Pulmonology

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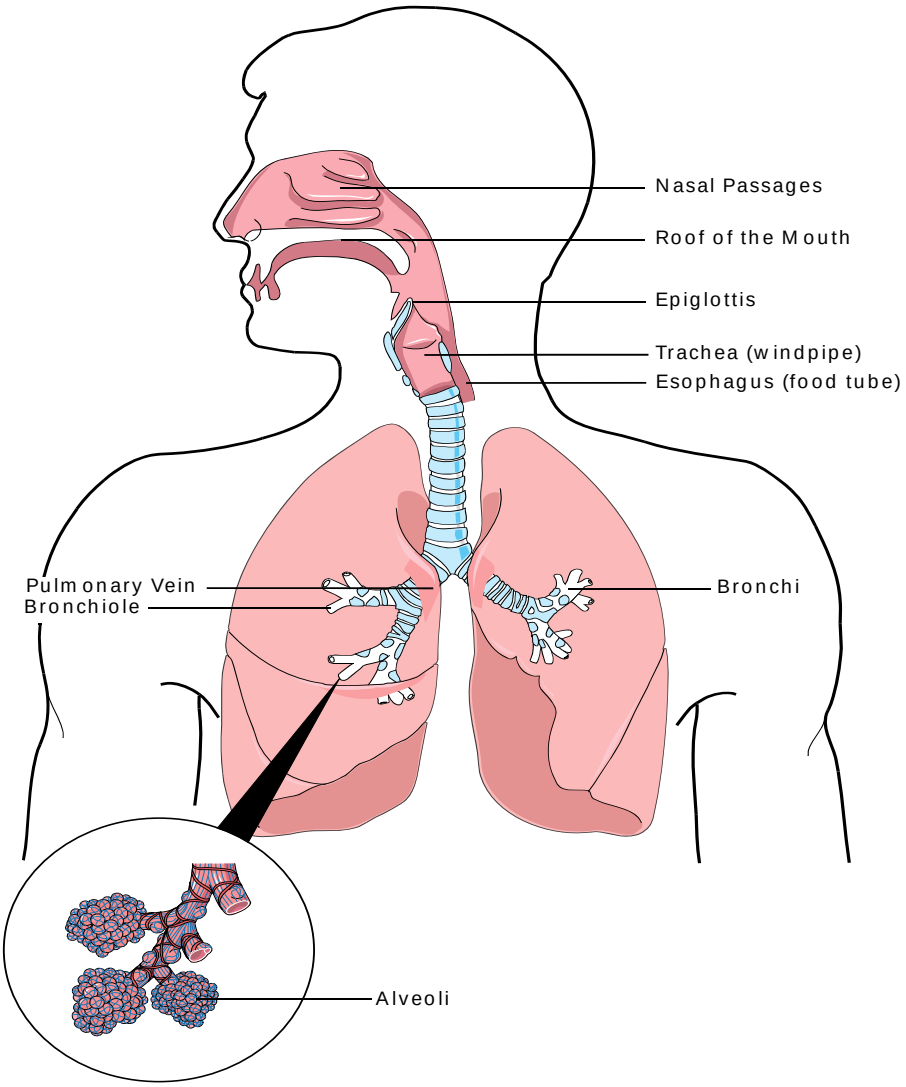
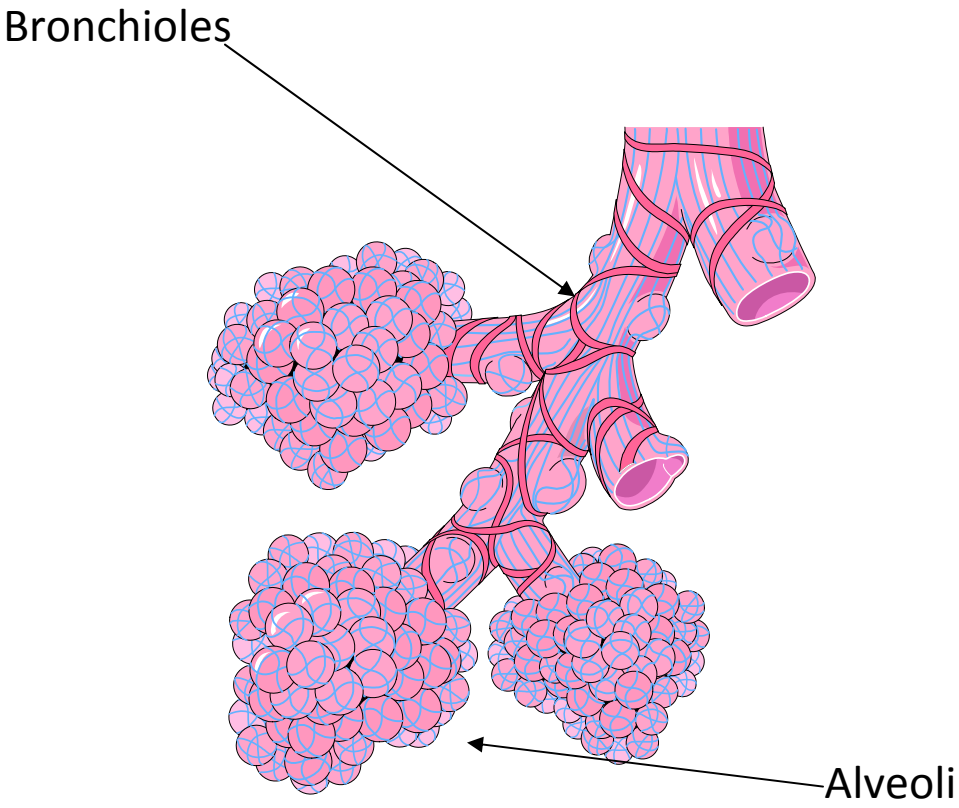
2/10/2009



