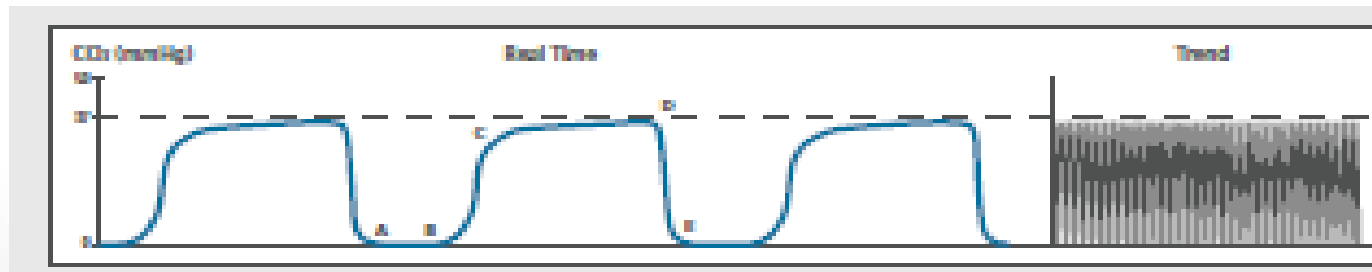


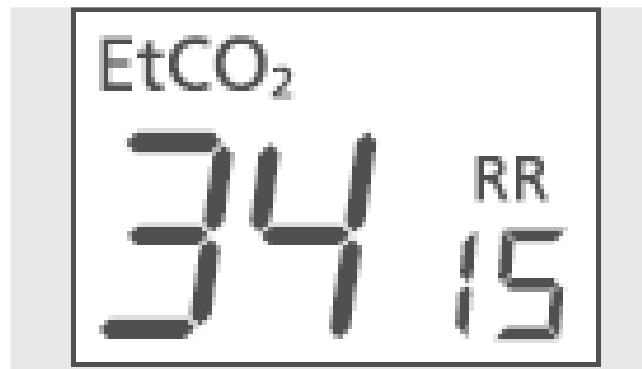
Capnography

By: DR.OLVYNA D'SOUZA

- Capnography is the graphic display of CO₂ concentration versus time (Time Capnogram) or expired volume (Volume Capnogram) during a respiratory cycle.
- Capnograph is the machine that generates a waveform and the capnogram is the actual waveform.



- Capnometry is the measurement and numerical display of maximum inspiratory and expiratory CO₂ concentrations during a respiratory cycle.
- Capnometer is the device that performs the measurement and displays the reading.



Physiology

- The infrared method is most widely used and most cost-effective.
- This technique involves beaming of infrared light through a column of a gas mixture, the carbon dioxide within the column subsequently absorbs part of the infrared energy yielding a beam of less intensity at the opposite end of the column.

- The resultant beam has a specific wavelength (ie that of carbondioxide) and proportional to the amount of CO₂ in the mixture.

Types of Capnographs

- Side stream –
 - the CO2 sensor is located in the main unit itself (away from the airway) and a tiny pump aspirates gas samples from the patient's airway through a 6 foot long capillary tube into the main unit. The sampling tube is connected to a T-piece inserted at the endotracheal tube or anaesthesia mask connector.

