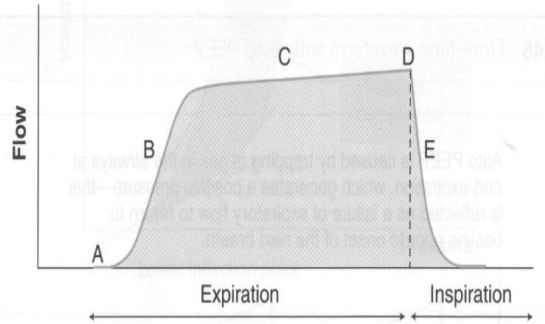
capnography

general

- Capnometry consists of the measurement and numeric display of expired carbon dioxide (CO2) at the patient's airway opening. When a waveform plotting CO2 against time or volume is also displayed, it is referred to as capnography, and the waveform is referred to as a capnogram.
- Capnometry works by passing infrared light through a sample chamber to a detector on the opposite side. More infrared light passing through the sample chamber (i.e., less CO2) causes a larger signal in the detector relative to the infrared light passing through a reference cell.

normal capnography waveform



A = Zero baseline
B = Rapid sharp rise at start of expiration
C = Alveolar plateau
D = End-tidal CO_2 value
E = Rapid sharp downstroke with inspiration

interpretation

PaCO2-PetCO2 GRADIENT:
- Normal subjects have a PaCO2-PETCO2 gradient of 4 to 5 mm Hg,
- In critically ill patients, the PaCO2-PETCO2 gradient can be markedly elevated
- During expiration, lung regions with high ventilation-to-perfusion ratios dilute the mixed CO2 concentration so that PETCO2 is usually lower than PaCO2
- When CO2 production is elevated (or expiration is prolonged), PETCO2 more closely resembles mixed venous PCO2, as a higher amount of CO2 diffuses into a progressively smaller lung volume.
- Thus, the PaCO2-PETCO2 gradient can be affected by changes in respiratory rate and tidal volume (VT), owing to alterations in expiratory time, and by CO2 production and mixed venous CO2 content.
- Inotropic or vasoactive drugs may affect the PaCO2-PETCO2 gradient in an unpredictable manner, either by increasing cardiac output and pulmonary perfusion (thereby reducing alveolar deadspace) or by reducing pulmonary vascular resistance and magnifying intrapulmonary shunt by countering hypoxic pulmonary vasoconstriction.

PaCO2-PETCO2 GRADIENT, PEEP, AND LUNG RECRUITMENT:
- PEEP recruits collapsed alveoli, improves ventilation-perfusion matching, and reduces alveolar deadspace, although excessive levels cause overdistention and increased alveolar deadspace.
- Because the PaCO2-PETCO2 gradient correlates strongly with the physiologic deadspace-to-tidal volume ratio (VD/VT), it may be useful in titrating PEEP in acute respiratory distress syndrome (ARDS) although data in humans are limited.

PetCO2 MONITORING DURING CARDIOPULMONARY RESUSCITATION:
- Monitoring end-tidal CO2 concentration is a reliable method for evaluating the effectiveness of cardiopulmonary resuscitation with changes in PETCO2 directly proportional to changes in cardiac output.
- PETCO2 during precordial compressions can distinguish successful from unsuccessful resuscitation, with values greater than 10 mm Hg or greater than 16 mm Hg depending on the study associated with successful resuscitation.

MEASUREMENT OF DEADSPACE VENTILATION
- Ventilation-perfusion abnormalities are the primary physiologic disturbance in nearly all pulmonary diseases and the principal mechanism for elevated PaCO2.
- Deadspace ventilation (VD), the portion of VT that does not encounter perfused alveoli, directly impacts CO2 excretion and is used as an indirect measure of ventilation-perfusion abnormalities.
- Physiologic VD/VT is used to assess the severity of pulmonary disease and the efficacy of ventilator manipulations. It may be particularly useful in patients with suspected PE
- Expired gas collection with a Douglas bag is the classic method for measuring VD/VT.
- Metabolic monitors produce equally accurate, reliable results and are less cumbersome.
- In addition, newer monitors incorporating capnography and pneumotachygraphy now provide accurate single-breath determinations of VD/VT.

use

(i) the diagnosis of pulmonary embolism,
(ii) determination of lung recruitment response to positive end-expiratory pressure (PEEP),
(iii) detection of intrinsic PEEP,
(iv) evaluation of weaning,
(v) indirect marker of elevated deadspace ventilation,
(vi) assessment of cardiopulmonary resuscitation,
(vii) indirect determination of cardiac output through partial CO2 rebreathing,
(viii) verification of endotracheal cannulation,
(viii) detection of airway accidents, and
(ix) verification of feeding tube placement.

capnography traces

Waveform characteristic	Significance
Sudden drop in $ETco_2$ to zero or near zero	Circuit disconnection Dislodged, occluded or kinked endotracheal tube Oesophageal intubation Massive CO_2 embolism during laparoscopy
Sudden drop in $ETco_2$ to lower levels without well-defined normal plateaus	Circuit leak Partial airway occlusion
Persistent low $ETco_2$ with normal plateaus	Hypothermia Hyperventilation Deep anaesthesia/sedation Increased dead-space ventilation
Persistent low $ETco_2$ without normal plateaus	Incomplete expiration related to partial airway occlusion, bronchospasm, mucus plugging or poor stream sampling
Marked decrease in $ETco_2$ with normal plateaus	Reduced pulmonary blood flow—pulmonary embolism (clot, fat, air), profound hypotension
Elevated $ETco_2$ with normal plateaus	Inadequate minute volume but adequate tidal volumes Increased CO_2 production (e.g. hyperthermia)
Gradually increasing $ETco_2$ with normal plateaus	Hypoventilation Sudden increase in metabolic rate (e.g. malignant hyperthermia)