The upper airway provides a physiological PEEP. PEEP is defined as the pressure against which exhalation occurs. The purpose of PEEP is to keep the alveoli open.



The term Alveoli is Italian for 'bunch of grapes'. O_2 and CO_2 exchanges at the capillary-alveolar membrane.

Ventilation is the movement of air.

- Chemoreceptors sense the increase in CO_2 and triggers ventilation
- Diaphragm contracts and moves downward
- Intercostal muscles contract and move up and out
- Chest volume increases and pressure decreases causing air to move into the lungs

DEFINITIONS

- TIDAL VOLUME (Vt): The amount of air moved in one breath. About 500cc in an adult at rest

- Anatomical Dead Space (Vd): Air not available for gas exchange. About 150cc

- Alveolar volume (Va): Air that is available for gas exchange. About 350cc (Vt – Vd= Va).

- Anything that affects tidal volume *only* affects the alveolar volume.

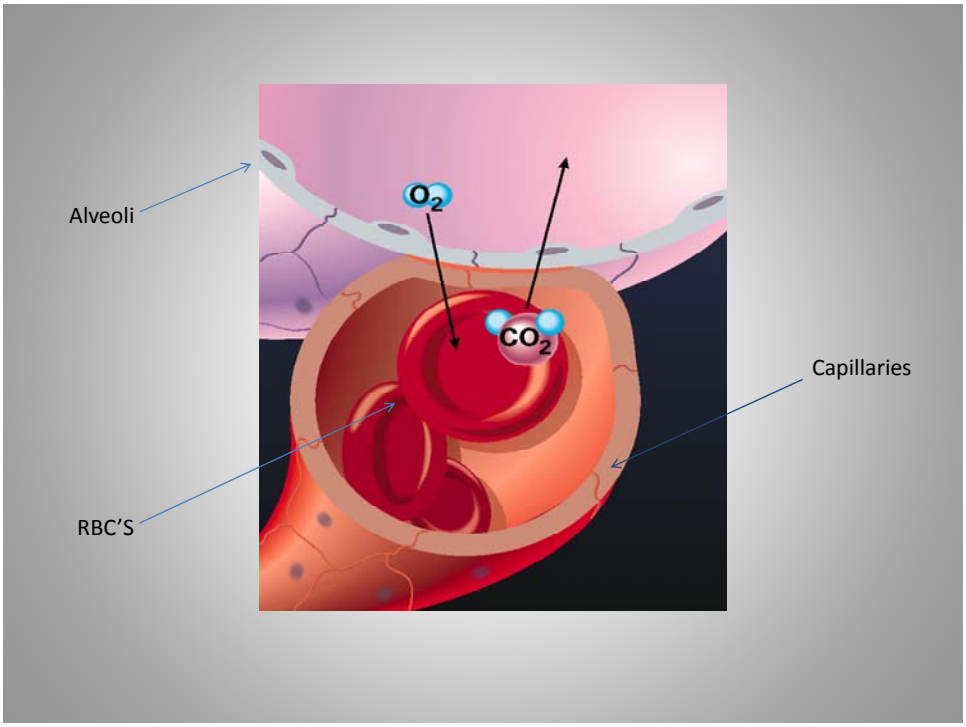
Factors that affect tidal volume

- **HYPERVENTILATION**
  - Fast breathing (tachypnea) does not necessarily increase tidal volume
  - Anxiety, head injuries, PE, AMI, diabetic emergencies, etc.

- **Hypoventilation**
  - Slow breathing does not necessarily decrease breathing
  - CNS disorders, narcotics, etc.

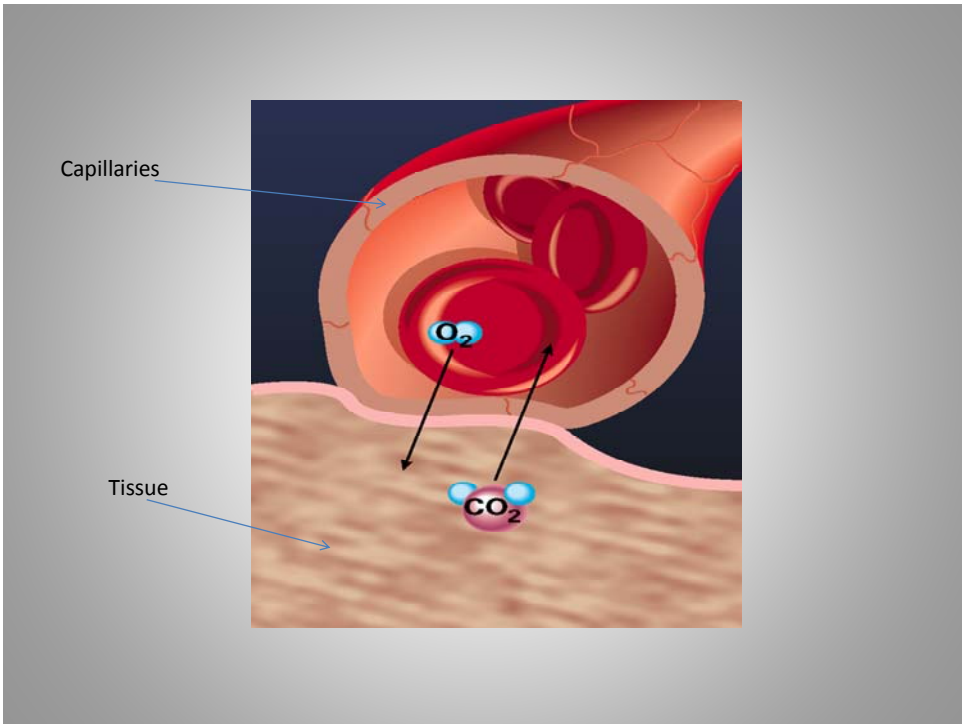
RESPIRATION IS THE EXCHANGE OF GASES

With alveolar respiration, O_2 diffuses from the alveoli into the capillaries while CO_2 diffuses from the capillaries into the alveoli.



CELLULAR RESPIRATION occurs between the capillaries and the tissues.

