

Technical Guideline

End-Tidal CO₂

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Summary

End-tidal CO₂ (EtCO₂) monitoring is a noninvasive technique which measures the partial pressure or maximal concentration of carbon dioxide (CO₂) at the end of an exhaled breath, which is expressed as a percentage of CO₂ or mmHg. The normal values are 5% to 6% CO₂, which is equivalent to 35-45 mmHg. CO₂ reflects cardiac output (CO) and pulmonary blood flow as the gas is transported by the venous system to the right side of the heart and then pumped to the lungs by the right ventricles. When CO₂ diffuses out of the lungs into the exhaled air, a device called capnometer measures the partial pressure or maximal concentration of CO₂ at the end of exhalation.

Key Definitions:

End-tidal CO₂ - EtCO₂ is a noninvasive technique which represents the partial pressure or maximal concentration of CO₂ at the end of exhalation. Normal value is 35-45 mmHg.

RERAs - Respiratory Effort Related Arousal events occur as a result of increasing respiratory effort leading to an arousal from sleep, while the criteria for a hypopnea or apnea are not met.

Sleep Facility - Any sleep center whether it is hospital based or independent.

Sleep technologist - Refers to a trainee, technician or technologist that is credentialed according to their state's requirements for the purpose of this document.

1.0 Scope

This technical guideline will address end-tidal carbon dioxide (ETCO₂) monitoring which is the measurement detected by capnography. A sleep technologist can utilize capnography to establish a patient's baseline reading of CO₂ at the end of exhalation or during a PSG to record breath-by-breath levels of expelled CO₂ at the end of each exhaled breath.

1.1 Indications for End Tidal CO₂

Capnography has traditionally been used in the hospital setting with critically ill patients and in patients receiving general anesthesia (1), but has become a standard assessment during pediatric sleep studies and during adult sleep studies with special populations. In 2015, The Centers for Medicare & Medicaid Services (CMS) included Capnography in the fee schedule for pediatric polysomnography (2).

As the use of Home Sleep Apnea Testing (HSAT) has become more common in the diagnosis of Obstructive Sleep Apnea (OSA), in-lab PSG is being used with a more complex population of sleep disordered patients. During the PSG, CO₂ monitoring is recommended for the following patient populations where hypoventilation can have adverse effects on development, comorbid disease and mortality: pediatric (3); neuromuscular disease; respiratory failure; hypoventilation.

2.0 Recording Techniques

Capnography is the monitoring of the concentration or partial pressure of carbon dioxide (CO₂) in the respiratory gases. It is usually presented as a graph of expiratory CO₂. An infrared signal is used to detect the level of carbon dioxide at the ending plateau waveform during exhalation to capture alveolar gas. End tidal CO₂ (EtCO₂) is the maximum expired carbon dioxide concentration during a respiratory cycle. The graphical representation of EtCO₂ is shown in a waveform format and is known as a capnogram.

2.1 Calibration

During each recording, prior to “lights off” and after “lights on,” the calibration of the Capnograph is verified. Most capnography equipment requires a “warm up” period and must be calibrated on room air. Always refer to the manufacturer guidelines for proper device calibration prior to use on a patient.

- 2.1.1** The technologist verifies the calibration of the capnograph according to the Capnograph Operation Manual.
- 2.1.2** The technologist documents and saves this information at the beginning and end of each recording.
- 2.1.3** If the initial reading is incorrect as described in the Capnograph Operation Manual, the technologist re-calibrates the capnograph according to the Capnograph Operation Manual.
- 2.1.4** If the capnograph is re-calibrated repeat step 2.1.1.
- 2.1.5** The sleep software recorder should display the same values that the capnograph displays. This must be verified initially and throughout the recording per your lab protocol. Technologists should clearly document this on the PSG recording.
- 2.1.6** If the display on the sleep software recorder is incorrect, refer to the sleep software User Manual in order to re-calibrate the sleep software to the Capnograph.
- 2.1.7** If the sleep software recorder is re-calibrated repeat step 2.1.1.

