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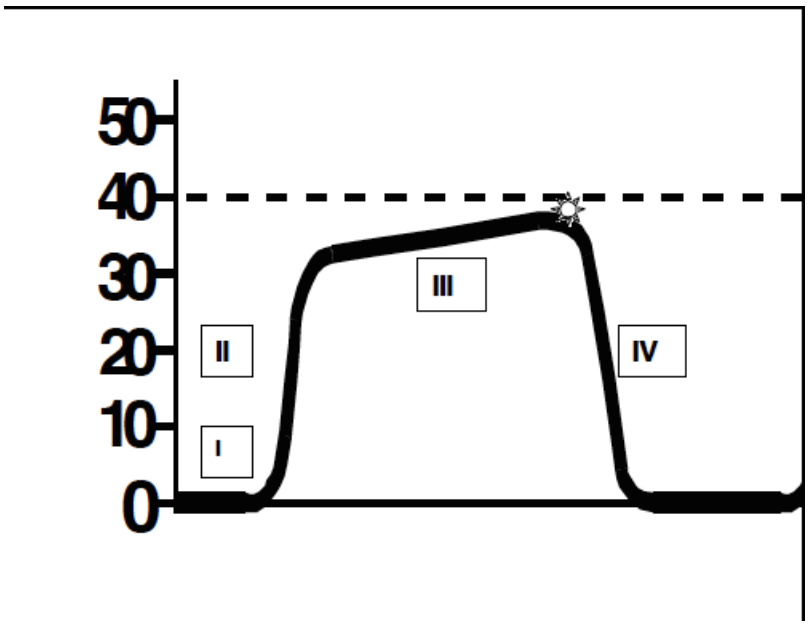
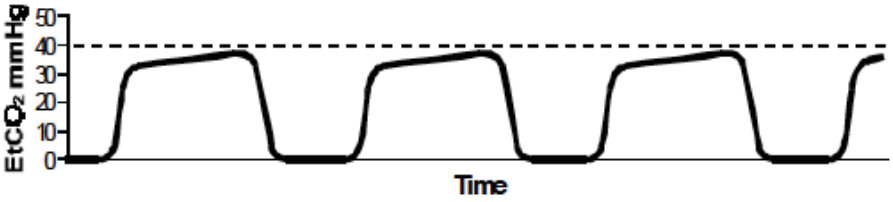
ETCO2: What Every Technician Should Know

Capnography is the method of monitoring the amount of CO2 in the air that is breathed in and out by the patient. Capnography is a non-invasive, continuous method, of monitoring ventilation in anesthetized patients.

Capnograph monitors monitor breathing by measuring exhaled (end tidal CO2 or etCO2) and inhaled carbon dioxide (inspired CO2 or INspCO2). EtCO2 and INspCO2 values change with each breath.

There are two methods of sampling for capnography, either of which is appropriate for veterinary patients. Either a monitor sensor is placed between the endotracheal tube and the anesthetic circuit (mainstream capnography) or the monitor samples airway gas through a small tube attached to the junction of the endotracheal tube and the anesthetic circuit (sidestream capnography). In both systems, the instrument measures the CO2 in the air that passes the monitor on both inspiration and the expiration and displays the information in graph form or as a readout. During inspiration, the amount of CO2 should be close to zero unless there is some rebreathing taking place or the CO2 absorber is not working properly (A and B on the diagram). During expiration, the CO2 content of the air rises (B to C) and should reach approximately 35-40 mmHg at the end of the expiration when the last volume of alveolar gas is exhaled (C to D). This value is called the end tidal carbon dioxide (etCO2) and is important because it closely approximates PaCO2 (the CO2 partial pressure in the arteries-CO2 dissolved in plasma and is measured by evaluating blood gases). The CO2 level then falls as expiration ends and inspiration begins (D to E).





The etCO2 is of great significance to the anesthetist. The normal exhaled etCO2 is 32 to 35 mm Hg in the cat and 35-46 mm Hg in the dog. Hypercapnia (higher than normal CO2) is present if the etCO2 is greater than 40 mm Hg. Hypocapnia (lower than normal CO2) is present if the etCO2 is less than 30 mm Hg.

