Volumetric capnography option

(159136 CO_2 preparation kit, 281718 HAMILTON Capnostat 5 CO_2 sensor)

Capnography has become an important tool to evaluate the adequacy of ventilation, as the obvious goal of ventilation is to remove the volume of CO_2 produced by the body's metabolic processes. Conventionally, minute ventilation (MinVol) is used as a measure of overall ventilation. However, minute ventilation does not tell how much CO_2-removing volume reaches the alveoli, because it includes not only ventilation of the lungs but also ventilation that is wasted in the airways. Thus, minute ventilation does not conclusively indicate the actual alveolar reach. Instead, alveolar ventilation (V'alv) should be measured*.

The HAMILTON-G5 is the only ventilator that provides the option to measure alveolar ventilation plus other measures of volumetric capnography. With the unique combination of fast capnography and accurate spirometry, the HAMILTON-G5 accurately determines a number of other parameters:

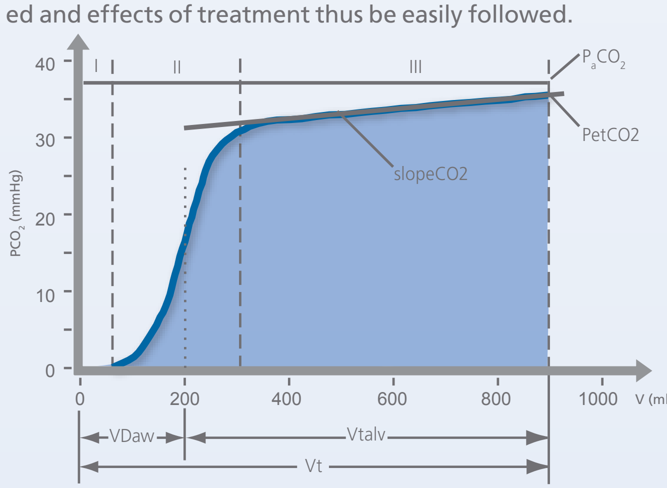
- The CO_2 elimination (V'CO2) measurement permits assessment of metabolic rate (e.g., it is high with sepsis, tetanus, etc.) and treatment progress
- The end-tidal CO_2 (PetCO2) measurement permits assessment of arterial CO_2 partial pressure. (Note that it is inaccurate in pulmonary embolism)
- The airway dead space (VDaw) measurement permits assessment of actual alveolar ventilation (as opposed to minute ventilation)
- The capnogram shape (slopeCO2) permits assessment of COPD, asthma, inefficient ventilation, gastric intubation, and pulmonary embolism
- The physiological dead space fraction (VD/VT) permits assessment of risk [Nuckton 2002]

Method

Alveolar ventilation is defined as minute ventilation minus dead space ventilation. Dead space is measured using the volumetric capnogram, which is divided into phase I (no CO_2 present), phase II (rapid rise in CO_2), and phase III (alveolar plateau). Phases I and II represent airway dead space.

To obtain the volume of CO_2 exhaled in a single breath, the conventional CO_2 versus time curve and the spirogram are combined into the CO_2 versus volume diagram shown in the figure below. This requires the simultaneous measurement of flow and CO_2 at the airway opening.

The slope of phase III (slopeCO2) is a very sensitive lung function indicator. Like other parameters, it is calculated breath-by-breath on the HAMILTON-G5. A steep slope is seen in COPD patients, while a flat plateau is seen in post-operative patients. The parameter slopeCO2 can be trended and effects of treatment thus be easily followed.



Description of volumetric capnogram:

Phase I: Pure airway dead space, from point of measurement of CO_2 toward the lungs

Phase II: Weighted average of alveolar gas from different lung spaces, at the sensor location; measurement is VDaw

Phase III: Alveolar plateau; measurement is $slopeCO_2$ together with end-tidal CO_2.

