor, dispose of the plastic patient adapter and wipe the sensor and cable with alcohol.

CO2 Troubleshooting and Key Points (Refer to Operator Manual)

Problem –	Possible Cause	Action
Measurement is too low	CO2 is mixed in inspiration	Refer to “Measurement error” in operator manual
	Airway adapter is dirty	Replace disposable adapter
	Atmospheric pressure is low	Consider the atmospheric pressure as a variable
Value is inaccurate	Oscillation in the circuit	Check respirator and remove cause
	A Jackson Rees or Mapleson D respiration circuit is used	Cannot measure correctly
	Respiratory rate is high or irregular	Cannot measure correctly
CO2 waveform does not appear	Airway adapter is disconnected from the sensor kit	Connect the adapter
LED on CO2 sensor blinks Green to Red	Disposable adapter is older than 24 hours	Change adapter
	Apnea for longer than 20 seconds.	Red LED blinks when apnea is longer than 20 sec. regardless of alarm settings
	Sensor is faulty	Replace sensor

Customer Support

Technical and Clinical Support are available at 1-800-325-0283 option 6
Supplies can be ordered through customer service at 1-800-325-0283 option 2

American Heart Association (AHA) Recommendation for Continuous Capnography during Adult CPR

As previously mentioned, End Tidal Carbon Dioxide (EtCO2) is the measurement of expired carbon dioxide (CO2) at the end of the expiratory cycle, its point of maximum concentration. This number is valued because it closely approximates the concentration of CO2 in the blood stream, although typically it is 3 to 8 mmHg less than the arterial blood value, where the normal values are between 35-45 mmHg. Once a gradient is established, it remains constant barring any significant change in the patient's condition.

CO2 is a byproduct of cellular metabolism and it is transported to the lungs by the circulatory system for excretion. Therefore, EtCO2 can be used to evaluate a patient's metabolic, circulatory, and respiratory status. All three of these mechanisms are compromised during cardio-pulmonary arrest.

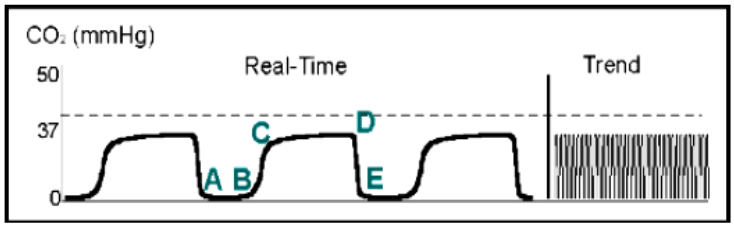
How?

1. Metabolism is affected by the cessation of breathing and blood flow, and resulting oxygen deprivation (hypoxemia). Even though oxygen and blood flow are not present or sufficient, metabolism must continue so to support life of the tissue and organs.
2. The circulatory system is compromised by decreased or absent blood flow (decreased cardiac output). Therefore, oxygen is not transported to the cells and CO2 is not moved to the lungs.
3. Cessation of, or ineffective breathing, does not introduce oxygen to the blood, nor does it excrete CO2.

Earlier we stated that capnography is the measurement and display of the EtCO2 value (capnometry) along with the display of the capnogram (the waveform created by continuously plotting the measured concentration of CO2 over time). The resulting number and waveform can assist the rescuers in evaluating the three processes described above, allowing for evaluation of the effectiveness of CPR, the patient's response to these efforts, and the maintenance of the rescue airway post intubation. The Respiratory Rate is derived by counting the number of expiratory cycles per minute of time.

Because CO2 is not a significant atmospheric gas, its presence in any measurable quantity makes EtCO2 monitoring the most reliable method of detecting respiration and evaluating the status of the three previously mentioned systems.

Understanding the Capnogram



A-B	Baseline – The pause between inspiration and expiration.
B-C	Expiratory Upstroke – Beginning of expiration.
C-D	Expiratory Plateau – Continued expiration.
D	**EtCO2 Value – Point of maximum concentration.**
D-E	Inspiration – The next breath is initiated.

