CE BROKER NUMBER 20-303391

Capnography In the Resuscitating Patient

By George Encinosa

Course Objective

The student will understand principles of how Capnography work

The student will have knowledge on the importance of CO_2 in the respiratory system

The student will have knowledge on the mechanism behind the capnograph

The student will go over the different method of monitoring CO_2 and compare them with capnography.

The student will have knowledge on how to read a capnography waveform

The student will have knowledge on interpret waveform to confirm or troubleshoot tube placement.

The student will have the knowledge to determine if proper ventilation are being perform by using Capnography.

The student will recognize if proper CPR is being perform using Capnography.

End-tidal CO2 (EtCO2) is the measurement of carbon dioxide (CO2) in the airway at the end of each breath.

Capnography provides a numeric reading (amount) and graphic display (waveform) of the EtCO2 throughout the respiratory cycle. CO2, produced by cells, is transported via the vascular system and diffused into the alveoli to be exhaled. PaCO2, the partial pressure of CO2 in arterial blood, is normally 2–5mmHg higher than EtCO2 in the airway.

Capnography is the continuous, noninvasive measurement and graphical display of end-tidal carbon dioxide ($ETCO_2$). Capnography is an underutilized assessment tool in the management of respiratory patients. Managing the respiratory status of the intubated and ventilated patient may prove a challenge for the clinician.[1] Determining endotracheal tube placement has become a significant issue in many health care environments. The technology of capnography provides an assessment tool for ventilation management.

Capnography was used originally in mechanically ventilated patients to assess patient levels of carbon dioxide on a breath-by-breath basis, continuously and noninvasively. The capnography sample chamber or sensor, placed between the patient's artificial airway and the ventilator, inspects the inhaled and exhaled gases for specific concentrations of carbon dioxide. The inhaled and exhaled concentrations of carbon dioxide are graphically displayed as a waveform on the monitor, with a corresponding numerical value. Today, capnography plays a key role in confirming intubation and verifying placement of an airway throughout intubation, ventilation assessment, and resuscitation. Hyperventilation often occurs preceding or following intubation. A real risk in continued hyperventilation is the associated cerebral vasoconstriction caused by the low carbon dioxide.

Various forms of capnography are available in health care facilities, enabling RCPs to identify problems with ventilation immediately. Capnography is also useful in monitoring nonintubated patients to assess ventilation and perfusion of the pulmonary vessels. The RCP can use capnography as a supplemental tool and an early warning system to identify trends in ventilation and perfusion.

Carbon Dioxide

Carbon dioxide is the waste product of cellular metabolism. As cells consume oxygen, carbon dioxide is produced, transferred to the circulation, and delivered to the lungs via venous return.

Cellular production of carbon dioxide is a metabolic by-product of the oxidative breakdown of metabolic fuels. The higher the metabolic rate, the higher the carbon dioxide production rate. Carbon dioxide dissolves rapidly in the cells and easily diffuses out of the cells and into the venous blood. Carbon dioxide is carried by the poorly oxygenated venous blood through the right heart and into the pulmonary arteries to reach the capillaries surrounding each pulmonary alveolus.

As ambient air is drawn into the alveolus during inspiration, the carbon dioxide in the blood diffuses through the capillary and alveolar walls into the alveolar air sac. Under normal conditions, one pass of the blood through the alveolar capillary drives the alveolar Pco_2 nearly to match (usually within 5 mm Hg) the $Paco_2$. As expiration begins, the gas containing carbon dioxide is expelled from the alveoli to displace and mix with the air in the bronchial tree. As this mixture of gases reaches the upper airways and the capnography monitor, the measured Pco_2 rises sharply to a plateau and then slowly increases to a peak as the carbon dioxide level continues to increase. This peak Pco_2 at the end of expiration is known as the end-tidal carbon dioxide; in healthy individuals, it is generally within 5 mm Hg of the $Paco_2$. These differences can be affected by many patient factors, increasing, for example, in patients undergoing aggressive emergency procedures and in patients with significant cardiopulmonary disease.[3]

Once inspiration begins, the Pco_2 measured at the mouth or nose drops rapidly to almost zero. The rapid expiratory rise, slowly rising plateau, and drastic decrease at the beginning of inspiration constitute the characteristic waveform of the capnogram. The importance of the $ETCO_2$ waveform and numerical value resides in their ability to reflect the cardiopulmonary status of the patient. A capnograph ($ETCO_2$ monitor) provides this information to the prehospital clinician continuously

Excretion of carbon dioxide is the final common pathway of metabolism, and it provides a useful global indication of patient status. Ventilation must be adequate to carry oxygen into the lungs.