Low values for etCO2 may occur with rapid respiratory rates, overzealous assisted ventilation, and hypothermia. Low values may also be seen if the endotracheal tube is in the esophagus or bronchus or if the capnometer has been disconnected from the endotracheal tube. Cardiac failure causes a sudden drop in etCO2 because etCO2 is directly correlated to cardiac output. Capnometers are useful for monitoring cardiac resuscitation efforts, because etCO2 values should rapidly rise when effective cardiopulmonary resuscitation is instituted.

Elevated CO2 values may occur at any point in the graph and indicate that the patient is retaining CO2. Elevated values during the inspiratory phase (A to B) may occur if excessive CO2 is being breathed in by the patient (for example if the CO2 absorber is depleted or if there is excessive dead space). Hyperthermia can also cause increased CO2 production. Elevated CO2 during the expiratory plateau is most commonly due to hypoventilation (C to D). If this is the case, etCO2 should rapidly fall when ventilation is assisted by bagging or mechanical ventilator.

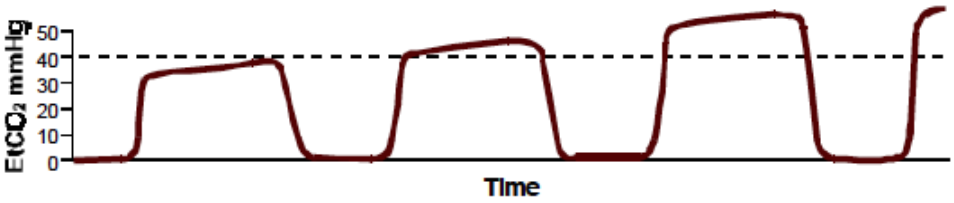
It can be seen that there may be a variety of reasons for hypercapnia or hypocapnia, including metabolic, ventilatory and circulatory abnormalities. Some of these need to be quickly corrected, whereas others may be self limiting. It should be noted that erroneous readings sometimes arise, and it is important for the anesthesia technician to work with the veterinarian to properly identify problems and correct them when necessary.

The shape of the CO2 curve provides useful information about:

- Placement of the endotracheal tube (accidental esophageal or endobronchial placement)
- Leaks around the endotracheal tube cuff
- Functioning of the circle absorber and unidirectional valves
- Appropriateness of the oxygen flow eate for a non-rebreathing anesthesia circuit
- Apnea
- Hypoventilation
- Hyperventilation
- Airway obstruction/bronchospasm
- Cardiac arrest

What Abnormal Capnograph Displays Mean

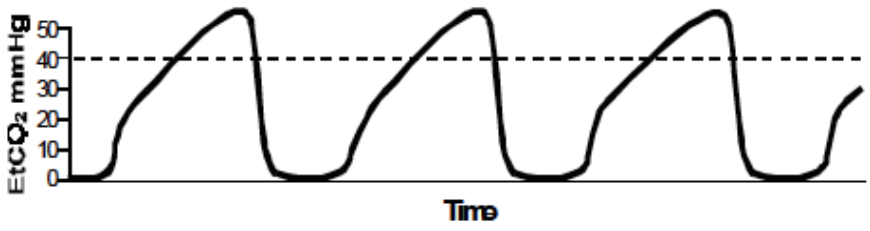
*All images from *Veterinary Anesthesia Update, Guidelines and Protocols for Small animal Anesthesia**



Increasing etCO2 (Hypoventilation)

Possible causes:

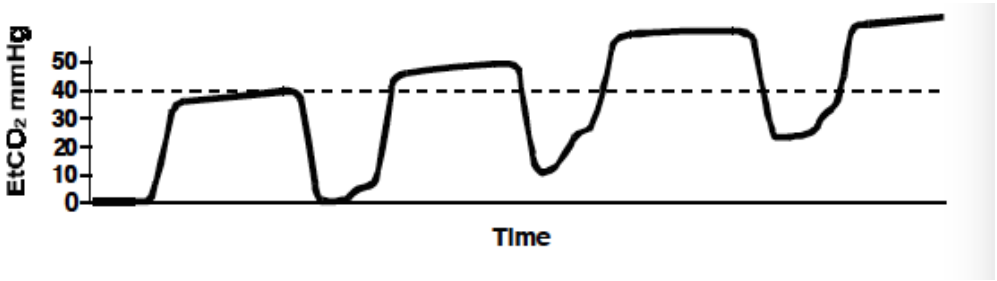
- Decreased respiratory rate or depth from: deep anesthesia, interference with chest expansion
- Early malignant hyperthermia (rare)
- Equipment dead space
- Early stage of expanding pneumothorax



