ANIMAL ANESTHESIA MONITORING GUIDELINES

ECG MONITORING

REASONS FOR MONITORING ECG

- Diagnosing arrhythmias or conduction abnormalities
- As part of preoperative work-up in senior patients
- Routine or indicated screens
- During surgery and to evaluate effects of cardiac drugs
- Assess patients with breathing problems or that are in shock
- Assess patients with cardiac murmurs
- To help decide on further diagnostic tests (thoracic radiography or echocardiography)
- Periodic assessments of arrhythmia prone breeds
  - Boxers (myocarditis),
  - Doberman pinschers (ventricular arrhythmias or cardiomyopathy),
  - German shepherds (congenital ventricular arrhythmias), and
  - Miniature schnauzers (sick sinus syndrome and sinus arrest/block)

ECG TECHNIQUE

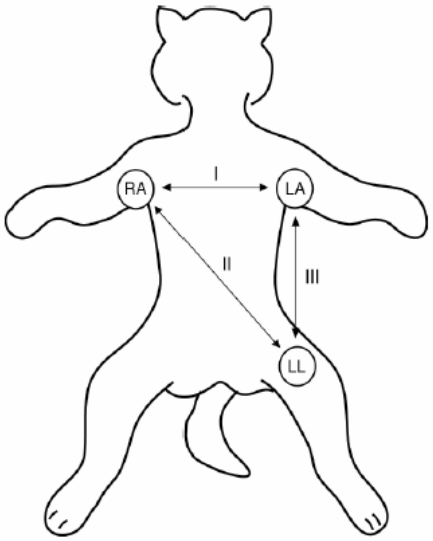
For veterinary patients, especially small ones, following the tips below will allow for the optimal measurement of ECG.

- Place animal in right lateral recumbence
- Hair should not be clipped over lead site.
- If matted, only lightly clip, but not down to skin
- Prepare the lead sites w/ alcohol first, then apply ultrasound gel or KY jelly if desired. *Caution: ECG paste may corrode metal skin clips*
- For cats, place a thin layer of alcohol-saturated cotton over site, apply gel and attach skin clips
- Do not allow the metal clips to come in contact with metal (each other, metal exam table, etc)
- Increase GAIN setting on monitor for small complexes
- Insure that skin clips have adequate spring tension
- If electrical interference is encountered move electrical equipment away from the monitor and check ECG filter setting on monitor (High or Low)
  Note: Operating monitor with battery will reduce interference

SETTING UP ECG LEADS

- Prepare site with alcohol
- Use figures below for lead selection
- Connect lead wires to patient cable
- Connect patient cable to monitor
- Turn monitor on
- Metal clips must not contact metal table or each other

Figure 2: **3-Lead Placement**



USA Standard	International Standard
LA = black (Left Foreleg)	L = yellow (Left Foreleg)
RA = white (Right Foreleg)	R = red (Right Foreleg)
LL = red (Left Hind Leg)	F = green (Left Hind Leg)

Note: LA above is reference electrode. Reference electrode can also be placed on right hind leg. This electrode is Green in USA standard

TEMPERATURE MONITORING

Better temperature management was cited as one of the three major factors in improving general anesthesia mortality rates. During anesthesia, hypothermia is a frequent, serious risk, although hyperthermia is also a risk in some Nordic breeds

ADVERSE EFFECTS OF HYPOTHERMIA

- Immune system depression; triple the post-operative infection rate
- Coagulopathy and increased blood viscosity leading to sludging
- Increased systemic vascular resistance and afterload
- Hypocapnia that may lead to alkalemia if positive pressure ventilation is not adjusted
- Physiologic response to hypoxemia and hypercarbia is blunted
- Effect on central nervous system delays recovery and causes confusion, stupor or coma
- Hypovolemia and/or hyperglycemia
- Minimum alveolar concentration decreases 5%/Cº below normal: anesthetic overdose may occur
- Delayed drug metabolism, decreased liver metabolism leading to drug toxicity
- Post operative shivering increases intraocular pressure, intracranial pressure and wound pain

ANIMAL BLOOD PRESSURE MONITORING

DURING SURGERY

- Assess anesthetic depth*
- Monitor trends to provide:
  - an index of a patient's cardiovascular status
  - the depth of anesthesia
  - response to therapeutic intervention
  - an indication for adjusting fluid therapy, and
  - titrating drug doses.
- Monitor adequacy of circulation
- Discover hypotension* (SAP<80mmHg; MAP<60mmHg)
- Use MAP for the best determinant of good organ perfusion
- Monitor the effect of pre-anesthetic agents that can cause hypotension*
- Compare SAP to normal intraoperative pressure between 110-160mmHg.
- Detect inadequate anesthesia and resulting pain by increase in heart rate