Oxygen is transferred into the erythrocytes and transported to the cells at the tissue level. Transport is a function of the cardiovascular system. The process of aerobic metabolism consumes the oxygen and produces carbon dioxide. The carbon dioxide is transferred from the tissue into the red cells and is transported to the lungs for elimination. Hypoxemia, cerebral ischemia, and coronary ischemia are possible even in the presence of normal capnography waveforms and numerical values.

The capnograph uses infrared light technology that incorporates a very sensitive emitter and a detector that identifies only the light-absorption signal of carbon dioxide. This specificity for carbon dioxide allows the use of capnography in the presence of other gases or aerosolized medications. The accuracy of $ETCO_2$ measurements can be confirmed using the waveform identifying the unique shape of the characteristic capnogram. Newer devices allow for accurate monitoring even with high respiration rates and respiratory low tidal volumes, as are often present in neonatal and pediatric patients.

Oxygenation Versus Ventilation

Oxygenation is how we get oxygen to the tissue. Oxygen is inhaled into the lungs where gas exchange occurs at the capillary-alveolar membrane. Oxygen is transported to the tissues through the blood stream. Pulse oximetry measures oxygenation.

At the cellular level, oxygen and glucose combine to produce energy. Carbon dioxide, a waste product of this process (The Krebs cycle), diffuses into the blood.

Ventilation (the movement of air) is how we get rid of carbon dioxide. Carbon dioxide is carried back through the blood and exhaled by the lungs through the alveoli. Capnography measures ventilation.

Capnography versus Pulse Oximetry

Capnography provides an immediate picture of patient condition. Pulse oximetry is delayed.

Hold your breath. Capnography will show immediate apnea, while pulse oximetry will show a high saturation for several minutes.

Circulation and Metabolism

While capnography is a direct measurement of ventilation in the lungs, it also indirectly measures metabolism and circulation. For example, an increased metabolism will increase the production of carbon dioxide increasing the ETCO2. A decrease in cardiac output will lower the delivery of carbon dioxide to the lungs decreasing the ETCO2.

PaCO2 vs. PeTCO2

PaCO2= Partial Pressure of Carbon Dioxide in arterial blood gases. The PaCO2 is measured by drawing the ABGs, which also measure the arterial PH.
If ventilation and perfusion are stable PaCO2 should correlate to PetCO2.
In a study comparing PaCO2 and PetCO2 in 39 patients with severe asthma, the mean difference between PaCO2 and PetCO2 was 1.0 mm Hg, the median difference was 0 mm Hg. Only 2 patients were outside the 5 mg HG agreement (1-6, 1-12). -Jill Corbo, MD, et al, Concordance Between Capnography and Arterial Blood Gas Measurements of Carbon Dioxide in Acute Asthma, *Annals of Emergency Medicine*, October 2005

Connecting ET tube to a Capnography

Respiratory gases analysed by two possible methods:

