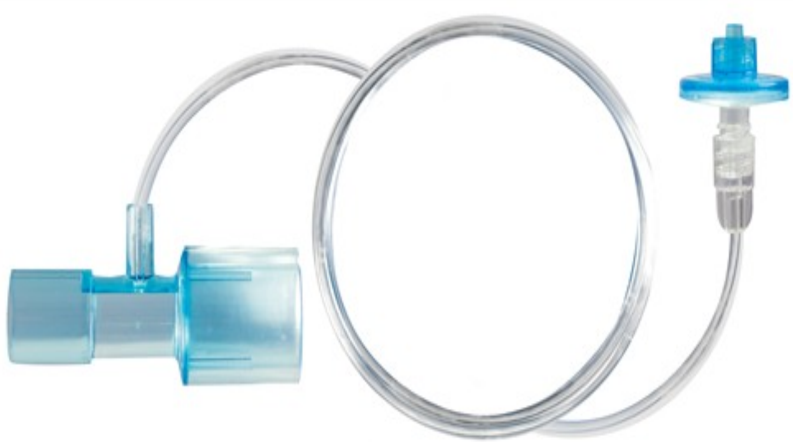
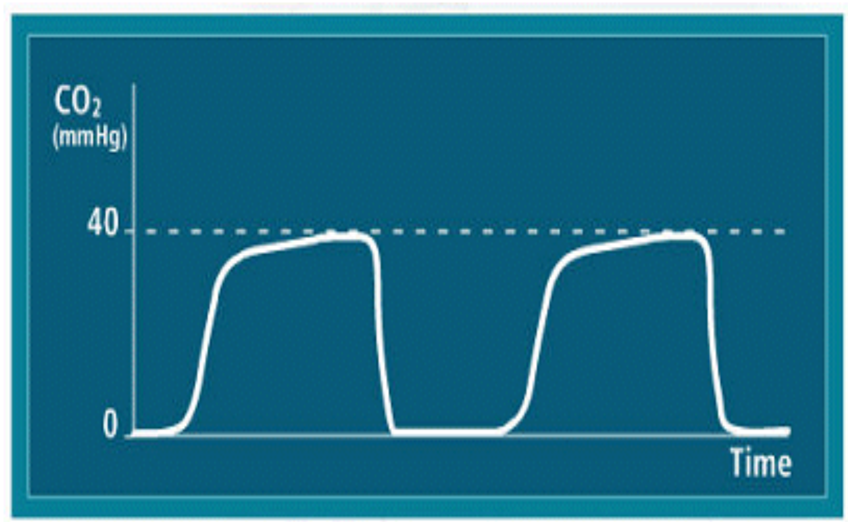
Everything you never knew you needed to know about End tidal C02 monitoring





Aims

1. Establish the relationship between ETC02 and paC02
2. Understand capnography
3. Types of capnograph analyser
4. The capnograph waveform
5. Interpreting the capnograph

C02 metabolism

- Carbon dioxide (CO2) is produced as a by-product of metabolism and returned to the lungs via perfusion, where it is then removed via alveolar ventilation

- $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3$

The paC02 and ETC02 relationship

- The gradient, or the difference between the PaCO2 and etCO2 values is a result of the relationship between
  - Ventilation (V) - airflow to the alveoli
  - Perfusion (Q) - blood flow to the pulmonary capillaries
- In normal, healthy lungs there is a good match of alveolar ventilation and perfusion to the pulmonary capillaries resulting in an etCO2 that closely correlates with, or matches, the PaCO2

Figure 2A. *(Example)* Normal match of ventilation (V) and perfusion (Q) in healthy lungs