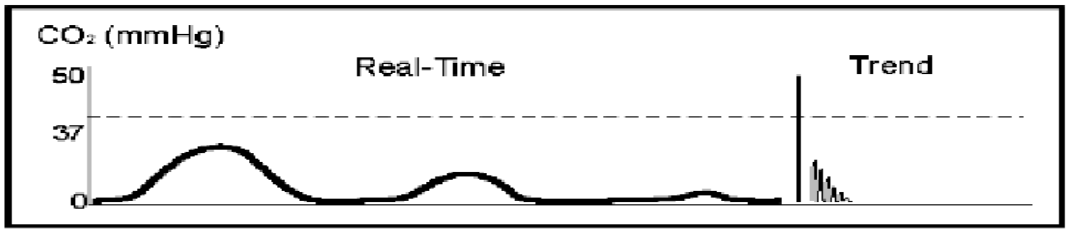
During expiration (B-C), dead-space air is cleared from the upper respiratory tract and CO2 values begin to rise. The dead-space air dilutes the expired CO2. The plateau (C-D) indicates the continued expiration of gasses from deep within the lung. With the dead-space air cleared out, the concentration of CO2 is near its maximum. Just prior to inspiration (D), the CO2 is at its point of maximum concentration. This is the point where the EtCO2 value is measured. Inspiration (D-E) quickly clears away the exhaled gas and any remaining CO2 (A).

Why Waveform Capnography and Why During and Post CPR?

In the *2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care,* the AHA recommended that capnography be monitored during CPR by ACLS trained healthcare professionals for a number of reasons.

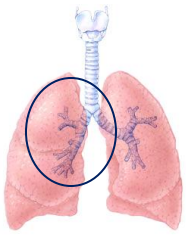
Studies have indicated that emergency Intubation is associated with a 6% to 25% incidence of Endotracheal Tube Misplacement or Displacement. Misplacement means never actually intubating the trachea, and Displacement indicates accidental extubation post successful intubation. The conditions under which emergency intubations occur are less than optimal. It may be difficult to visualize the larynx and trachea because of gastric secretions, blood, anatomy of the mouth and throat, etc. If the airway is missed, the tube will likely follow the path of the esophagus. It is entirely possible the rescuer may believe they have successfully intubated the patient, when in fact they have not.

Though intubations should always be assessed by listening for bilateral breath sounds, observing the rise and fall of the chest, and listening over the stomach for the absence of sounds of rushing or gurgling air; the physical assessment is highly subjective and prone to misinterpretation by even the most skilled providers. Only the immediate and sustained presence of measurable CO2 and subsequent visualization of a waveform consistent with tracheal intubation is a direct indicator of the efficacy of the procedure. Should the esophagus be intubated either no CO2 will be detected, or any small amount that is detected will quickly clear.



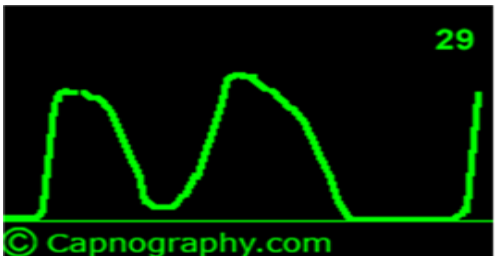
Esophageal Intubation

In the instance of Displacement, the waveform and EtCO2 value will quickly change. The normal, crisp, “plateau-like” waveform that was previously visualized will deteriorate or disappear all together. The measured EtCO2 value will also deteriorate and lessen. The reasons for tube displacement can be many, but typically include spontaneous movement of the patient, repositioning of the patient for transport, and also the placement of a backboard beneath the patient so to improve the quality of chest compressions.



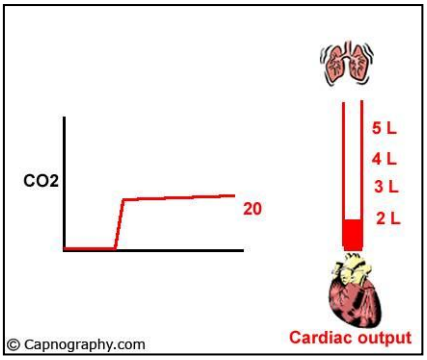
Another concern relating to emergency intubations is the possibility of over inserting the endotracheal tube. The anatomy of the lung is such, that should the endotracheal tube be inserted too far, it will likely follow the gentle angle of the Right Main Bronchus, sealing off the left lung from rescue breathing. This will effectively decrease the efficiency of respirations by at least half.