- Sidestream.
- Mainstream

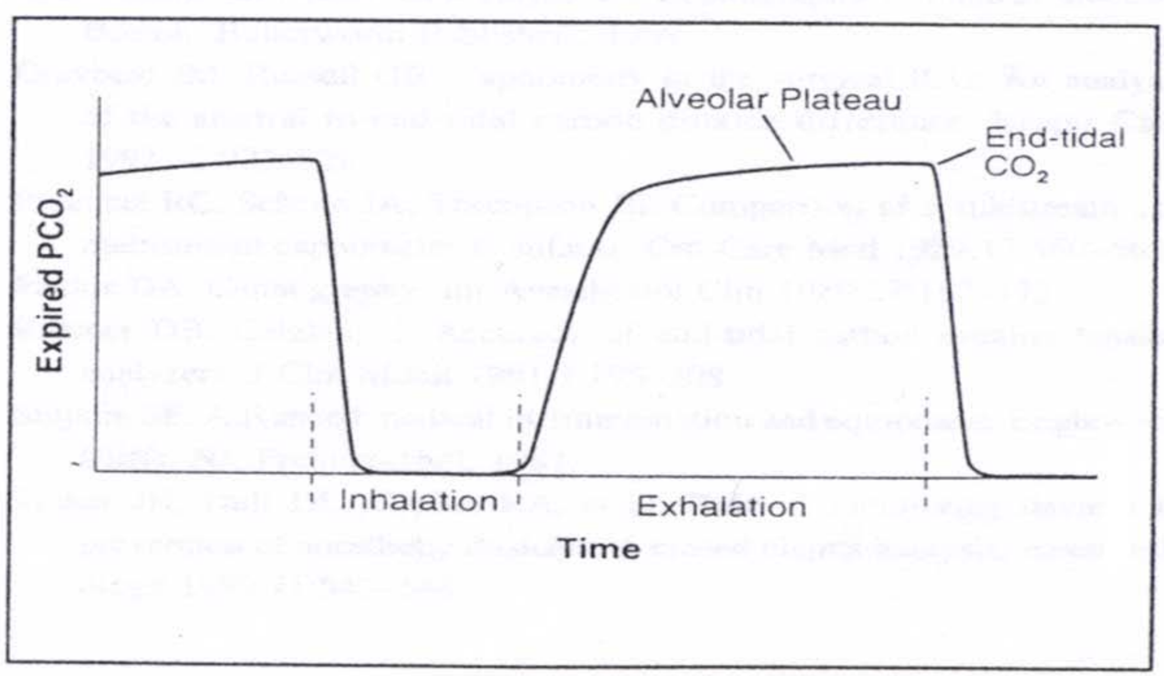
Sidestream analysis : sample of respiratory gas withdrawn continuously throughout respiratory cycle and sampled in an analyzer contained within main unit. Units typically have a 1.0-2.0 m small bore pipe leading from ET tube to main unit.

Mainstream analysis : gas is analysed as it passes through sensor at end of ET tube. Sensor connected to main unit by a cable. CO2 concentration assessed as patient breathes through sensor.

Different sampling mechanisms have differing implications for their use:

In order for us to to use a capnography we must understand the wave form and the information given to us by the wave form. The positive deflection of the wave represent the exhalation of the patient. The top of the wave represent the alveolar plateau and the end of the elevated wave represent the end tidal CO2. The sharp drop of the wave represent the inhalation stage. The Normal range is between 35-45mmHg

Below is an example of a Normal waveform



Normal Wave Form

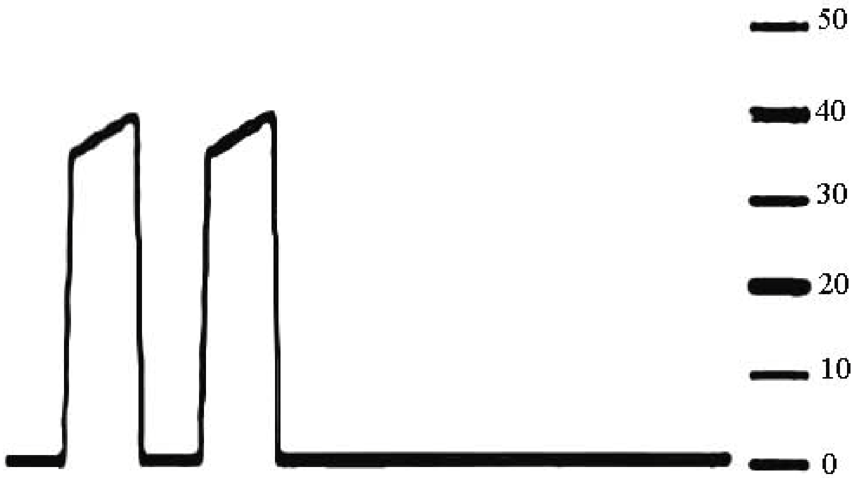
There is a large amount of information that can be gathered by the waveform. The amplitude of the wave will tell you how much oxygen exchange is occurring and the wave configuration tells you the quality of the respiration. Lets go over some of these waveform and see what information is being provided for us

Obstructive airway

- **Shark fin waveform**
- **With or without prolonged expiratory phase**
- **Can be seen before actual attack**
- **Indicative of Bronchospasm(asthma, COPD, allergic reaction)**

You can see that this patient is having trouble with exhalation giving it the shark fin form. These waveform will appear much faster than any other signs of deterioration.