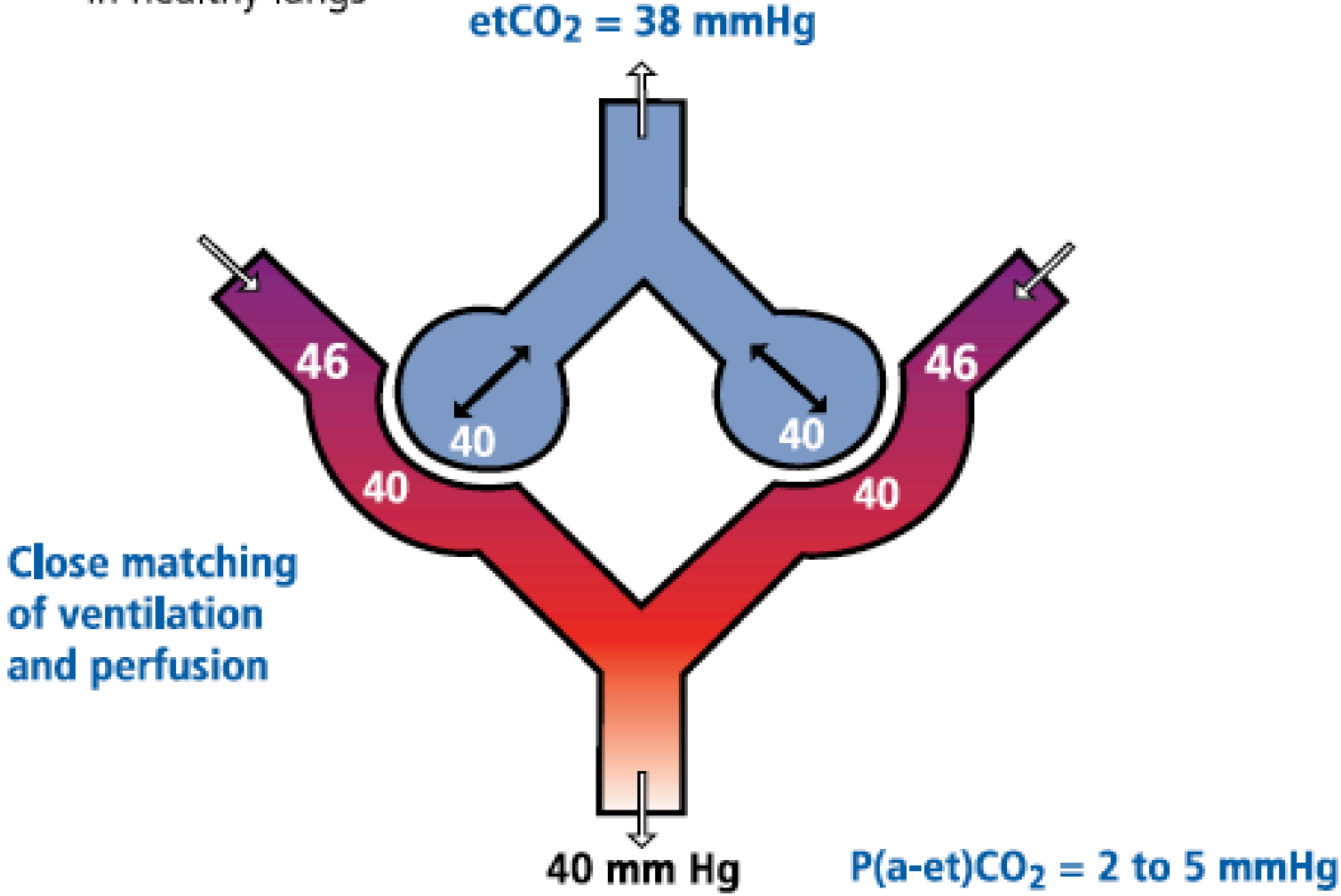
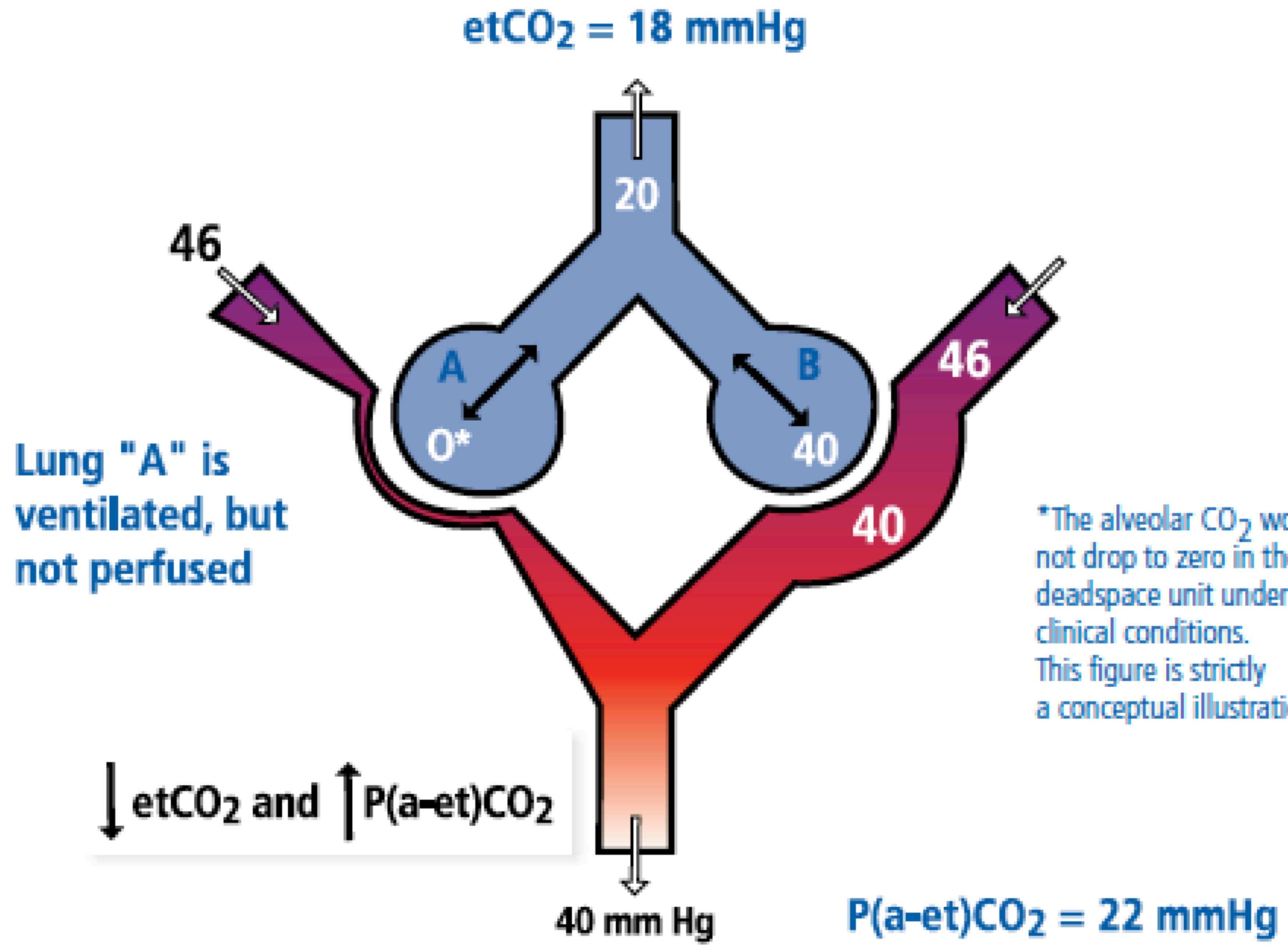