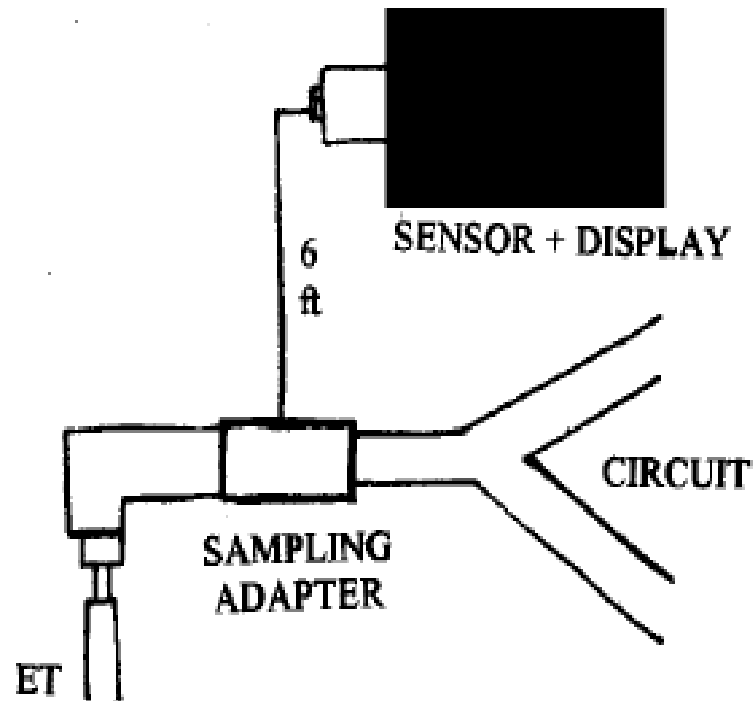
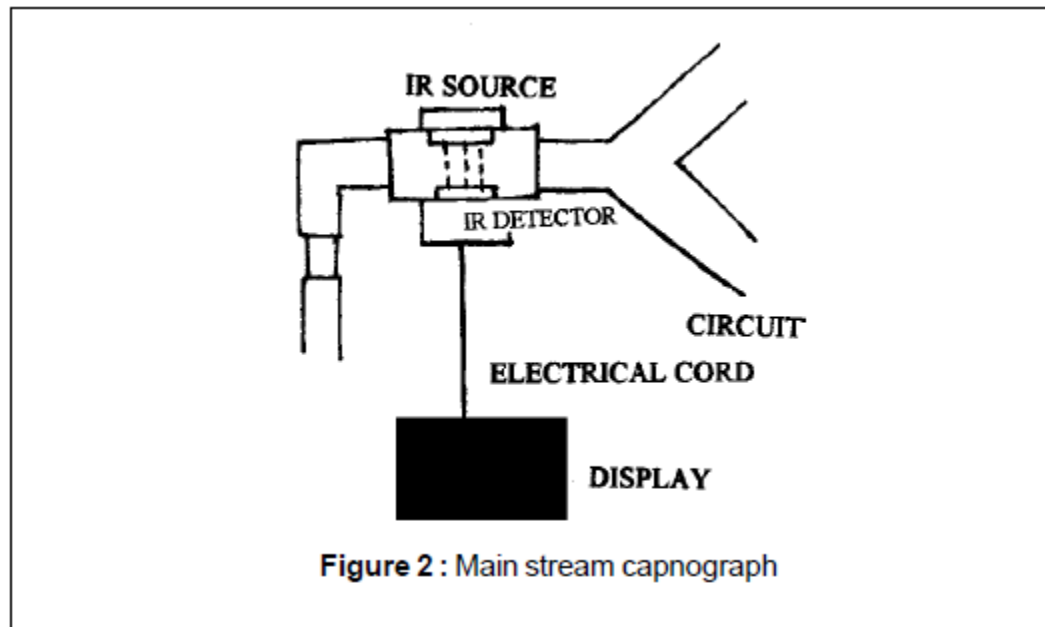