Capnography is an extremely important tool when it come verification or monitoring of an endotracheal tube placement. If the tube is in place you should see a normal waveform. Lets look at some wave form of tracheal intubated patient.

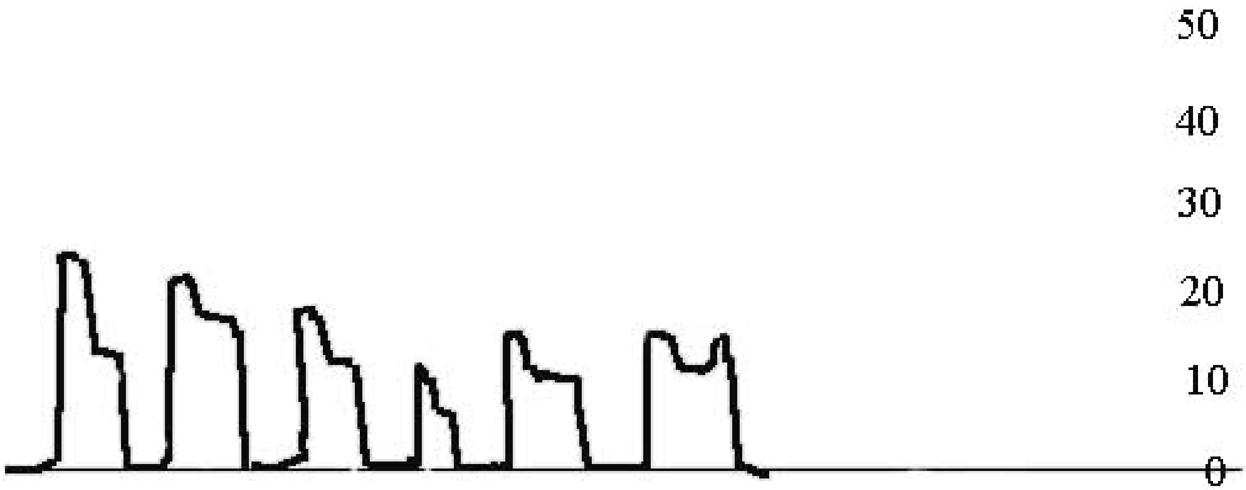


Endotracheal tube Dislodge

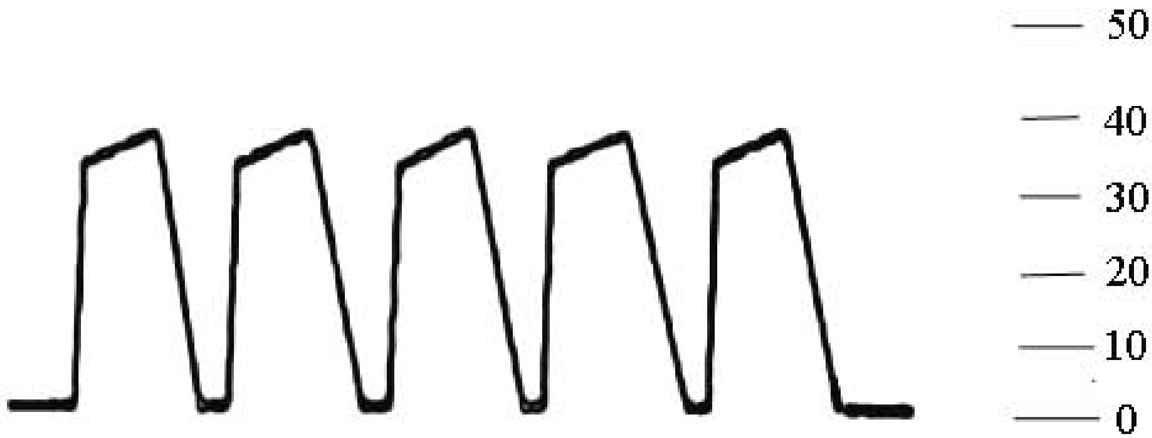
- **Loss of waveform**
- **Loss of ETCO2 reading**

Notice that you begin with a good waveform with good ETCO2 exchange of 40mmHg then it went down to 0mmHg with no waveform.