** Studies have shown that >25% of surgery patients are hypotensive and that hypotension is a major risk factor in 1 year post-surgery mortality*

IN THE EXAM ROOM

HYPERTENSION

- Suspected if systolic pressure >150 mmHg
- Confirmed if systolic >160 mmHg; or
- Diastolic >100 mmHg
- 60-70% of animals w/renal disease are hypertensive
- Hypertension often accompanies hyperthyroidism
- Blood pressures rise slowly but steadily with age
- Overweight animals have higher blood pressures
- Baseline BP should be established (annual/semi-annual)

AIRWAY $C0_2$ CAPNOGRAPHY

Capnography: "The Anesthesia Disaster Early Warning System"

Because all three components of respiration (metabolism, transport, and ventilation) are involved in the appearance of CO_2 in exhaled gas, capnography gives an excellent picture of the respiratory process. Nicknamed the "Anesthesia Disaster Early Warning System," it is greatly responsible for the reduction in death rates during general anesthesia in human medicine from 1 in 5,000 in 1983 to 1 in 300,000 in 2005.

Factors that affect CO_2

- Metabolism - Substrate metabolism, drug therapy, and core temperature
- Transport - Cardiac output and pulmonary perfusion.
- Ventilation - Obstructive and restrictive diseases, and breath rate
- Ventilation/Perfusion ratios - Shunt perfusion and dead space ventilation

Animal $C0_2$ monitors provide digital read out of end-tidal CO_2 only or with a waveform (capnograph). The digital read out of $ETCO_2$ can be in mm Hg (partial pressure of CO_2 in exhaled gas) or as % in exhaled gas. Most of the commonly used devices use 'infra red absorption of CO_2 as principle of operation.

Capnometry measures the amount of end-tidal (exhaled) carbon dioxide during ventilation. The end-tidal level of carbon dioxide is generally less but is reflective of carbon dioxide in arterial blood and can serve as an indirect noninvasive method of assessing the adequacy ventilation. A more complete picture of carbon dioxide transfer can be obtained from a capnogram, similar to an ECG tracing. A capnogram provides a continuous waveform that reflects the changes in airway carbon dioxide levels throughout inspiration and expiration. In contrast, capnometry simply reports the maximum and minimum carbon dioxide levels associated with expiration and inspiration respectively; similar to the heart rate output from an ECG.

Capnography is a useful monitoring tool in mammals with normal lungs. In reptiles, however, capnography has not been evaluated and the presence of right-to-left intracardiac shunts and dead space ventilation associated with the unique structure of many reptilian lungs makes this technology prone to inaccuracies. The end-tidal carbon dioxide will not necessarily reflect arterial carbon dioxide levels and the gradient between arterial and end-tidal carbon dioxide cannot be predicted.

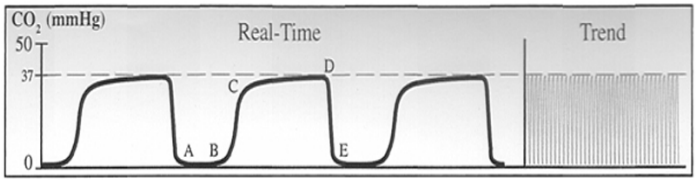
Capnometers and capnographs measure carbon dioxide tension ($ETCO_2$) in exhaled gases. Endotracheal intubation is not required for sample collection when a side-stream analyzer is used. Samples may be collected from tubing placed in the nasal passage. The value represents the concentration in the alveoli which approximates arterial carbon dioxide tension ($PaCO_2$). $ETCO_2$ tends to underestimate $PaCO_2$ by 2 - 5 mm Hg. This difference is usually not clinically significant though may increase in patients with respiratory and/or circulatory compromise. Ventilation is defined by $PaCO_2$, with a normal range of 35 - 45 mm Hg; thus, $ETCO_2$ provides continuous, noninvasive quantitation of adequacy of ventilation. Values above 40 - 45 mm Hg for $ETCO_2$ indicate inadequate ventilation.

The information provided will direct the need for ventilatory assistance and will provide the fine-tuning necessary if mechanical ventilation is in place. Capnometers provide an $ETCO_2$ value and respiratory rate, while capnographs also provide a waveform of every breath. Display of a normal capnogram requires cellular metabolism, blood circulation and alveolar ventilation; abnormalities detected in the capnograph may provide an early indication of developing cardiopulmonary problems.

The measurement of $C0_2$ in the expired air directly indicates changes in the elimination of $C0_2$ from the lungs. Indirectly, it indicates changes in the production of $C0_2$ at the tissue level and in the delivery of $C0_2$ to the lungs by the circulatory system. Therefore, capnography constitutes an important non-invasive technique that can monitor $C0_2$ production, pulmonary perfusion and alveolar ventilation as well as respiratory patterns.