2.2 Troubleshooting

- 2.2.1** The main source of difficulty in maintaining a reliable ETCO₂ Signal is occlusion of the sampling line.
- 2.2.2** Occlusion can occur from:
 - 1. A crimp in the sample line to the patient.
 - 2. A no longer functioning moisture trap.
 - 3. A crimp in the scavenger port line located on the back of the device.
 - 4. A break or disconnect in the internal tubing that moves the patient airflow sample through the testing components.

- 2.2.3** A crimp in a line, or need for replacement moisture trap are easily remedied. Split cannulas and replacement filters should always be kept on hand
- 2.2.4** Never open the ETCO₂ casing to repair internal components. Contact the manufacturer for instructions on repair.

2.3 Application

Capnography can be either mainstream (measuring specifically from the collection/sample site such as in an endotracheal tube) or side-stream (measuring a sample in a location separate and more distant from the sample site). In most clinical outpatient sleep testing environments, a side-stream sample is adequate. A side-stream sample can be measured from a variety of patient interfaces including nasal cannula and tracheostomy or endotracheal tube (3). The sample line from the cannula is connected to the Capnograph according to the Capnograph Operation Manual.

2.4 Recording

The technologist monitors the ETCO₂ waveform and values throughout the night and ensures that quality signals are recorded. Interventions to correct signal quality are documented and corrected per your lab protocol. It is recommended that sleep centers using EtCO₂ utilize a split cannula for simultaneous monitoring of CO₂ and Pflow rather than attempting to place two separate Pflow and EtCO₂ cannulas on a patient.

- 2.4.1** The technologist monitors the ETCO₂ trending data throughout the night. Normal EtCO₂ fall between 30 and 45 mmHg or 5-6% total CO₂. Patients with known COPD will often have +/- 11 mmHg over normal ranges. Always refer to your facilities safety and emergency policies and when in doubt contact your medical director or physician on call.
- 2.4.2** If the ETCO₂ value exceeds the CO₂ value in mmHg for the duration defined in the sleep center's Policy & Procedure manual or Emergency Protocol criterion, the technologist should take appropriate action to notify the sleep medicine physician on call for his/her recommendation. Patients with elevated EtCO₂ levels should be titrated carefully if being placed on positive airway pressure therapy of any modality.
- 2.4.3** The sleep physician reviews the PSG data and completes the final report which includes the End-tidal CO₂ data.

2.5 Scoring

- 2.5.1** In the pediatric patient population, ETCO₂ is used:
 - 1. For the detection of hypoventilation syndrome in children.
 - 2. Scoring Respiratory Effort-Related Arousals, RERA's (if RERA's are being scored).
 - 3. As an "acceptable" channel in scoring respiratory events (4).
- 2.5.2** In the adult patient population, ETCO₂ is used to detect hypoventilation (4)

3.0 Cleaning

Refer to the Instruction Manual, or Technical Manual for maintenance/cleaning recommendations per manufacturer guidelines.

4.0 References

- 1) Richardson M, Moulton K, Rabb D, et al. Capnography for Monitoring End-Tidal CO₂ in Hospital and Pre-hospital Settings: A Health Technology Assessment [Internet]. Ottawa (ON): Canadian Agency for Drugs and Technologies in Health; 2016 Mar. (CADTH Health Technology Assessment, No. 142.) Executive Summary. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK362368/>
- 2) Centers for Medicare & Medicaid Services. Federal Register / Vol. 79, No. 219 / Thursday, November 13, 2014 / Rules and Regulations.
- 3) Beck SE, Marcus CL. PEDIATRIC POLYSOMNOGRAPHY. *Sleep medicine clinics*. 2009;4(3):393-406. doi:10.1016/j.jsmc.2009.04.007.
- 4) Berry RB, Albertario, CL, Harding, SM, et al.; for the American Academy of Sleep Medicine. *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications*. Version 2.5. Darien, IL: American Academy of Sleep Medicine; 2018.