Figure 1 : Side stream capnograph

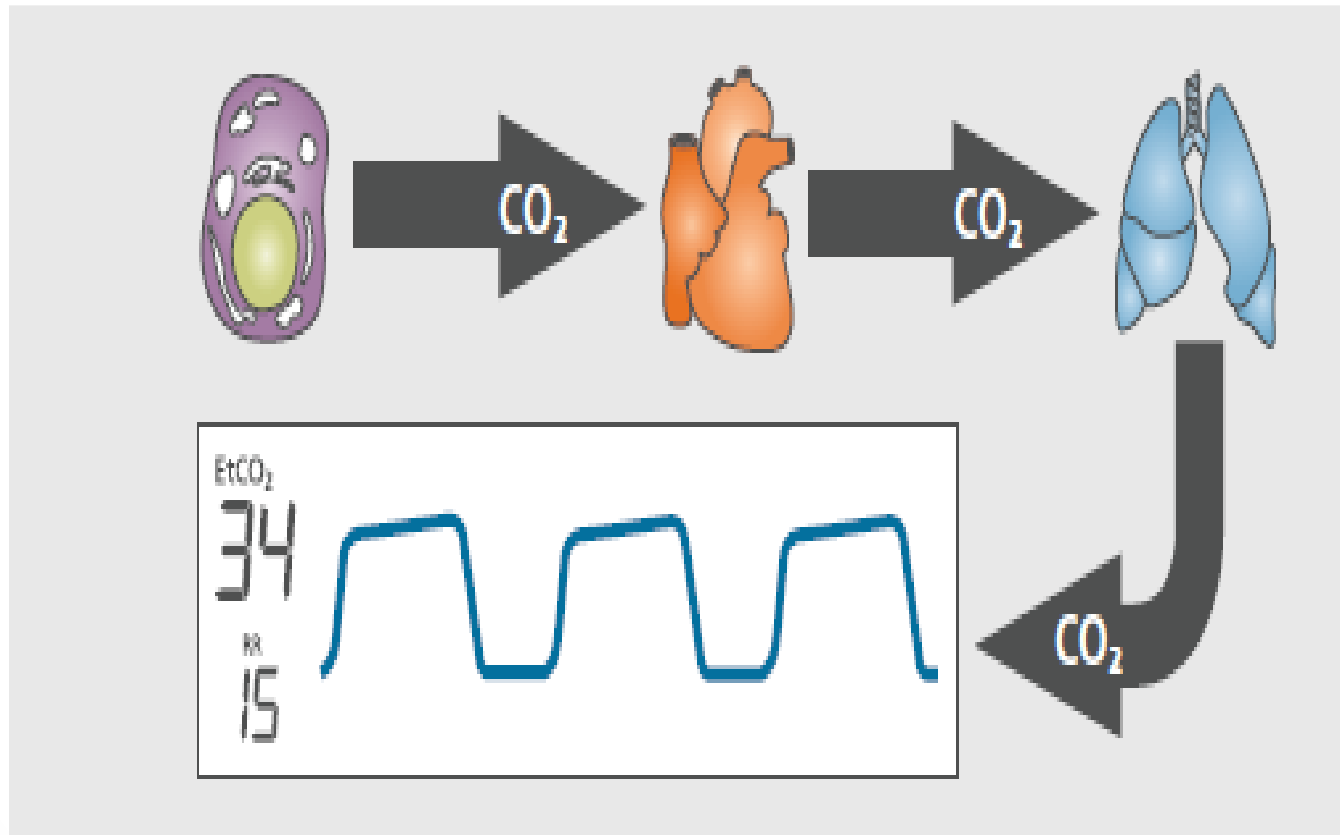
The side stream capnographs have a unique advantage:

- they allow monitoring of spontaneously breathing non intubated subjects.
- no problems with sterilisation, ease of connection.
- ease of use when patient is in unusual positions like the prone position.

- **Main stream capnograph**
 - a cuvette containing the CO₂ sensor is inserted between the breathing circuit and the endotracheal tube.



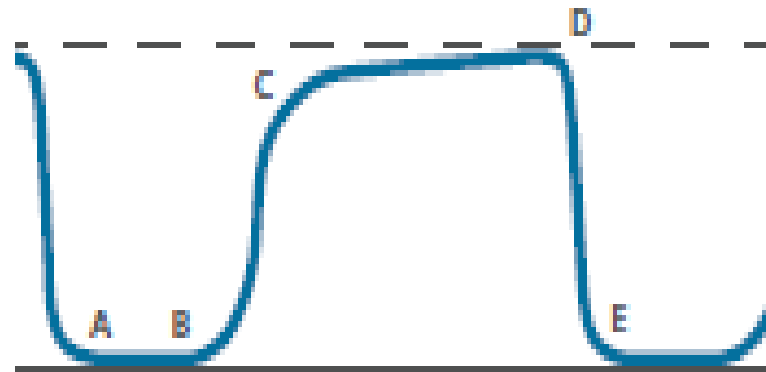
Capnography depicts respiration:



- The passage of CO₂ from the alveoli to the upper airway during exhalation and inhalation of CO₂ free gases during inspiration gives the characteristic shape to the CO₂ curve, which is identical in all humans with healthy lungs.
- Any deviation from this shape should be investigated to determine a physiological or a pathological cause producing the abnormality.

Normal capnogram

Real Time



Waveform characteristics:

A-B Baseline

D End-tidal concentration

B-C Expiratory upstroke

D-E Inspiration

C-D Expiratory plateau

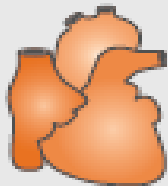
Factors affecting capnographic readings

The factors that may affect capnographic readings can be classified as follows:

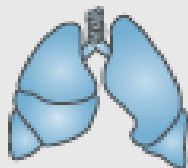
Physiologic



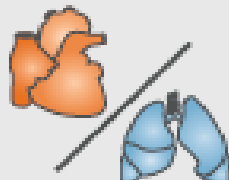
Factors which can affect CO_2 production include substrate metabolism, drug therapy and core temperature.