Note that there is not waveform which means no ET CO2 being produce. This is an indication of esophageal intubation.



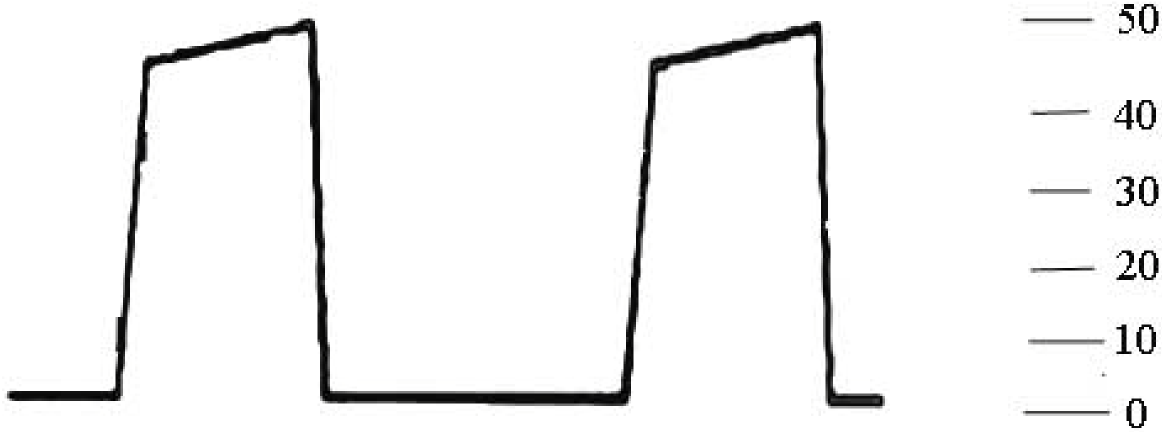
If The patient had ingested some carbonated beverage it can produce a wave form even thou the patient has been esophageal intubated. Note that the waveform is jagged and irregular in amplitude. So as you can see it as equally important to look at the waveform as much as the amount of CO_2 being produced.



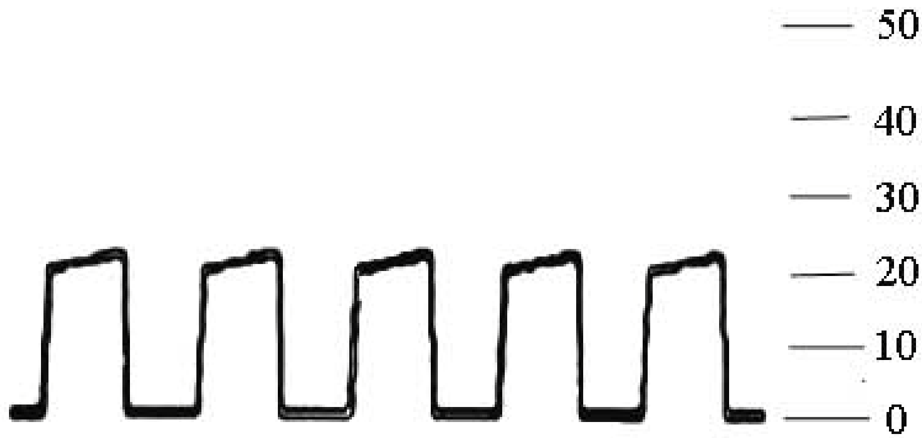
- **Angled, sloping down stroke on the waveform**
- **In adults may mean ruptured cuff or tube too small**
- **In pediatrics tube too small**

Note the steep inclined and the sloping decline, this is because as the patient is being ventilated the air pressure is escaping around the cuff or tube.

Capnography can also give you an indication of the Quality of the Ventilation. This will give you an indication if the patient is being oxygenated properly.

