**ETCO2 – why would that be a minimum**

**mandatory monitoring standard**

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a. What is ISA’s view regarding ETCO2 as a minimum mandatory standard

b. Physics behind ETCO2

c. Various types

d. How is it helpful in crisis?

**Introduction:**

Measurement of exhaled CO2 is called capnometry. This has become a part and parcel of general anaesthesia with endotracheal tube for major surgeries. ETCO2 monitoring has proved to be very useful not only in endotracheal anaesthesia but also in other fields. In Greek, kapnos means smoke and graphein means to write. Capnometer is a device that measures CO2 concentration and displays on an analogue or digital scale whereas capnography is the graphic record of instantaneous CO2 concentrations in the respired gases esp. during exhalation. This correlates well with the arterial CO2in most patients (ETCO2 is 2 – 6mmHg less than PaCO2).

**CO**2 **production and elimination:**

Oxygen Lungs body tissues cellular metabolism

CO2Transported to lungs CO2 production

Breathed out in exhalation into the atmosphere (ETCO2)

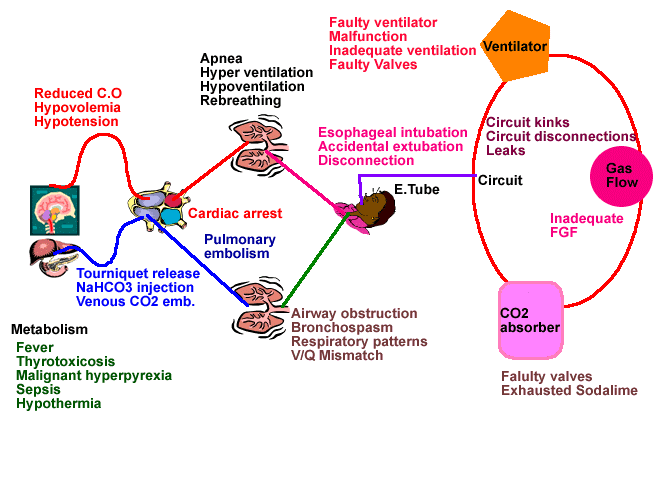
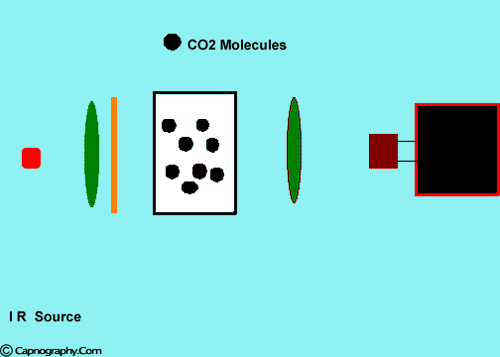


Diagram depicting problems recognizable with capnography

**PHYSICS behind ETCO**2 **monitors:**

1. **Chemical method** – calorimetric method
2. **Physical methods**
3. IR spectrometry
4. Raman Spectrometry
5. Mass spectrometry
6. Photo-acoustic Spectrometry
7. Molecular Correlation Spectrometry

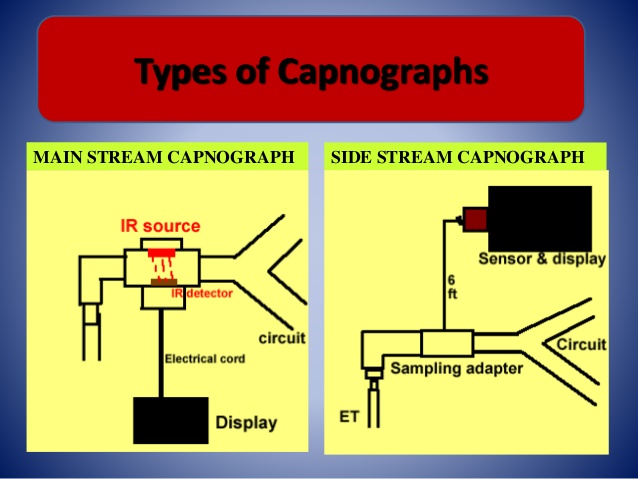
**Infra – red spectrometry:**



Most popular method of measuring CO2. First CO2 measuring and recording apparatus was by Luft in 1943. CO2 selectively absorbs 4.28 µm IR light. Amount of IR absorbed is proportional to the concentration of CO2. Comparing the absorption with a known standard, the concentration of CO2 can be calculated. Very compact and less expensive. Measured value is expressed in % or mmHg or Kpa.

**Types of capnography:**

1. Main stream capnography
2. Side stream capnography



**Main stream capnography:**

Advantages:

1. No need for tubing and no calibration required
2. Fewer disposable items
3. No theatre pollution & sample gas contamination unlikely
4. Faster response time and more accurate

Disadvantages:

1. Warm up time longer
2. Chance of facial burns & pressure injury
3. Heavy sensor can exert traction on the ETT
4. Sensor vulnerable to breakage
5. Can’t use it for spontaneously breathing patients via face mask
6. Can’t be used for gases other than CO2

**Side stream capnography:**

The measurement is done away from the ETT. A tiny pump aspirates gas samples from the patient’s breathing circuit to the monitor through a fine long tubing. Sensor is located in the main unit. Sampling flow rate is usually around 50 - 200 ml/min.