Factors affecting CO_2 transport include cardiac output and pulmonary perfusion.



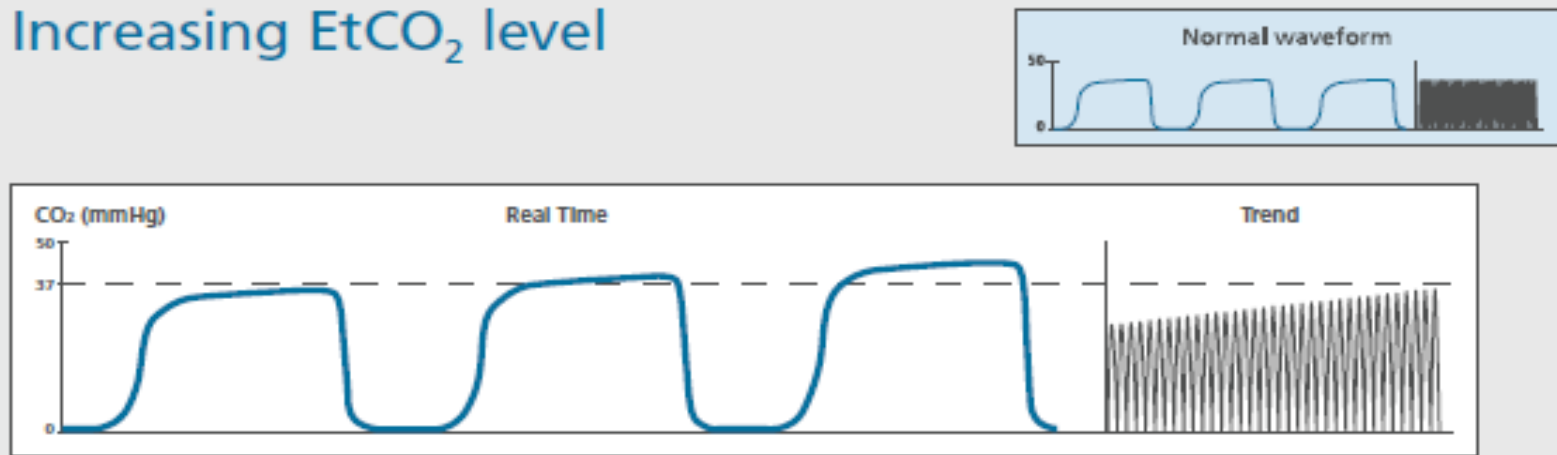
Factors which can affect ventilation include obstructive and restrictive diseases, and respiratory rate.



Ventilation-perfusion ratios (described on page 9) can also affect capnographic readings.

Abnormal capnograms

Increasing EtCO₂ level

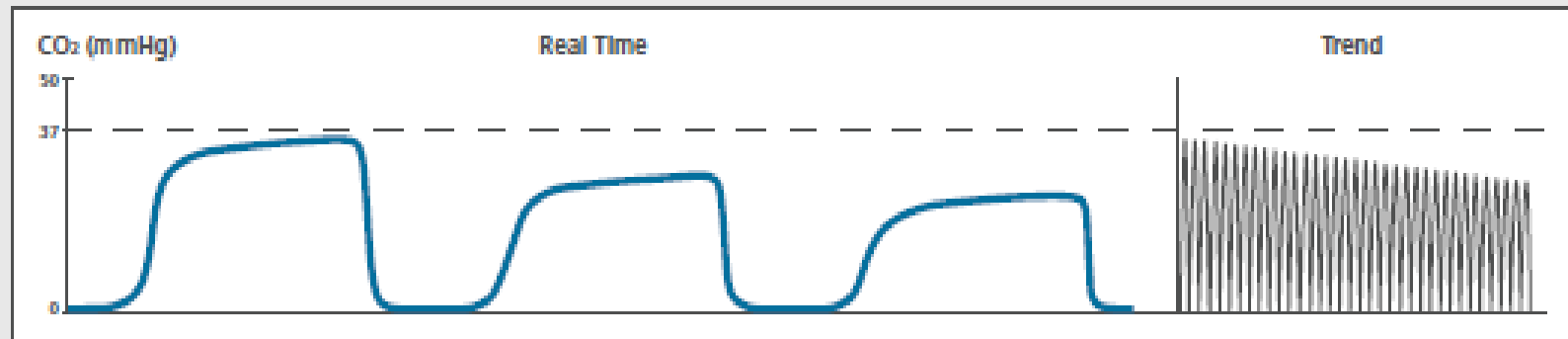


An increase in the level of EtCO₂ from previous levels.