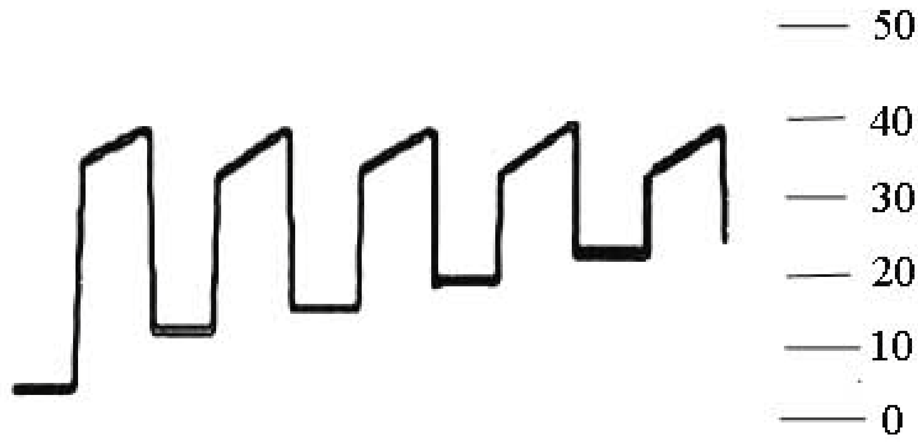


This Patient is being Hyperventilated. This indicated by the amplitude of the wave and the prolong waveform. ETCO2 end tidal is at 50mmHg which indicated increase CO2 retention.



In perspective with Hyperventilation you can see an increase in rate and decrease in ETCO2

Below 35mmHg. It is good to noted that Hypoxemia is a common cause of hyperventilation, and it may be seen in patients who have asthma, COPD, pneumonia, or traumatic injury. Anxiety or neurological disorders may also produce hyperventilation

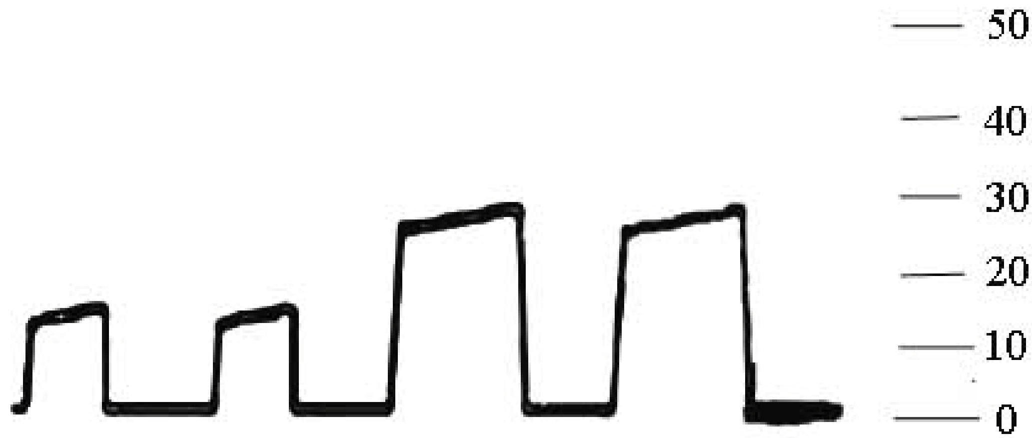


This patient is re-breathing CO_2,check equipment for adequate oxygen flow.If patient is intubated allow more time to exhale. Note that the $ETCO_2$ in the inhalation is increasing.

Along with the effectiveness of the patient ventilation capnography can assess the effectiveness

of CPR to the resuscitative patient. If good CPR is being perform and affective than there will be an exchange of O_2 and CO_2 which can be noted on the capnography waveform. The $ETCO_2$ will be lower but would range about 15-10mmHg below 10 would indicate ineffective CPR . CPR should be reassess to determine that compression and ventilation are being performed properly.

CPR Waveform: ETCO2 of 12mmHg. A sudden increase inETCO2 may indicate a ROSC.



In summary Capnography is an extremily usefull tool when it comes to resuscitation. It can confirm proper tube placement, determine the quality of ventilation and oxygenation. Capnagrapy can help to monitor your CPR effort to see it’s effectiveness.

Once you understand and become familiar with it, You will find it as useful of a tool as a blood pressure cuff to determine circulatory status.

To Start the Post Exam process and receive Credit Hours for the class just Click on start. Make sure you are connected to the internet

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