When there is a difference in partial pressure between two containers, gas will move from the area of higher concentration to the area of lower concentration. (Diffusion)



THE FICK PRINCIPLE

1829 – 1901

In order from adequate cellular perfusion to occur, the following must be present:

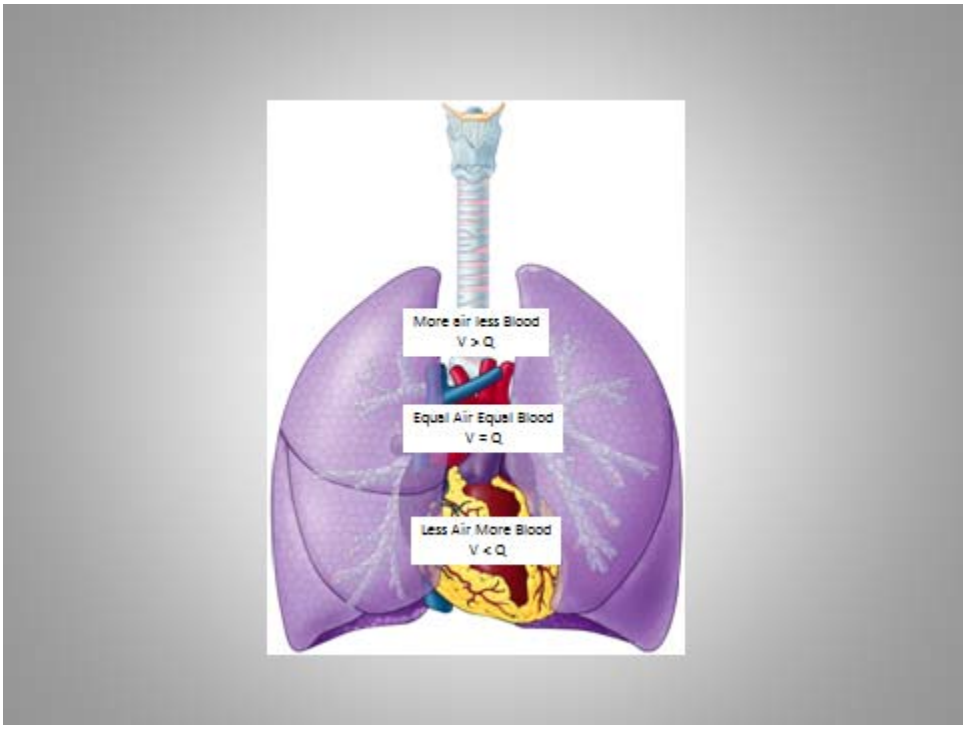
- Adequate number of Red Blood Cells (RBC's)
  - ♦ Hemoglobin on the RBC's carry the oxygen molecules

- Adequate O_2
  - ♦ Patient must have adequate O_2 coming in. See Rule of Life #1

- RBC's must be able to offload and take on O_2
  - ♦ Some conditions such as carbon monoxide poisoning and cyanide poisoning affect the RBC's ability to bind and release O_2 molecules.

- Adequate blood pressure to push cells

THE BALANCE



➢ Pathological Conditions

- Normal ventilation, poor perfusion: P.E., Arrest
- Abnormal ventilation, good perfusion: obstruction, O.P.D., drug OD
- Bad ventilation and perfusion: Arrest
- Bad exchange area: CHF

Critical Thinking Cases – Designed to illustrate the pathophysiology

- Normal ventilation/normal perfusion
- Normal ventilation/compromised perfusion
- Compromised ventilation/normal perfusion
- Compromised ventilation and perfusion

1. 26 year-old female patient took an overdose of Valium. She is UNCONSCIOUS. V/S are 110/70, pulse is 64, RR is 12 and very shallow, skin is warm and dry.

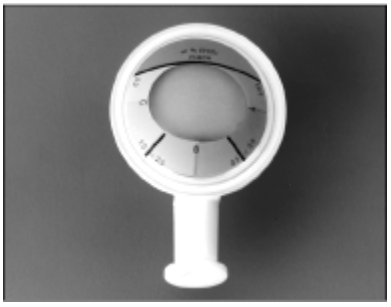
2. 65 year-old male patient complaining of a sudden onset of right sided chest pain and dyspnea. He has no medical history except for a hip replacement surgery about 3 weeks ago. His lung sounds are clear. VS are B/P 140/78, pulse is 110, and RR is about 20 and normal depth.

3. 80 year-old man complains of a sudden onset of severe headache. He has flushed skin, and has obvious facial droop to the left side. He has a history of high blood pressure. V/S are B/P 180/110, pulse is 100 and RR is 16 and normal depth.

