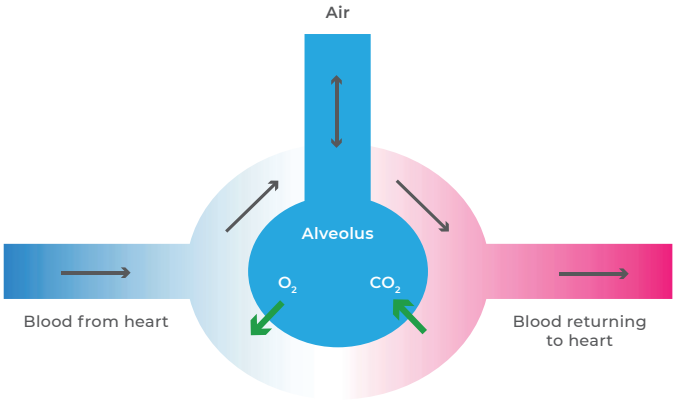
Understanding Capnography

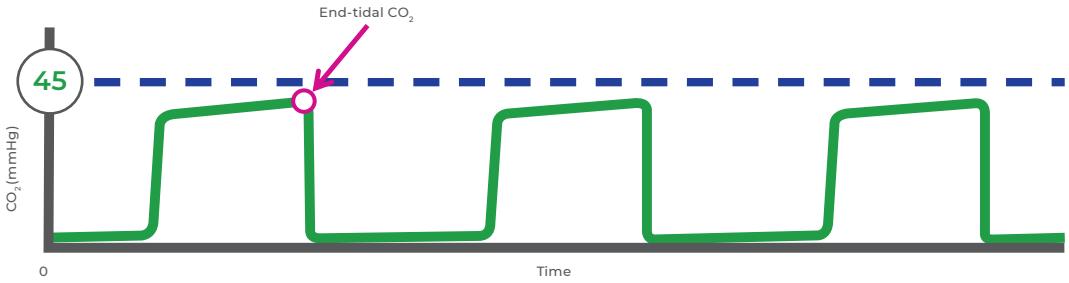
Anaesthesia Information Sheet

What is capnography?

A 'real time', non-invasive measurement and numerical display of the carbon dioxide concentration in the respiratory gases during breathing. It also measures the patient's respiratory rate. The end-tidal carbon dioxide ($ETCO_2$) is usually displayed as a number with the units of mmHg. This is taken to represent the alveolar partial pressure of CO_2.



NORMAL CANINE CAPNOGRAM



NORMAL CAPNOGRAM

- Each wave is square/rectangular
- Trace reaches baseline (0 mmHg) on inspiration
- CO_2 rises steeply from 0 mmHg on exhalation, reaches an alveolar plateau, and then drops steeply on inspiration
- There might be a slight upward gradient on the alveolar plateau

Hypocapnia: < 35 mmHg
Normocapnia: 35 - 45 mmHg
Hypercapnia: > 45 mmHg

Top tip: Capnography identifies patient problems

End-tidal CO_2 is determined by three physiological elements:

- Metabolism
- Circulation
- Alveolar ventilation

} If two of three patient factors are constant, capnography provides information on the third.

Top tip: Capnography can identify equipment errors

- Correctly positioned and patent endotracheal tube
- Leaks in the anaesthetic breathing system
- Adequacy of fresh gas flow with non-rebreathing systems – *use to waste less O_2 and volatiles*
- Exhaustion of soda lime (CO_2 absorbent) or malfunction of one way valves in rebreathing systems
- Excessive equipment dead space

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Practical capnography use

First determine if there is increased or decreased $ETCO_2$ and consider the most common reasons in relation to alveolar ventilation, circulation and metabolism:

Increased $ETCO_2$ (hypercapnia):

1. HYPOVENTILATION
- Excessive anaesthetic depth
- Patient factors e.g. obesity, pregnancy, positioning, resistance to breathing
- Underlying patient disease
- Increased breathing system dead space

2. INCREASED PRODUCTION OF CO_2
- Hypermetabolic state
  - Fever, hyperthermia, pain
  - Shivering, seizures

3. INCREASE IN INSPIRED CO_2 CONCENTRATION (rebreathing – see common traces)
- Insufficient O_2 flow in non-rebreathing systems – increase FGF to eliminate rebreathing
- Exhausted soda lime
- Malfunctioning one way valves
- External source of CO_2 e.g. capnoperitoneum

Decreased $ETCO_2$ (hypocapnia):

1. HYPERVENTILATION
- Anaesthetic depth too light
- Nociception
- Severe hypoxaemia

2. REDUCED PRODUCTION OF CO_2
- Hypothermia
- Hypometabolic state e.g. hypothyroid

3. SAMPLING ERROR
- Water blocking the sample line
- Air entrainment or leaks e.g. deflated ET tube, cracked sample line
- Inadequate tidal volume +/- high fresh gas flows (due to dilution of the sample from smaller patients)