CAPNOGRAPH INTERPRETATION

NORMAL CAPNOGRAPH

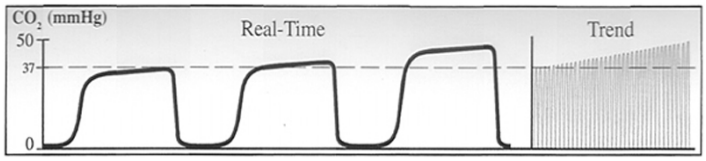


The "normal" capnograph is a waveform which represents the varying CO_2 level throughout the breath cycle.

Waveform Characteristics:

- A-B Baseline
- B-C Expiratory Upstroke
- C-D Expiratory Plateau
- D End Tidal Concentration
- D-E Inspiration Begins

INCREASING $EtCO_2$ LEVEL

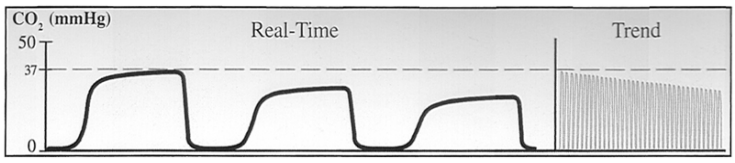


An increase in the level of $EtCO_2$ from previous levels.

Possible Causes:

- Decrease in respiratory rate hypoventilation)
- Decrease in tidal volume (hypoventilation)
- Increase in metabolic rate
- Rapid rise in body temperature (malignant hyperthermia)

DECREASING $EtCO_2$ LEVEL

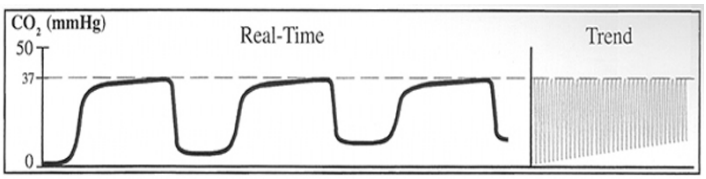


A decrease in the level of $EtCO_2$ from previous levels.

Possible Causes:

- Increase in respiratory rate (hyperventilation)
- Increase in tidal volume hyperventilation)
- Decrease in metabolic rate
- Fall in body temperature

REBREATHING

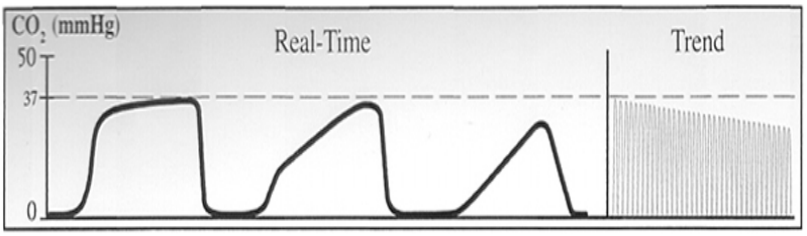


Elevation of the baseline indicates rebreathing (may also show a corresponding increase in $EtCO_2$).

Possible Causes:

- Faulty expiratory valve
- Inadequate inspiratory flow
- Malfunction of a CO_2 absorber system
- Partial rebreathing circuits
- Insufficient expiratory time

AIRWAY OBSTRUCTION

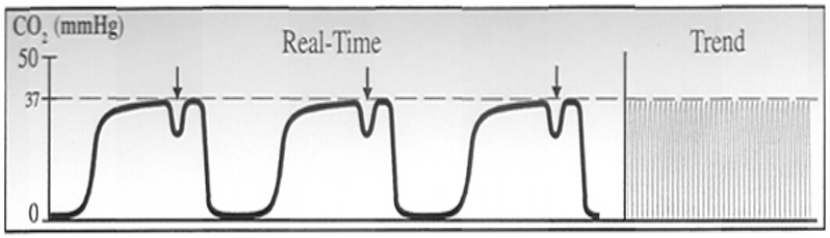


Obstructed expiratory gas flow is noted as a change in the slope of the ascending limb of the capnograph (the expiratory plateau may be absent).

