Capnography

Application Note

This note provides you with a basic overview of the application and clinical benefits of capnography which is available on the entire IntelliVue patient monitor family. There is a choice between two state-of-art capnography solutions, enabling clinicians to select the method which best suits their use-model.

Introduction

Capnography, which is also referred to as end tidal carbon dioxide (etCO2) monitoring, is a non-invasive measure of the inspired and expired carbon-dioxide concentration. It provides a graphical and numerical display of the partial pressure of carbon dioxide within the patients' airway. A detailed analysis of the waveform (capnogram) can reveal to the clinician both complex and subtle changes of the patients ventilatory status.

Clinical Application

New technologies for monitoring etCO2 now provide clinicians with the opportunity to easily monitor the ventilatory status in both spontaneously & mechanically assisted breathing patients. Several accessories have been designed to meet the most challenging applications. Together, they provide healthcare institutes with the tools that assist them to comply with the latest recommendations.

Confirmation tracheal versus esophageal intubation

In some patient populations, it is difficult to directly visualize the vocal cords during intubation, therefore it is essential to confirm correct placement of the tube. Carbon dioxide is eliminated by the lungs, so the measure of etCO2 and display of a capnogram confirms to the clinician the success of the procedure. If the tube is misplaced in the esophagus, then neither the etCO2 value nor a normal capnogram will be displayed.

The American Heart Association guidelines for Advanced Cardiovascular Life Support recommend that emergency responders confirm tracheal tube positioning by using nonphysical examination techniques. These include esophageal detector devices, quantative end-tidal C02 indicators, and capnographic and capnometric devices, this includes capnography.

Continuous etCO2 monitoring is extremely useful during patient repositioning when there is the risk of accidental tube displacement or extubation. The clinician is quickly alerted to this as the measured etCO2 value will drop and the capnogram will loose its normal rectangular appearance.

Monitoring severity of lung disease and impact of treatment

Since etCO2 offers a measure of the alveolar O2/CO2 exchange capabilities, clinicians are able to assess the effect of medications being used to treat asthma and chronic obstructive pulmonary disease in both intubated and non-intubated patients. As the therapy is given, the capnogram appearance is assessed for its slope and timing. The aim of therapy would be to have a near to normal capnogram displayed.

Monitoring efficiency of mechanical ventilatory support

Patients who are intubated and receiving mechanical ventilatory support benefit from etCO2 monitoring in several ways;

- Disappearance of the etCO2 value & capnogram is suggested of ventilator disconnect. This may be detected on the patient monitor prior to the ventilator associated alarm.
- Rebreathing of CO2 can be assessed by observing the upward trend of the capnogram over time.
- There is a correlation between the etCO2 and PaCO2; a gradient between 1-5mmHg is normal & expected. When detecting a drop in etCO2, the clinician can measure the PaCO2 and compare the two values. When there is a widened gradient, this is suggestive of a pulmonary emboli and the patient needs immediate investigation.
- One of the earliest indicators of insufficient neuromuscular blockade is the attempt of the patient to breath

spontaneously. This can be seen on the capnogram which will have a notched appearance.

Monitoring adequacy of pulmonary and coronary blood flow e.g. Cardiac Arrest

Research has shown a close correlation between cardiac output and etCO2 readings. Therefore several organizations are now recommending that during cardio-pulmonary resuscitation (CPR), etCO2 be measured and used as an indicator effectiveness of CPR.

Monitoring spontaneous breathing in non-intubated patients receiving procedural sedation

Pulse oximetry (SpO2) is the standard used for measuring oxygen saturation of the blood; however it does not provide an accurate snapshot of the patient's current ventilatory status. Studies have shown that the earliest indicator of respiratory depression and apnea are changes in the etCO2 level, which occur long before changes are detected in the SpO2 measurement.

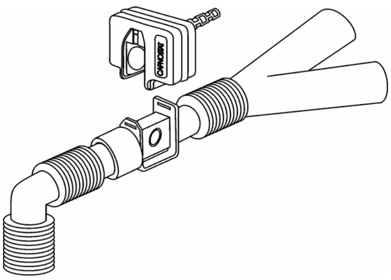
Because SpO2 does not provide information on the patients ventilatory status, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and the American Society of Anesthetists (ASA) have revised their monitoring standards and now recommend that all patients under heavy sedation or anesthesia should have continuous monitoring of their respiratory measurements. The mandated use of capnography applies whenever drugs are administered that interfere with the protective airway reflex.

Helping Choose the Appropriate CO2 Technology - Mainstream or Sidestream and/ or Microstream®

There are various types of CO_2 sampling technologies available with Philips. It is important to understand the difference between the applications in order to help you select the best option to satisfy your specific clinical requirements.

Mainstream CO_2 Technology

With mainstream CO_2 technologies, the CO_2 sensor is placed on an airway adapter which is directly in the breathing circuit. As a patient breathes or is ventilated, the sensor analyzes the gas passing through the adapter and reports the CO_2 values.



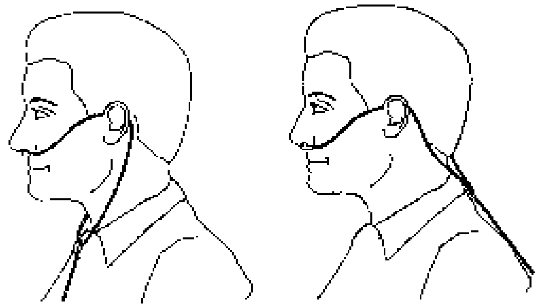
Mainstream technology is the ideal choice for intubated patients such as in the ICU. The benefits of this type of technology are that the measurement is made immediately at the airway. There is no sample removed from the breathing circuit.