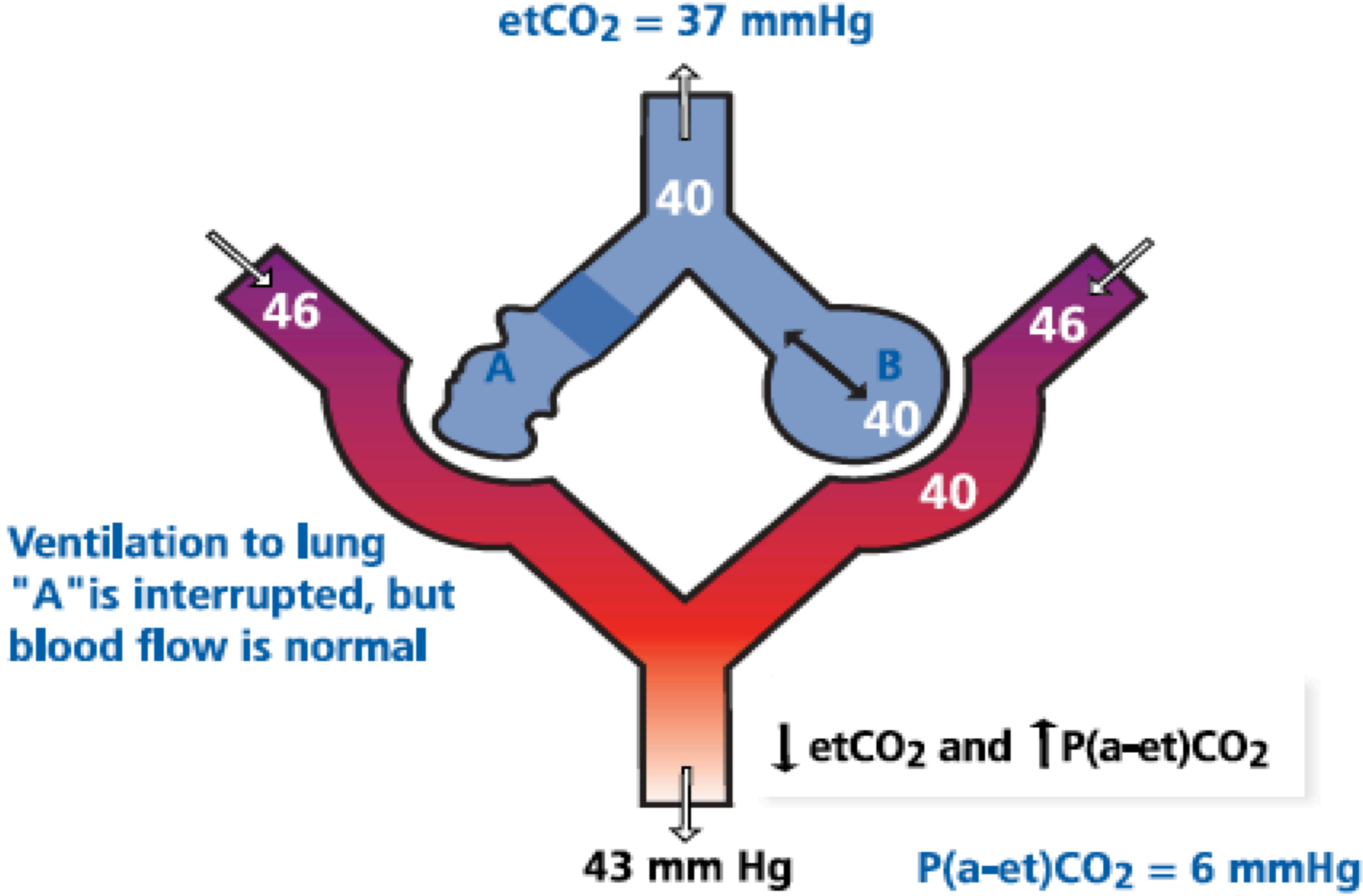