Possible causes:

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

Decreasing EtCO₂ level

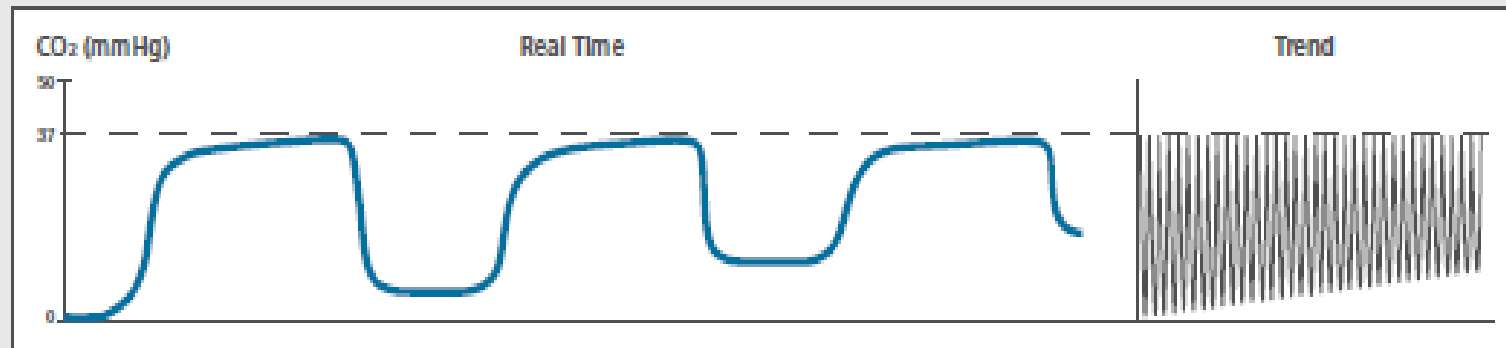
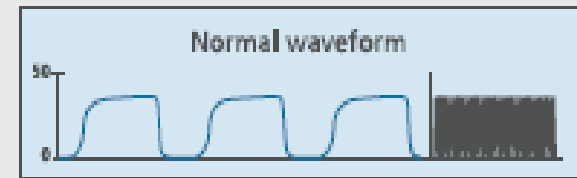


A decrease in the level of EtCO₂ from previous levels.

Possible causes:

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

Rebreathing

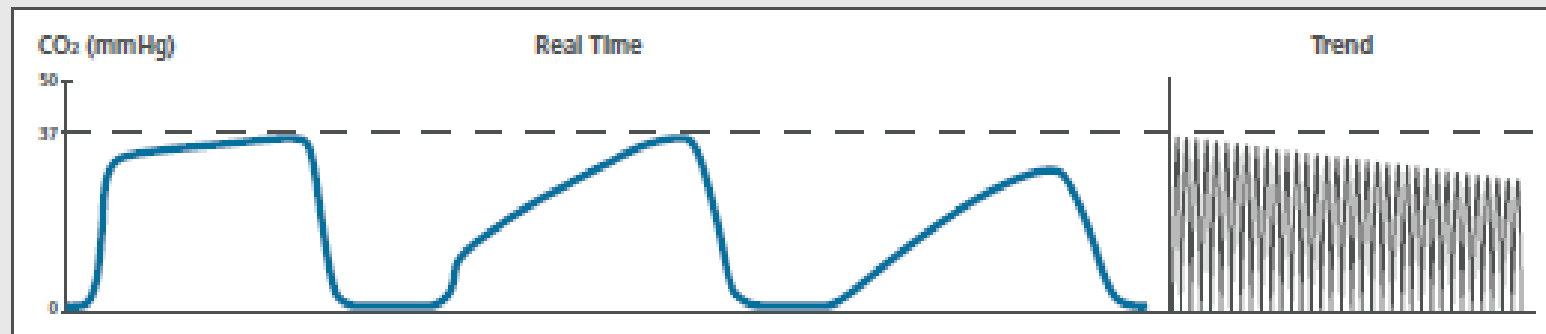
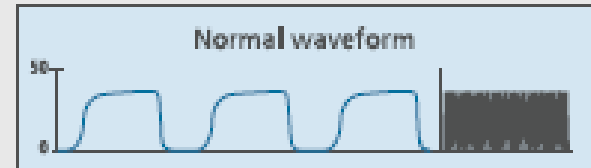


Elevation of the baseline indicates rebreathing (may also show a corresponding increase in EtCO₂).