What is the limitation of mainstream for non-intubated patients?

Because mainstream technology requires the insertion of an airway adapter into a breathing circuit, there is no easy connection for monitoring your non-intubated patients.

Sidestream CO_2 and Microstream ® Technology

With sidestream and Microstream® technology, a nasal cannula is placed on the patient, or, if the patient is intubated, an airway adapter set is connected to the breathing circuit. As the patient breathes, a portion of the breath is transported through the sample line, filtered and analyzed by an infrared sensor.



Sidestream and Microstream® technology is the ideal choice for monitoring non-intubated patients such as in the ED for conscious sedation or for use as a safety monitor in the ICU after a patient has been extubated to help assure that the patient maintains adequate ventilation on their own.

What is the limitation of sidestream for intubated patients?

Patients who require intubation and long term ventilation typically will have thick secretions that are expelled through coughing or by suctioning. Because sidestream technology requires that the gas sample be transported from the breathing circuit, through the sample line to reach the CO2 analyzer, these secretions often will be aspirated into the sample line, causing the line to occlude requiring user intervention to correct the situation.

Procedural Sedation case studies

Kindly provided by Oridion

Author; Jenifer R. Lightdale, MD, MPH. Children's Hospital Boston

Case 1:

A 6 ½ year-old boy with gastroparesis and symptoms of gastroesophageal reflux presented for upper gastrointestinal endoscopy in a Pediatric Endoscopy Unit.

Baseline vital signs were found to be stable at 10:30 am, and revealed the patient to have an SpO2 of 98% on room air. A dual-purpose nasal cannula was applied, and with 2L supplemental O2 via nasal cannula, the patient's SpO2 rose to 100%. A baseline ETCO2 was noted to be 38 mm/Hg.

10 mg of midazolam po were administered at 10:50, and an IV was placed at 11:10am. At 12:00pm, the patient was brought to the procedure room, and sedation for the procedure was initiated at 12:10pm using a combination regimen of intravenous midazolam and fentanyl. Heart rate, respiratory rate, SpO2, blood pressure, chest impedance and capnography were all monitored throughout the procedure, and a dedicated nurse noted vital signs and chest wall movement continuously.

The endoscope was introduced into the patient's oropharynx at 12:22 and the esophagus was intubated and traversed without difficulty. At 12:24, the capnogram revealed 30 seconds of hypoalveolar ventilation and apnea. ETCO2 detection at this time fell steadily from 35mmHg to undetectable.

Approximately 50 seconds later, at 12:25, the patient's pulse oximeter began to show arterial desaturation with a steady decline to a low of 84%. The patient was gently stimulated by the nursing staff, and the pulse oximetry reading had increased to 99% by 12:27.

Over the next 6 minutes, two further episodes of capnograms consistent with alveolar hypoventilation were noted, one lasting 25 seconds and the other lasting 50 seconds. No further arterial desaturation was noted on pulse oximetry, and the endoscope was withdrawn at 12:33.

The patient was discharged to the Post-Anesthesia Care Unit for recovery without complication.

Case 2:

A 9 year-old boy with persistent gastroesophageal reflux presented for upper gastrointestinal endoscopy in a Pediatric Endoscopy Unit.

Baseline vital signs were found to be stable at 8:00 am, and revealed the patient to have an SpO2 of 100% on room air. A dual-purpose nasal cannula was applied, and a baseline ETCO2 was noted to be 37 mm/Hg.

The patient entered the procedure room, and sedation for the procedure was initiated at 8:35am using a combination regimen of intravenous midazolam and fentanyl. 2L of supplemental oxygen was provided via the nasal cannula. Heart rate, respiratory rate, SpO2, blood pressure, chest impedance and capnography were all monitored throughout the procedure, and a dedicated nurse noted vital signs and chest wall movement continuously. At 8:47am, the patient was noted to be sleeping comfortably, with slow deep breaths, and his ETCO2 was reading 48 mm/Hg.

The endoscope was introduced into the patient's oropharynx at 8:50 and the esophagus was intubated and traversed without difficulty. At 8:54, there was a 30 second episode of abnormal capnograms with occasional notching and loss of wave. At 9:04, there was a second episode lasting more than a minute of abnormal capnograms that included 25 seconds of frank loss of waveforms consistent with apnea. At 9:05, slightly more than 1 minute into this episode, the patient's pulse oximeter began to show arterial desaturation with a steady decline to a low of 89%. Meanwhile, the patient was being gently stimulated by the nursing staff. By 9:07am, the waveform had returned to a normal pattern, and the patient's pulse oximetry did not show desaturation. There were no further episodes of abnormal capnograms, and the procedure finished at 9:11am. The patient was discharged to the Post-Anesthesia Care Unit for recovery without complication.

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www.medical.philips.com

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Philips Medical Systems
Global Information Center
P.O Box 1168
5602 BD Eindhoven
The Netherlands

Asia

Tel: +852 2821 5888

Europe, Middle East, Africa

Tel: +31 40 27 62092

Latin America

Tel: +55 11 2125 0764

North America

Tel: +1 800 285 5585

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