Figure 2B. *(Example)* Acute decrease in alveolar perfusion (deadspace ventilation)



*The alveolar CO_2 would not drop to zero in the deadspace unit under clinical conditions. This figure is strictly a conceptual illustration.

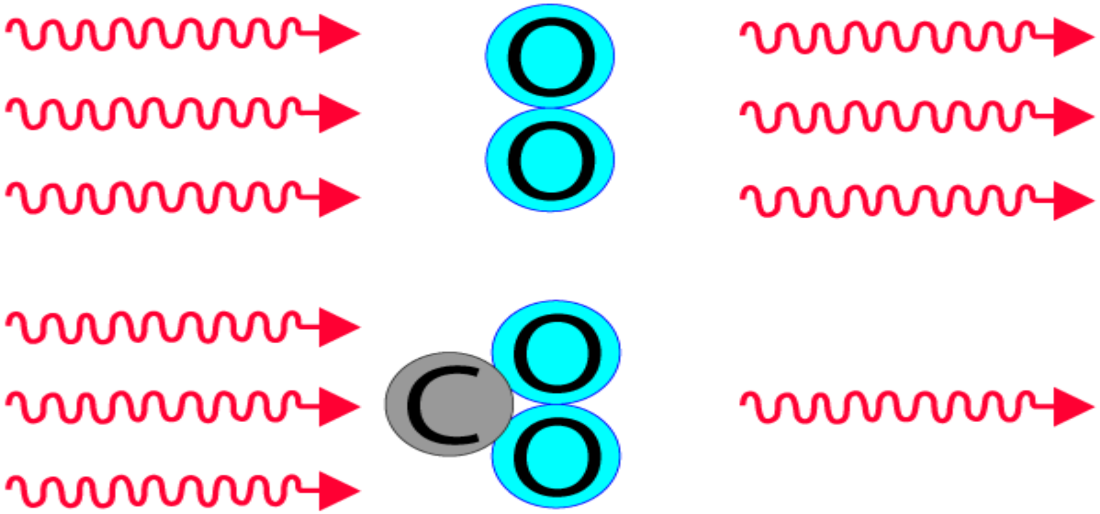
Figure 2C. *(Example)* Acute decreased lung ventilation (intrapulomonary shunt)



Capnography

- Infrared is absorbed by gases that have two or more different atoms. Oxygen gas has two atoms which are not different, therefore, oxygen does not absorb infrared waves

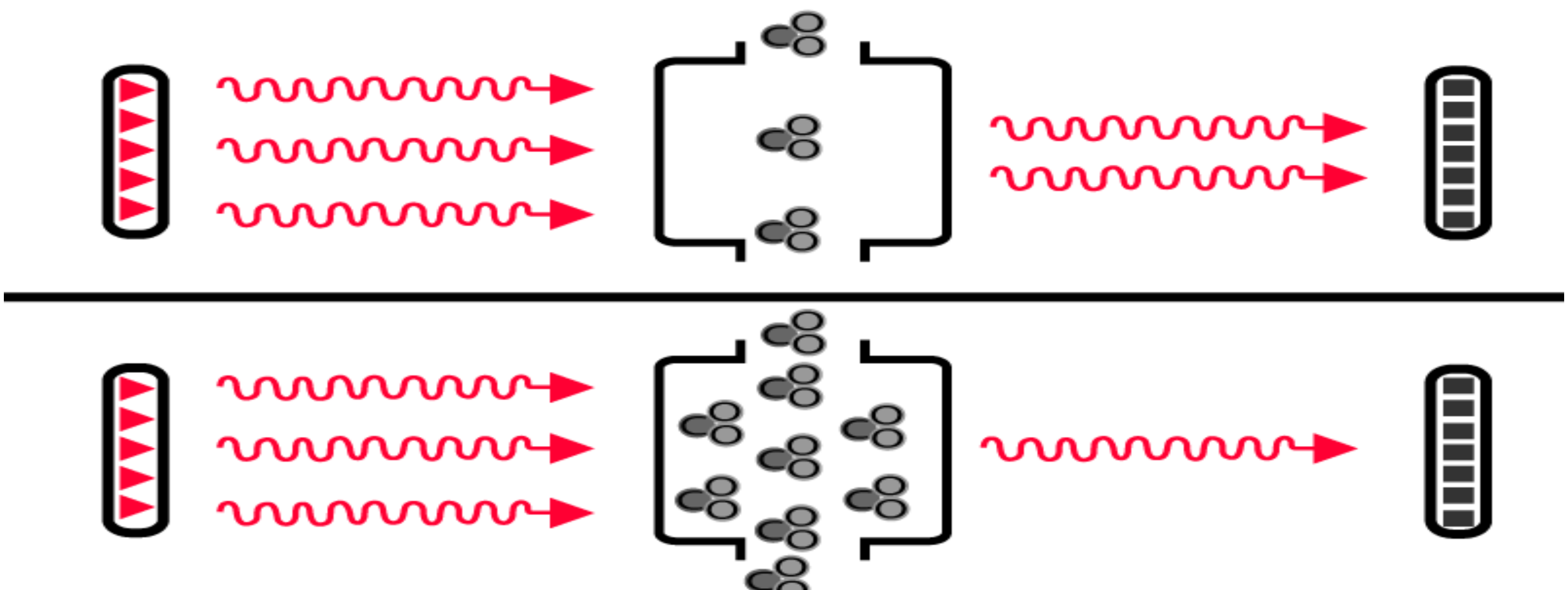
- Carbon dioxide has atoms that are different, therefore it does absorb infrared waves.



The Beer-Lambert law

- Amount of infrared rays absorbed is proportional to the concentration of the infrared absorbing substance.

- The CO2 analyser works on this principle. More the CO2 present, more is the infrared rays absorbed.