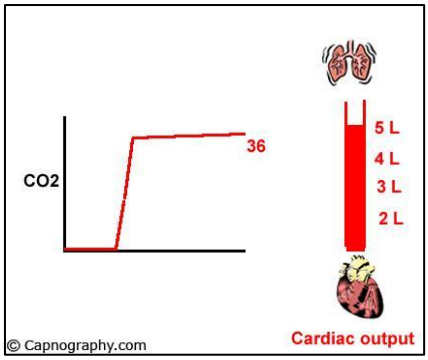
The tell-tale waveform indicating the possibility of the occurrence is called the “Bi-phasic Capnogram”. Caused by the unequal emptying of the two branches of the Right Main Bronchus, the “camel back” waveform is typically seen. Pulling the tube back above the Carina (where the tracheal splits into the Right and Left Main Bronchi) resolves the concern and a more typical waveform results.



CPR is the attempt of the rescuer to take over for the failed heart and/or lungs of the patient. Though it saves many lives, manual chest compressions are not nearly as efficient as the hearts own contractions. When the heart resumes beating and pumping on its own cardiac output increases and, therefore, blood flow increases throughout the body and to the lungs.

Knowing that circulation is the key to transporting CO2 to the lungs for excretion, any increase in that circulation will also increase expired CO2. Hence, a sudden rise in ETCO2 can signal a Return of Spontaneous Circulation, or ROSC. It is desirable to stop chest compressions upon ROSC, but most often there are few if any objective clinical signs that ROSC has occurred. The most typical indicator is the return of a palpable peripheral pulse, but in order to assess this, chest compressions and other life saving measures must be interrupted. A sudden rise in the measured expired CO2 may likely indicate the presence of ROSC, and capnography, with its continually displayed ETCO2 value, is the best indicator of this.





Capnography has been studied as a predictor of the likelihood of survivability post arrest. Though studies continue, to date they have suggested that when the ETCO2 does not rise above 10mmHg following sustained CPR, it is unlikely that the patient will survive to discharge. The greater the post arrest value, the greater the chance of survivability. Patient's with a post arrest ETCO2 of 30mmHg or greater, were likely to survive to discharge, but further studies are required to prove this theory. Knowing this provides the physician with an objective clinical measurement when determining when to cease rescue efforts. Also, it can help provide the information a family member may want to know when determining if it is in their loved one's best interest to pursue extraordinary measures that may prolong suffering, but not contribute to survivability.

Monitoring Capnography during Moderate Sedation Procedures

The Anesthesia Patient Safety Foundation (APSF) is recommending the use of both pulse oximetry and capnography when administering moderate sedation to patients in the hospital. In the June, 2011 report of the *Conclusions and Recommendations from June 08, 2011 Conference on Electronic Monitoring Strategies to Detect Drug-Induced Postoperative Respiratory Depression*, the committee members agreed that undetected respiratory depression and CO2 retention during these procedures is not acceptable, and that pulse oximetry for oxygenation monitoring alone is inadequate. In an attempt to better assess the ventilatory status of the patients undergoing moderate sedation procedures, they recommend monitoring continuous capnography for signs of hypoventilation and CO2 retention so that the monitoring personnel can take action sooner when adverse conditions occur.

Summary

The bedside monitor, with the CapONE sensor, provides key information when capnography is indicated on most patients in the hospital, with the exception of children under the age of 3 with a body weight of 7-10 Kg. In these patients, a sidestream version of capnography is available. The EtCO2 values are obtained at the end of the expiratory phase of the respiratory cycle, and are expected to be 3-8 mmHg lower than the arterial blood gas normal CO2 value of 35-45 mmHg due to the dead space in the airway. These values are displayed as a numeric value and as an expired CO2 level scaled waveform called a capnogram. Together, these components are referred to as "capnography".

Capnography is a tool for assessing ventilation during sedation and artificial ventilation, and it has recently been shown to be beneficial for assessing endotracheal tube placement and the return of spontaneous circulation during cardiac arrest and CPR efforts. It is also being studied as a predictor of survivability of a cardiac arrest during resuscitative efforts.

The simple system design allows clinicians to set alarms and review recent trends on the bedside monitor. For additional information, consult the operator manual for the bedside monitor and the CapONE sensor and the industry guidelines and standards for monitoring capnography.

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