Possible causes:

- Faulty expiratory valve
- Inadequate inspiratory flow
- Malfunction of a CO₂ absorber system
- Partial rebreathing circuits
- Insufficient expiratory time

Obstruction in breathing circuit or airway

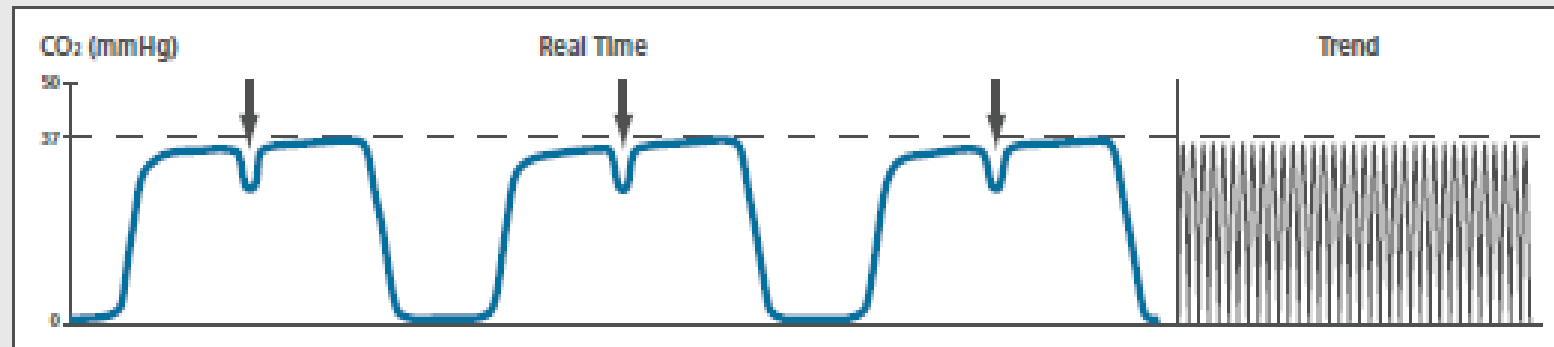
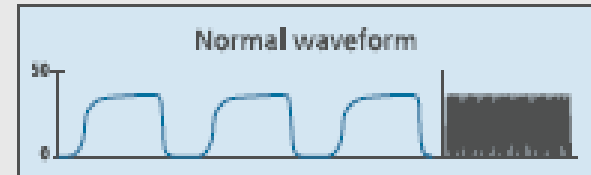


Obstructed expiratory gas flow is noted as a change in the slope of the ascending limb of the capnogram (the expiratory plateau may be absent).

Possible causes:

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

Muscle relaxants (curare cleft)

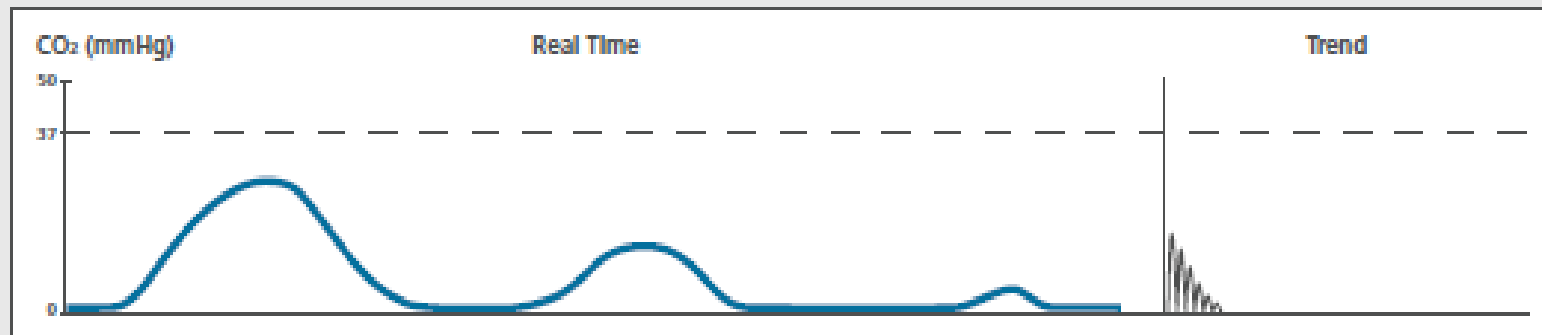
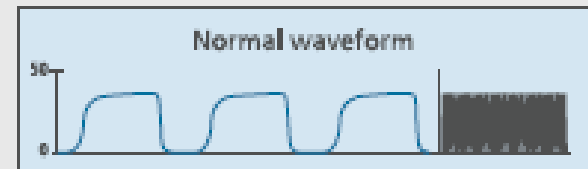