4. INCREASED ALVEOLAR DEAD SPACE
- Hypotension due to low cardiac output
- Pulmonary embolism e.g. air, thrombus, fat
- High inspiratory pressure during menual ventilation

SUDDEN OR COMPLETE DECREASE OF $ETCO_2$ (also 'flat-lines')
- Equipment calibration, blockage, disconnection or displacement
- Oesophageal intubation (present from intubation of trachea)
- Ventilation failure – apnoea or respiratory arrest
- Circulation failure – cardiac arrest (see CPR algorithms), venous obstruction

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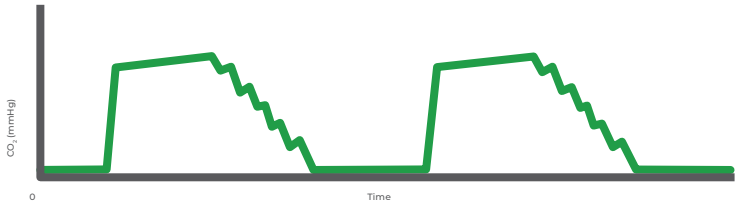
Examples of Common Traces (critical conditions highlighted in red)

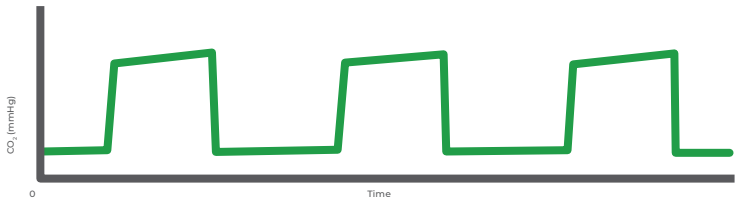
Cardiogenic oscillations (variation of normal):

- Undulations in the down-stroke match heart rate
- Generally seen in bradycardic and barrel chested patients with a lower respiratory rate



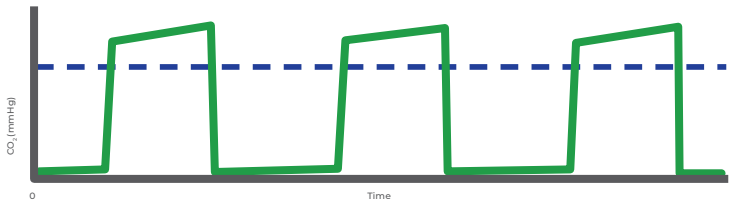
Rebreathing:

- Appears normal except not reaching baseline
- Represents rebreathing of carbon dioxide:
  - Flow rate in non-rebreathing system too low
  - Soda lime depleted in a rebreathing system
  - Fault in one-way valve in a rebreathing system or assembly of breathing system
  - Excessive dead space for patient to overcome



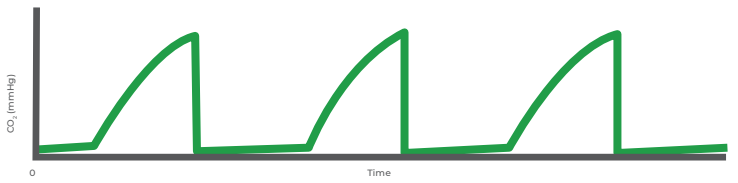
Hypercapnia:

- Appears normal except elevated $ETCO_2$
- Likely causes include:
  - Hypoventilation
  - Increased CO_2 production
  - Increased cardiac output



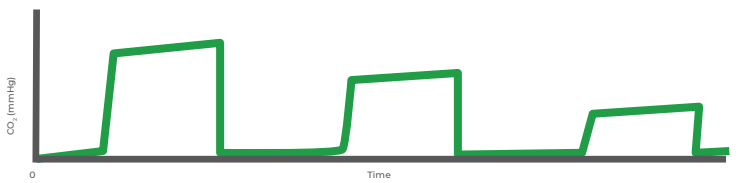
Airway obstruction:

- 'Shark fin' appearance due to increased expiratory airway resistance
- Likely causes include:
  - Bronchospasm e.g. asthma and anaphylaxis
  - Obstruction e.g. mucus plug, kinking of the ET tube, ET tube against tracheal wall



Decreasing $ETCO_2$:

- Gradual decrease:
  - Hyperventilation
  - Leaking cuff/faulty equipment
- Rapid decrease or sudden drop:
  - Disconnection of breathing system
  - Pulmonary embolism
  - Decreased cardiac output – possible early sign of cardiac arrest



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Further useful information available at www.capnography.com