Possible Causes:

- Obstruction in the expiratory limb of the breathing circuit
- Presence of a foreign body in the upper airway
- Partially kinked or occluded artificial airway
- Bronchospasm

MUSCLE RELAXANTS

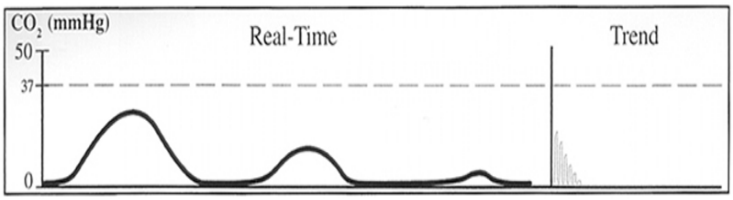


Clefts are seen in the plateau portion of the capnograph. They appear when the action of the muscle relaxant begins to subside and spontaneous ventilation returns.

Characteristics:

- Depth of the cleft is inversely proportional to the degree of drug activity
- Position is fairly constant on the same patient but not necessarily present with every breath

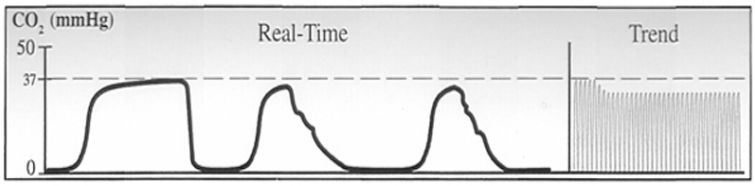
ET TUBE IN ESOPHAGUS



Waveform Evaluation:

A normal capnogram is the best available evidence that the ET tube is correctly positioned and that proper ventilation is occurring. When the ET tube is placed in the esophagus, either no CO_2 is sensed or only small transient waveforms are present.

INADEQUATE ET TUBE SEAL

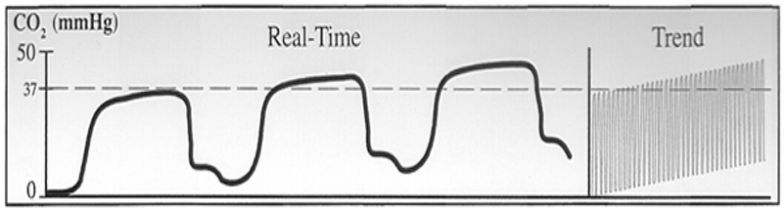


The downward slope of the plateau blends in with the descending limb.

Possible causes:

- A leaky or deflated endo-tracheal or tracheostomy cuff
- An artificial airway that is too small for the patient

FAULTY VENTILATOR CIRCUIT VALVE



Waveform evaluation:

- Baseline elevated
- Abnormal descending limb of capnogram
- Allows patient to rebreathe exhaled gas

PULSE OXIMITRY

REASONS FOR USING PULSE OXIMETRY

- Cardiac arrest warning system - pulse to pulse sensitivity seen before ECG
- Determine whether patient is receiving enough oxygen
- Monitor patient's ability to maintain oxygenation during recovery
- Extremely sensitive in detecting pneumothorax
- Warns of need to evacuate air or blood during postoperative thoracotomy
- Asses response to treatment in shocky, hypothermic or hypotensive patients

OPTIMIZE SENSOR ACCURACY

- Clean with alcohol
- Store fully-extended (don't wrap)
- Reposition periodically
- Use on cuff and catheter-free extremity
- Place close to heart level
- Cover site with opaque material to minimize ambient light
- Keep patient and extremity warm to minimize shivering
- If slippage occurs on tongue, use one layer of gauze over tongue to place the sensor

Note: Normal $Sp0_2$ values are 95-100% depending on area and placement of sensor. Check placement and probe security before reacting to abnormal readings.

NELLCOR'S VETSAT VETERINARY SENSOR The sensor comes with two sizes of clips so it can be applied to various sites on the animal.

Lip

Tongue

Vulva

CANINE

Other Sites:

- *Paw*
- *Ear*
- *Prepuce*

Lip

Paw

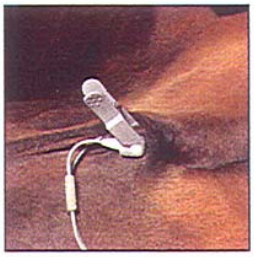
Ear

FELINE

Other Sites:

- *Tongue*
- *Lower leg*
- *Tail*

Ear



Prepuce

Tongue

EQUINE

Other Sites:

- *Lip*
- *Vulva*
- *Nostril*

MEAN CHARGES

PROCEDURE	ANNUAL REVENUE
Surgical Monitoring 5 patients/week x $27.50*/surgery	**$7,150**
Blood Pressure Screening 2 screenings/week x $27.50/screen	**$2,860**
Routine and Indicated ECG Screening 2 screenings /week x $27.50/screen	**$2,860**
TOTAL ANNUAL PRACTICE INCOME	**$12,870**

* $27.50 is average fee charged per AAHA Veterinary Fee Reference (4th Edition)