Clefts are seen in the plateau portion of the capnogram. They appear when the action of the muscle relaxant begins to subside and spontaneous ventilation returns.

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

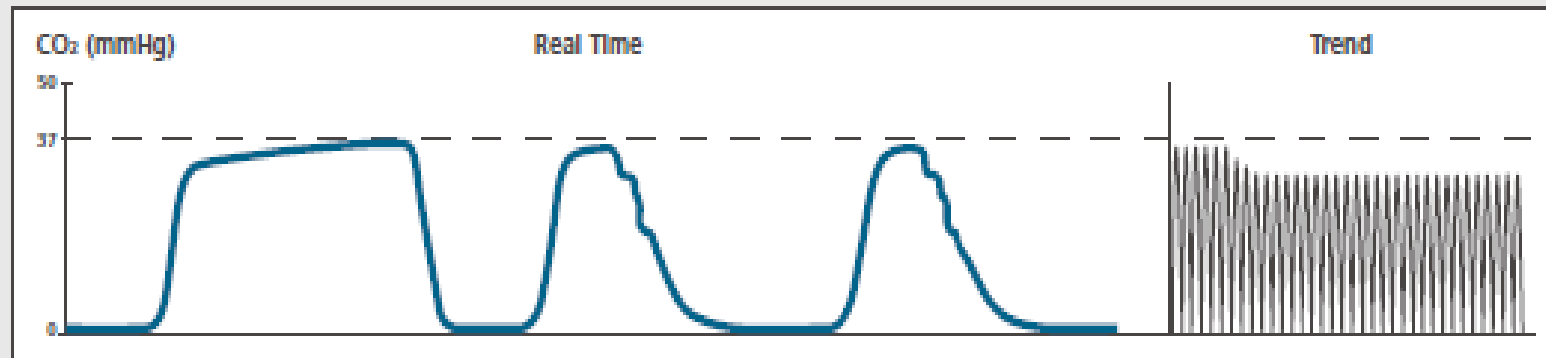
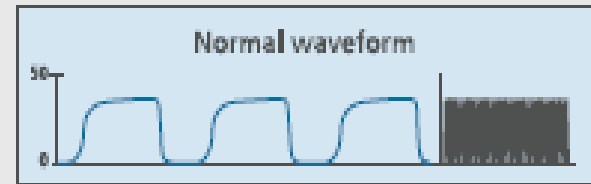
Endotracheal tube in the esophagus



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 CO₂ is sensed or only small transient waveforms are present.