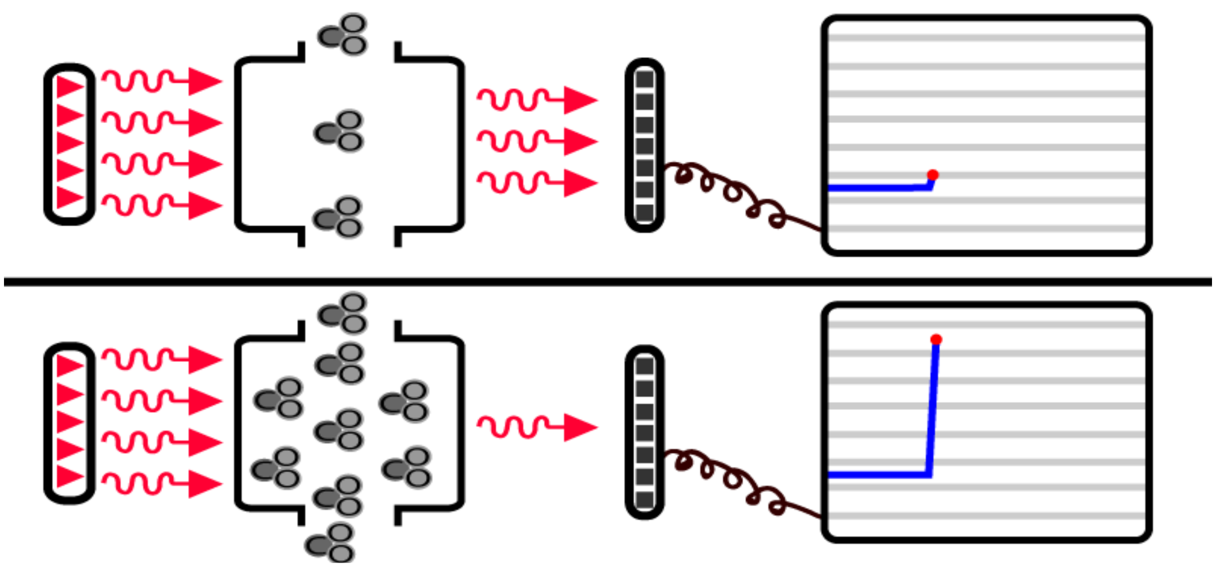


Translating to the monitor

- The computer uses the information from the detector to display the CO_2.

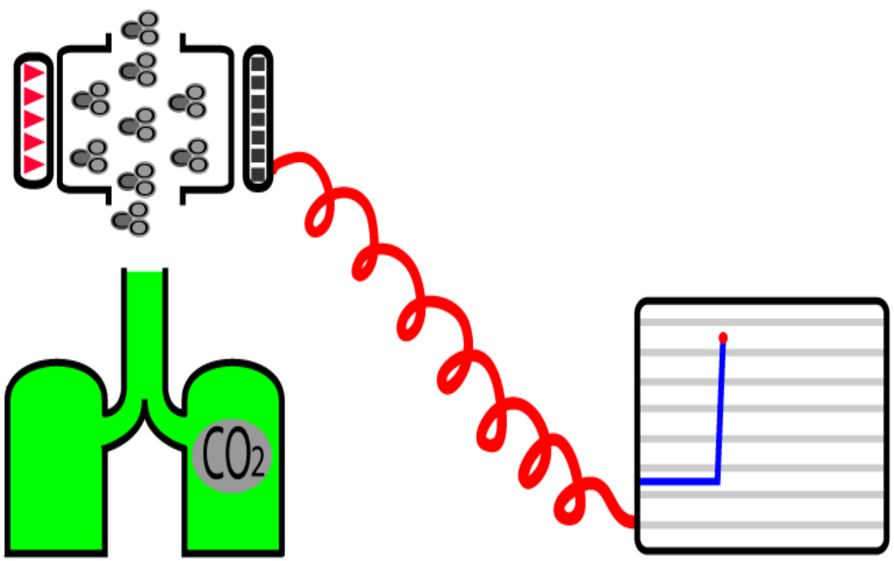
- Low CO_2 = more infrared reaching detector = low CO_2 display

- High CO_2 = less infrared reaching detector = high CO_2 display



Types of capnograph analyser
Main stream vs side stream

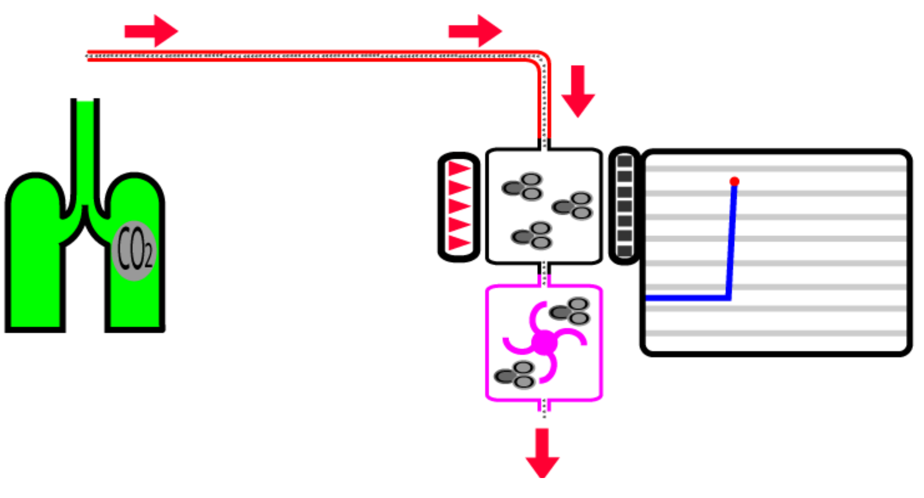
- Main stream analyser
  - Analyser is directly near the CO_2 expired by the patient. The main stream analyser is "attached" to the patient.