**Advantages:**

1. Warm up time quicker
2. No dead space
3. Can monitor spontaneously breathing patients also
4. Sampling device not heavy and hence no traction on ETT
5. Single sampling line detects O2, CO2, N2O & agent

**Disadvantages:**

1. Sampling tube may get kinked or blocked
2. Response time is longer and less accurate
3. Risk of theatre pollution
4. Have to be cautious during low flow anaesthesia
5. Needs more disposables

**Microstream capnography:**

1. Principle: molecular correlation spectroscopy
2. Few of the latest capnographs use this technology
3. Sampling rate is around 50 ml/min and hence theatre pollution is negligible.
4. Fast, accurate and portable
5. Ideal for neonates and children

**Ultra compact microrotor technology**

To measure CO2, nitrous oxide and five anaesthetic agents

Flow of 50ml/min to monitor CO2, even if breath rate is up to 150bpm

Long life filterline.

NOMOLINE

**Main stream sensors**

New development in main stream sensor technology and it has overcome many disadvantages associated with earlier models such as heavy weight, bulky size, facial burns and increased drag in ET tube .

**CAPNOSTAT 5**

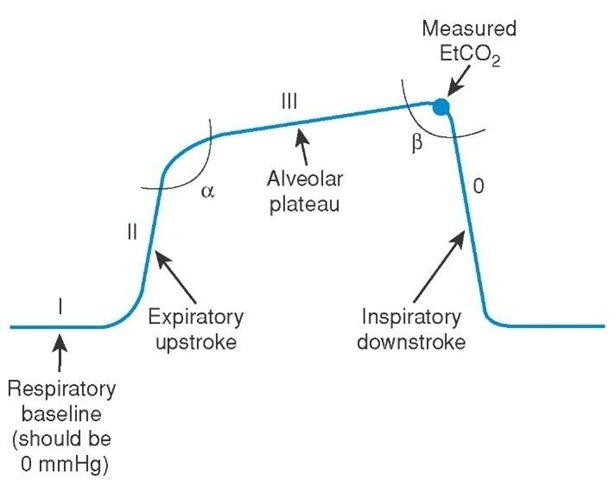
**Miniaturized main stream multi-gas monitor**

The sensor in the mainstream analyser has been made light weight.

**Parts of a capnograph**

Phase I : Anatomical and apparatus dead space

Phase II : Mixture of anatomical and alveolar dead space



Phase III : Alveolar plateau

Phase 0 : Down slope to zero (inspiration)

Alpha angle : angel between phase II & III – indirect indication of V/Q status

Beta angle : angle between III & 0. Increase indicates rebreathing

**How to analyse CO**2 **waveforms**

1. Baseline
2. Height
3. Shape
4. Frequency
5. Rhythm

**Elevated insp. baseline (Phase I)**

This usually means rebreathing

1. Exhausted CO2absorber
2. Inadequate inspiratory flows
3. Incompetent valves
4. Sudden increase in both baseline and ETCO2 means contamination of sample cell with water, mucous or dirt

**Prolongation or slanting of expiratory upstroke (Phase II)**

Due to obstruction to exhaled gas flows

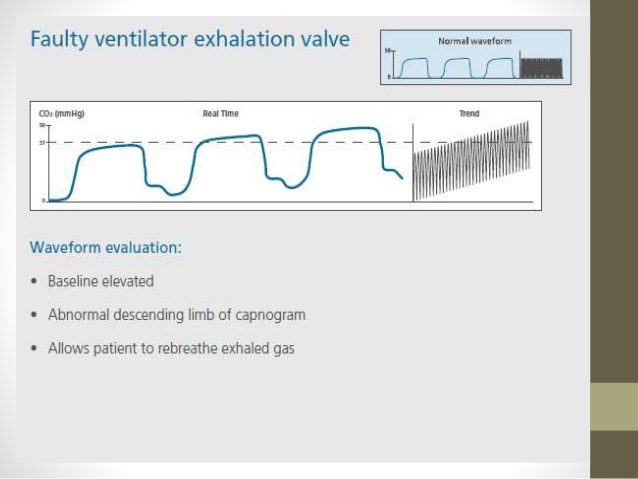
• Respiration
• The main use of the capnographic signal in anaesthesia is the
immediate verification of tracheal intubatio...

1. Bronchospasm
2. COPD
3. Kinked ETT

**Leaks in the breathing system**

• Questions
 

**Increase in height or the plateau**



1. Increased BMR
2. Malignant hyperthermia
3. Hypoventilation

**Decrease in height or the plateau**

• Metabolism
• An increase in end-tidal CO2 is a reliable indicatorof increased
metabolism only in mechanically ventilated...