Inadequately sealed endotracheal tube

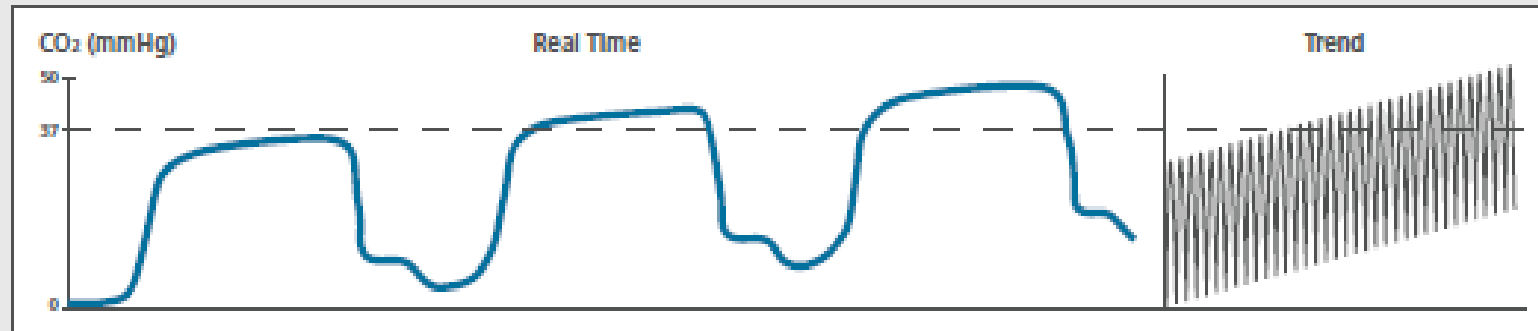


The downward slope of the plateau blends in with the descending limb.

Possible causes:

- An endotracheal or tracheostomy tube without a cuff or one that is leaking or deflated
- An artificial airway that is too small for the patient

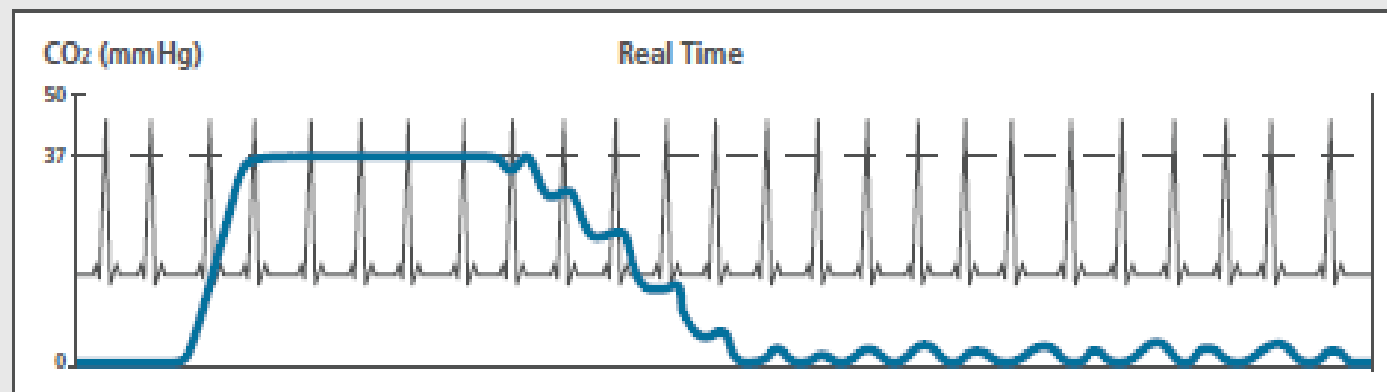
Faulty ventilator exhalation valve



Waveform evaluation:

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

Cardiogenic oscillations



Cardiogenic oscillations appear during the final phase of the alveolar plateau and during the descending limb. They are caused by the heart beating against the lungs.

Characteristics:

- Rhythmic and synchronized to heart rate
- May be observed in pediatric patients who are mechanically ventilated at low respiratory rates with prolonged expiratory times

Clinical applications of capnography

- Changes in respired CO₂ may reflect alterations in metabolism, circulation, respiration, the airway, or breathing system.
- Normal end expiratory CO₂ partial pressure ranges between 35 and 45 mmHg

- **Metabolism**

- An increase in end-tidal CO₂ is a reliable indicator of increased metabolism only in mechanically ventilated patients.
 - In spontaneously breathing patients, PET CO₂ may not increase as a result of hyperventilation.
- Causes: increased temperature, shivering, convulsions, malignant hyperthermia.

- **Circulation**

- A decrease in end tidal CO₂ is seen with a decrease in cardiac output if ventilation remains constant.
- Causes: surgical manipulations of the heart or thoracic vessels, wedging of a pulmonary artery catheter, and pulmonary embolism.
 - A rapid decrease of PET CO₂ in the absence of changes in blood pressure, central venous pressure and heart rate indicates an air embolism without systemic hemodynamic consequences.
- During resuscitation, exhaled CO₂ is a better guide to the presence of circulation than the ECG, pulse, or blood pressure.

- **Respiration**

- The main use of the capnographic signal in anaesthesia is the immediate verification of tracheal intubation beyond doubt by the immediate and continuous presence of metabolic CO₂ in the expired gas.

Thank you