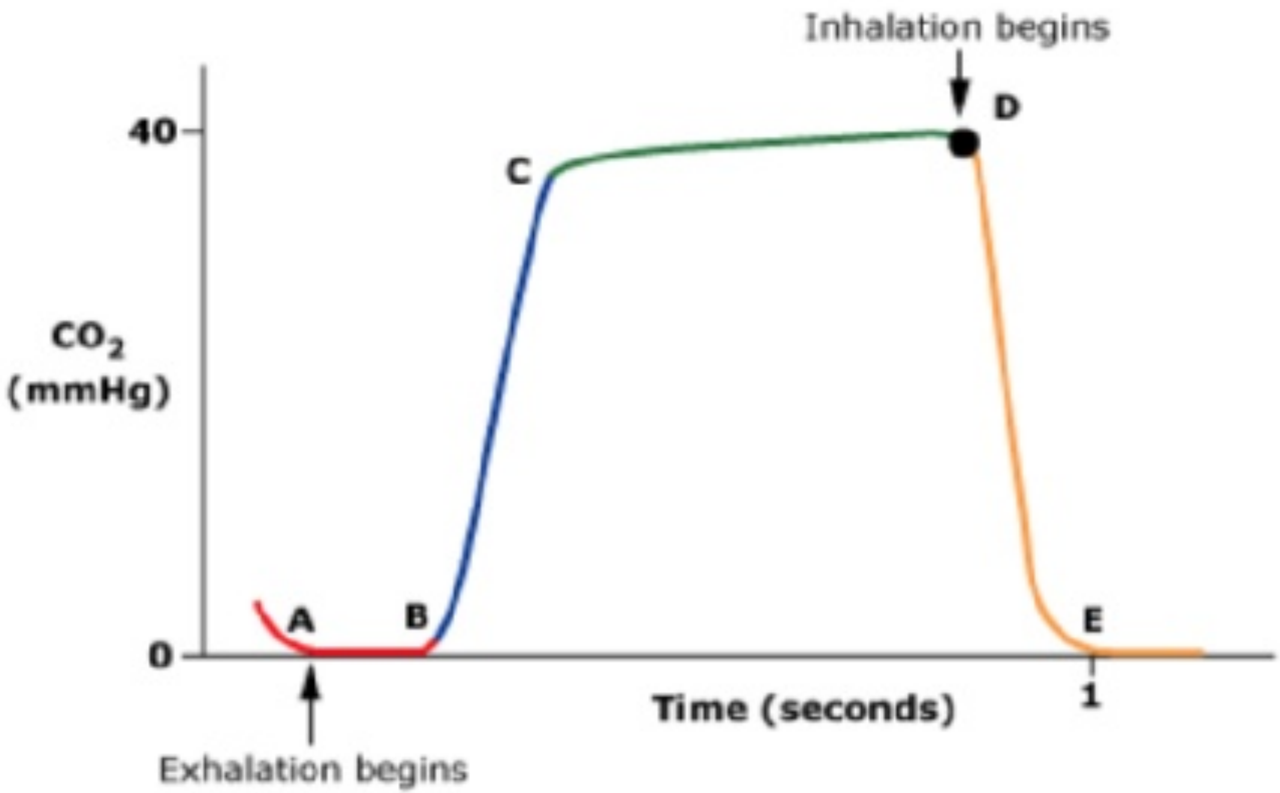
Side stream C02 analysers

- A long narrow tube is connected to the patient end. A pump (shown in pink) keeps suctioning a small quantity (e.g. 150 mL per minute) of the patients respiratory gases.

- This sample of gases flows across the analyser, which is located away from the patient.



Normal CO2 waveform



A - B: Dead space ventilation

B - C: Ascending expiratory phase

C - D: Alveolar Plateau

D: End-tidal CO_2

D - E: Descending inspiratory phase

What about $C0_2$ Colorimetry?

- The pH sensitive indicator changes color when exposed to $C0_2$
- The color varies between expiration and inspiration, as $C0_2$ level increases or decreases
- The color changes from purple (when exposed to room air or oxygen) to yellow (when exposed to 4% $C0_2$)
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- The response time of the device is sufficiently fast to detect changes of $C0_2$ breath-by breath
- However, this device is not very sensitive when CO_2 output is low as is during CPR

What about $C0_2$ Colorimetry?

- As with capnography, false negative results may occur even with correct endotracheal tube placement in patients in cardiac arrest, in whom sufficient CO_2 may not be present in the lungs

- There is also the possibility of color change in the device due to agents other than exhaled carbon dioxide - Gastric contents, mucus, and drugs such as adrenaline can cause false positive results