1. Decreased BMR
2. Decreased cardiac output
3. Hyperventilation

**Curare cleft**

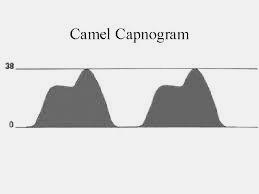
Return of spontaneous breaths in a paralysed patient

• So is capnography a prerequisite monitoring modality?
 

**Camel curve**

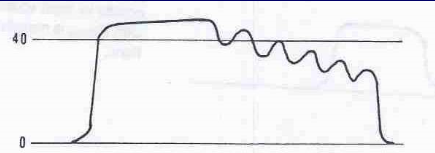
This capnograph occurs due to

1. sampling leaks in the sampling tube cracks
2. a loose connection between sampling tubes and the monitor
3. [breaks in the water filter](http://www.capnography.com/Capnoclips/dualplateaufilter.htm) of the carbon dioxide analyzer



1. differential lung emptying of the lungs transplanted lung and diseased lung
2. In addition, a dual capnogram can result during [endobronchial intubation](http://www.capnography.com/Capnoclips/endobronchial.htm" \t "_blank) and in patients with severe kyphoscoliosis

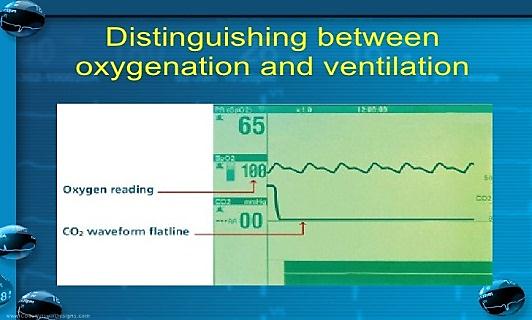
**Cardiogenic oscillations**



**Sudden drop or absent CO**2

Crucial additional info;
1. Capnography and atmospheric pressure
2. Capnography and water vapour
3. Capnography and PEEP
4...

1. Oesophageal intubation or accidental extubation
2. Disconnection or total airway obstruction
3. Apnoea or cardiac arrest or circuit disconnection
4. Pulmonary embolism
5. Water blocking sampling tube



**How is ETCO**2 **helpful in a crisis**

1. ETCO2 gives an estimate about the alveolar CO2 concentration.
2. Shape of the curve helps to determine various conditions like
   1. Adequacy of spontaneous respiration
   2. Integrity of anaesthetic apparatus
   3. Accidental oesophageal intubation
   4. Adequacy of fresh gas flows in closed circuit
   5. Weaning off of muscle relaxants
   6. Adequacy of cardio pulmonary resuscitation
   7. CO2 gradient between artery (PaCO2) and alveolus (ETCO2) indicates the dead space
   8. Useful monitor while providing sedation in OT or remote areas
   9. Postoperatively to know the adequacy of ventilation

**Why capnography should be made mandatory**

1. For confirmation of ETT placement
2. For prevention or avoidance of anaesthetic mishaps
   1. 93% of catastrophies could have been prevented with a combination of pulse oximeter & capnograph.
3. Non-invasive monitor ; easy to apply and interpret
4. ***Spo2 takes 5 minutes to reflect changes in oxygen saturation whereas Etco2 reflects changes almost instantaneously!*** Oesophageal intubation, cardiac arrest, pulmonary embolism, circuit disconnection, adequacy of CPR and return of spontaneous circulation (ROSC) will all be picked up instantaneously by capnograph.
5. Was made mandatory by ASA as far back as 1999. It was extended to iv sedation in peripheries also.

**Stand of ISA:**

ASA made ETCO2monitor for endotracheal anaesthesia as early as 1999. This was revised in 2010 to include it for moderate and deep sedation. A high level committee by the ISA, discussed various pros and cons of making ETCO2 a mandatory monitor. Taking into consideration the economic factors and variety of hospitals present in this vast country, they concluded that ETCO2 is a desirable monitor and not mandatory monitor for general anaesthesia. Recently the State of Telengana promulgated an ordinance that ETCO2should be a mandatory monitor for anaesthesia for laparoscopic surgeries. Hopefully ISA will also make this very useful monitor mandatory for anaesthesia and iv sedation.

**CONCLUSION:**

1. Capnography is a very useful and much required monitor for anaesthesia, sedation and CPR.
2. Eyes don’t see what the mind doesn’t know. All of us should be very familiar with the different wave forms and their interpretations so that even if we have the monitor, the interpretation is done by us instantaneously.
3. Considering the various financial constraints of different types of hospitals, ISA has made this a desirable monitor and not mandatory monitor. There is no doubt, ETCO2 will be made a mandatory monitor in the near future.
4. Beware of the falsely reassuring statement **“*His breathing must be adequate – the sats are OK”***. Saturation only tells us about the oxygenation and adequacy of ventilation can only be assessed with ETCO2 or PaCO2. So use ETCO2 to assess ventilation.
5. SpO2 takes 5 mins to reflect changes whereas ETCO2 almost immediately!

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