* For example, in a patient with airway dead space of 150 ml (68 kg IBW male), a tidal volume of 100 ml at a rate of 60 b/min yields the same minute ventilation as a tidal volume of 500 ml at a rate of 12 b/min, yet it has no real benefit to the patient since only dead space ventilation occurs.

Ordering information

159136 CO_2 preparation kit (without sensor)

281718 HAMILTON CAPNOSTAT 5 CO_2 sensor

281719 CO_2 sensor airway adapter, adult/pediatric, single-use, box of 10

281720 CO_2 sensor airway adapter, infant/pediatric, single-use, box of 10

281721 CO_2 sensor airway adapter, adult/pediatric, reusable, box of 1

281722 CO_2 sensor airway adapter, infant/pediatric, reusable, box of 1

281803 15mm Male/Female adapter for infant flow sensor, package of 25

Specifications for the CO_2 option

Parameter	Range	Resolution
FetCO2	0 to 19.7%	0.1%
PetCO2	0 to 150 mmHg	1 mmHg
slopeCO2	0 to 9.99 %CO_2/l	0.01 %CO_2/l
Vtalv	0 to 1000 ml	1 ml for < 100 ml 10 ml for ≥ 100 ml
V'alv	0 to 20 l/min	0.01 l/min for < 1 l/min 0.1 l/min for ≥ 1 l/min
V'CO2	0 to 5000 ml/min	1 ml/min for < 1000 ml/min 10 ml/min for ≥ 1000 ml/min
VDaw	0 to 1000 ml	1 ml
VDaw/VTE	1 to 99 %	1 %
VeCO2	0 to 999 ml	1 ml for < 100 ml 10 ml for ≥ 100 ml
ViCO2	0 to 999 ml	1 ml for < 100 ml 10 ml for ≥ 100 ml

Specifications of CO_2 mainstream sensor

Principle of Operation: Non-dispersive infrared (NDIR) single beam optics, dual wavelength, no moving parts.

CO2 Accuracy: 0 – 40 mm Hg ± 2 mm Hg
41 – 70 mm Hg ± 5% of reading

Compensations: Barometric Pressure 400 to 850 mm Hg
O_2 and He compensation

Calibration: No routine user calibration required. An airway adapter zero is required when changing to a different style of airway adapter.

Airway Adapters: < 5 cc deadspace (adult),
< 1 cc deadspace(infant)

The blue alarm lamp on top of ventilator lights to indicate heliox is being administered.

Further reading

Folkow B, Pappenheimer JR. Components of respiratory dead space and their variations with pressure breathing and bronchoactive drugs. J Appl Physiol 1955; 8:102-110.

Noe FE. Computer analysis of curves from an infrared CO2 analyzer and screen-type airflow meter. J Appl Physiol 1963; 18:149-157.

Severinghaus JW. Stupfel M. Alveolar dead space as an index of distribution of blood flow in pulmonary capillaries. J Appl Physiol 1957; 10:335-348.

Wolff G, Brunner JX, Weibel W. et al. Anatomical and series dead space volume: conept and measurement in clinical practice. Appl Cardiopul Pathophysiol 1989; 2:299-307.

Nuckton TJ, Alonso JA, Kallet RH, Daniel BM, Pittet JF, Eisner MD, Matthay MA. Pulmonary dead-space fraction as a risk factor for death in the acute respiratory distress syndrome. N Engl J Med. 2002 Apr 25; 346(17):1281-1286.

Astrom E, Niklason L, Drefeldt B, Bajc M, Jonson B. Partitioning of dead space – a method and reference values in the awake human. Eur Respir J. 2000 Oct; 16(4):659-664.

Swiss Quality

HAMILTON MEDICAL AG, Via Nova, CH-7403 Rhäzüns, Switzerland
Headquarters: Via Crusch 8, CH-7402 Bonaduz, Switzerland
Phone: +41 (0)81 660 60 10, Fax: +41 (0)81 660 60 20, www.hamilton-medical.com

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