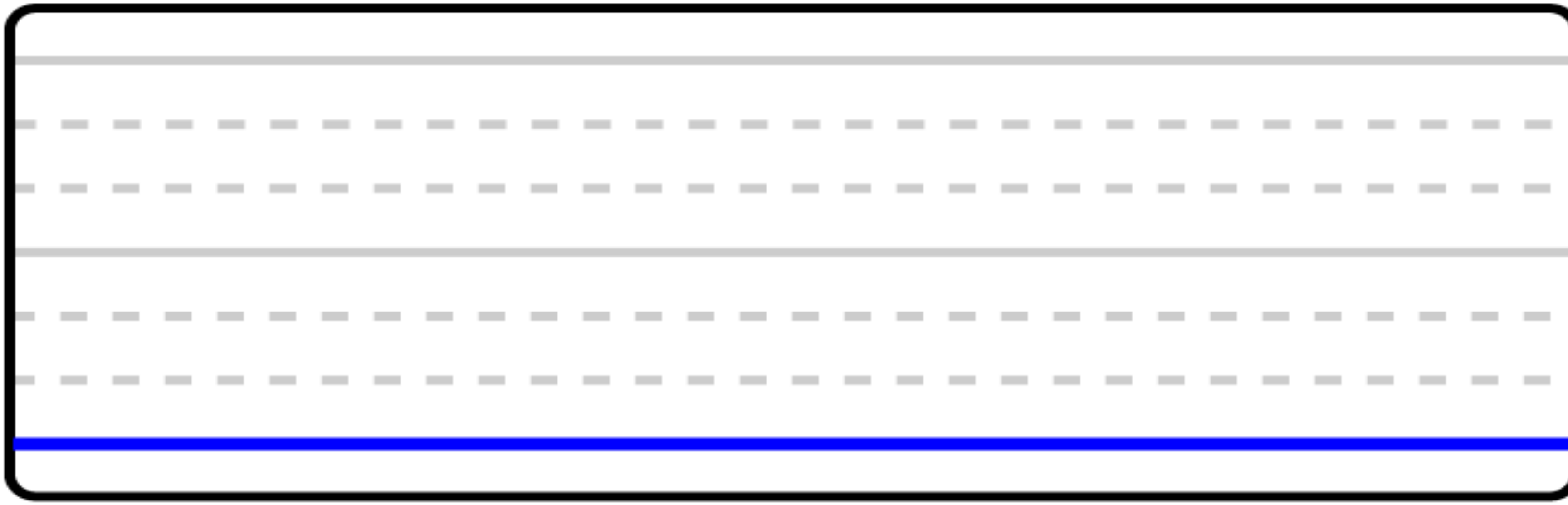
- A false positive result causes a permanent color change in the device; hence, the color does not vary with ventilation and will stay yellow even if the endotracheal tube is no longer in the airway

- False positives can also occur with tracheal intubation due to the presence of low concentrations of $C0_2$ which can be present in the trachea and can be picked up by the colorimeter at levels as low as 4%

Bhavani Shankar Kodali MD - **Chemical method of CO_2 measurement**

Interpreting the Capnograph

Differential diagnosis?



Rule out a capnograph that is not connected! An unconnected capnograph will read room air, which has nearly zero CO_2

Complete obstruction of lungs: e.g. very severe bronchospasm leading to complete obstruction

Complete obstruction of airway: e.g. tracheal tube obstruction

Complete obstruction of capnograph sampling tubing

Respiratory arrest (apnoea)

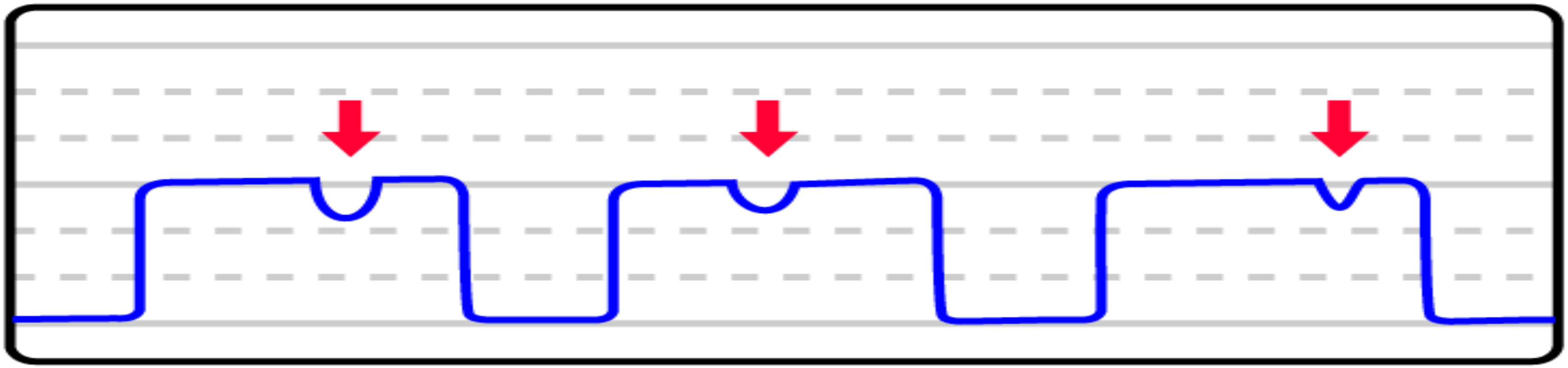
Cardiac arrest : There is no circulation to bring CO_2 to the lungs

Differential diagnosis?

- Partial obstruction of lungs:
  - bronchospasm
  - chronic obstructive pulmonary disease (COPD)

- Partial obstruction of airway:
  - tracheal tube secretions
  - kinking

Differential diagnosis?