Abnormal Upstroke (shark fins) Think Airway Obstruction

Possible causes:

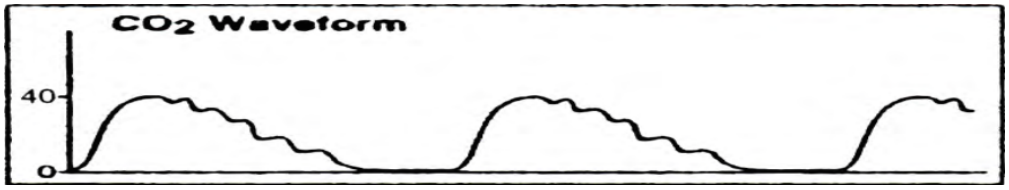
- Kinked ETT
- ETT plug
- Obstruction of respiratory side of anesthesia machine
- Bronchospasm



Baseline Does Not Return to Zero

Possible causes:

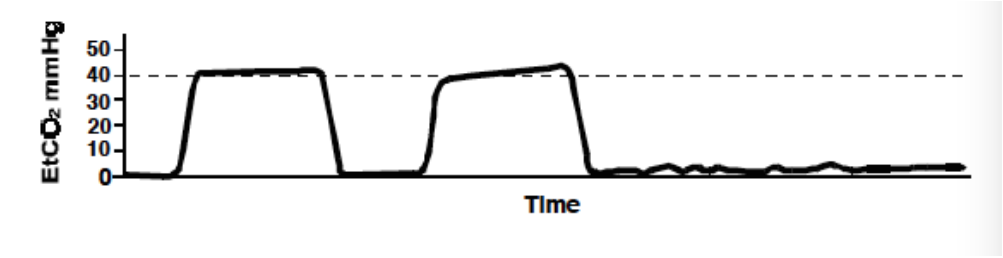
- Incompetent unidirectional dome valves
- Too low oxygen flow with non rebreathing circuit
- Depleted absorber granules
- Absorber canister bypassed
- Leak in Bain circuit inner hose
- Crack in mainstream sensor of capnograph



Abnormal Downstroke

Possible causes:

- Leak around ETT cuff
- Cardiac impulses transmitted to capnograph



No Carbon Dioxide Value Recorded

Possible causes:

- Apnea
- Accidental patient disconnect
- Esophageal intubation
- Airway obstruction
- Cardiac arrest
- Tension pneumothorax (air becomes trapped in the pleural space between the chest wall and the lung, builds up putting pressure on the lung and keeping it from inflating fully)

The Physiology of Ventilation

Rule #1: Air Must Go In and Out

Ventilation is the movement of air, designed to elimitate CO2

- Chemoreceptors in the medulla sense elevated levels of CO2 or lowered pH triggering ventilation; this is known as hyperbaric drive.
- Diaphragm contracts and moves downward
- Intercostal muscles spread chest wall out increasing the volume inside the chest
- Differences in pressure insude the chest and outside causes air to move into the lungs
- Hypoxic drive (low O2 levels) is a secondary drive

Respiration is the exchange of gases
SpO2 (pulse oximetry) measures oxygenation
ETCO2 (capnography) measures ventilation

Rule #2: Blood Must Go Round and Round

In order for adequate cellular perfusion ot occur, the following must be present:

- Adequate numbers of red blood cells
    - Hemoglobin on the red blood cells carry oxygen

- Adequate oxygen
    - Patient must have adequate oxygen coming in - refer to rule #1
    - Red blood cells must be able to offload and take on oxygen
- Adequate blood pressure to push cells

References:

McKelvy, D. and Hollingsworth, W. 2003. *Veterinary Anesthesia and Analgesia*, Third ed., Missouri: Mosby.
Brock, Nancy, DVM, Dip. A.C.V.A. Second Edition. *Veterinary Anesthesia Update, Guidelines and Protocols for Small animal Anesthesia*. Veterinary Anesthesia Northwest.