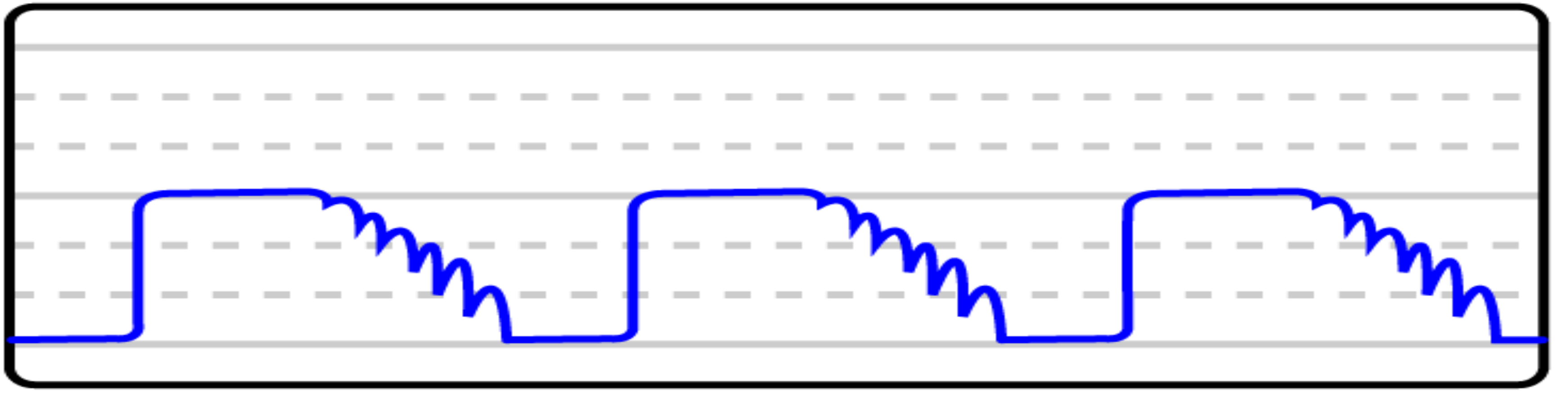


- When a patient has been given a muscle relaxant, the respiratory muscles are paralysed

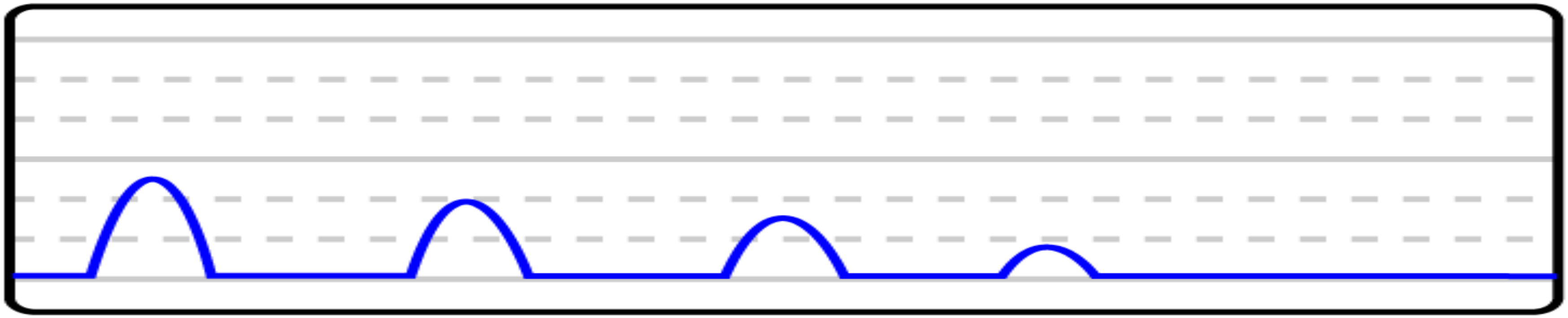
- However, when the relaxant has worn off, the diaphragm can contract and disturb the flow of CO_2 out of the lung which results in brief depressions in the CO_2 trace.

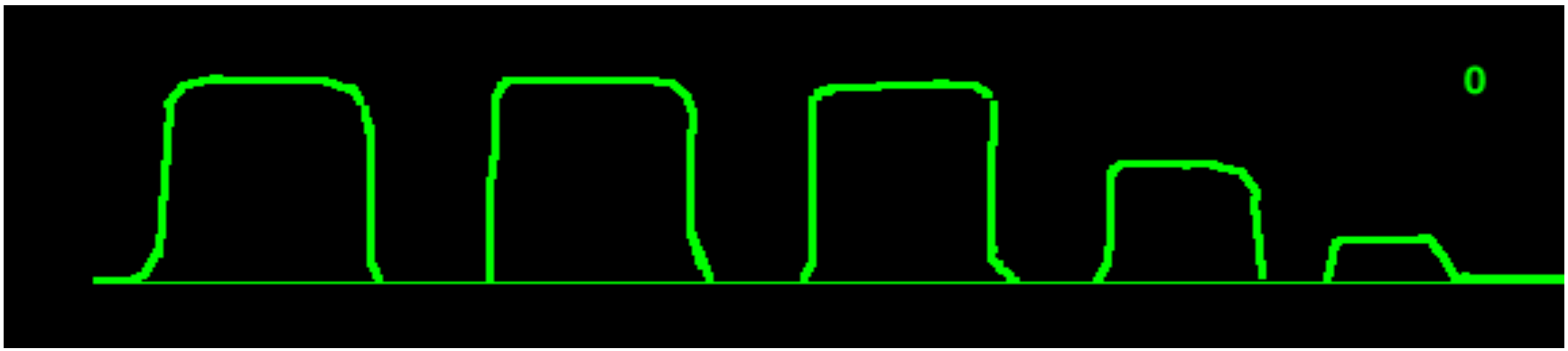
- A similar effect can be seen when a surgeon presses on the chest wall

Diagnosis?



- The disturbance caused by the cardiac oscillations may be seen as a series of notches in the waveform.





Oesophageal intubation

Occasionally enough alveolar gas can be forced down the esophagus into the stomach during mask ventilation resulting transiently in a few decremental wave forms

The concentration of carbon dioxide falls dramatically after three breaths and to zero in about six breaths