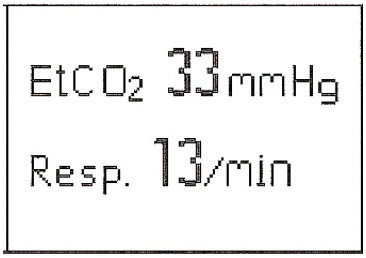
4. 37 year-old female that was involved in a head on collision. Windshield is starred and the steering wheel is broke. Bruising and crepitus found over the left chest. Pt is unconscious, difficult to bag with absent lungs sounds on the left side. Blood pressure is 60/40; pulse is 130 and weak at the carotid. There is obvious JVD. Skin is cool and clammy.

Measurement of $EtCO_2$ (Capnometry)

- Qualitative
  - (CO_2 turns the sensor from purple to yellow)

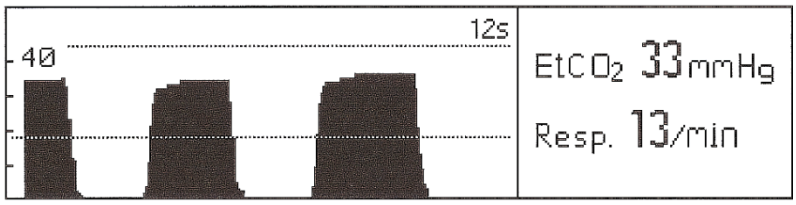


- Quantitative
  - Gives you a value ($EtCO_2$)
  - Respiratory Rate



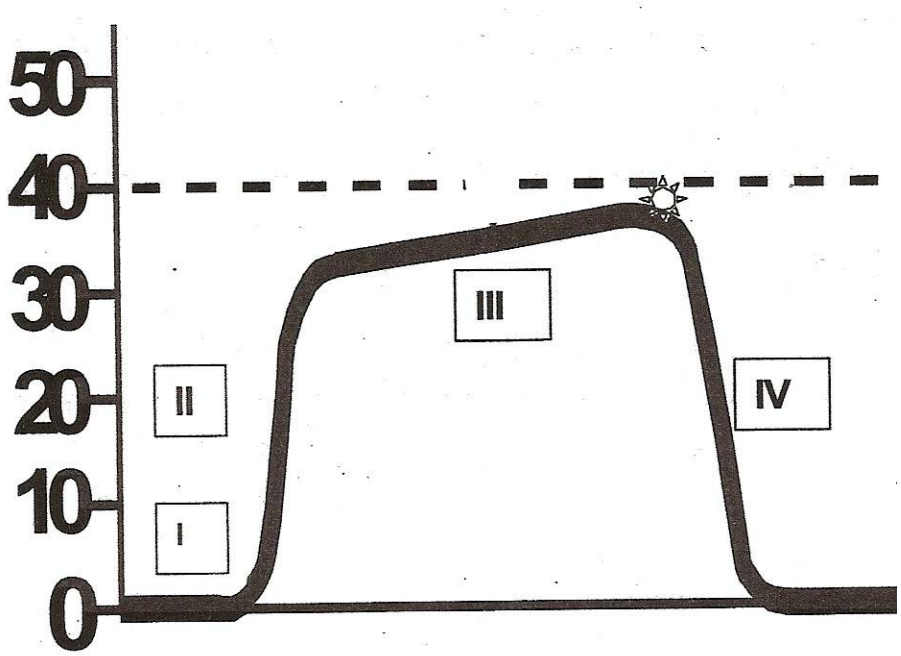
Waveform Capnography

- Features quantitative value and waveform



CLINICAL APPLICATIONS OF CAPNOGRAPHY

- **THE NORMAL CAPNOGRAM**



Phase I: Respiratory Baseline

Phase II: Expiratory Upstroke

Phase III: Expiratory Plateau

ETCO_2: Peak EtCO_2 ☼ level

Phase IV: Inspiratory Downstroke

Systematic Approach to Waveform Interpretation

1. Is CO_2 present? (waveform present)
2. Look at the respiratory baseline. Is there rebreathing?
3. Expiratory Upstroke: Steep, sloping, or prolonged?
4. Expiratory (alveolar) Plateau: Flat, prolonged, notched, or sloping?
5. Inspiratory Downstroke: Streeep, sloping, or prolonged?
6. Read the $EtCO_2$

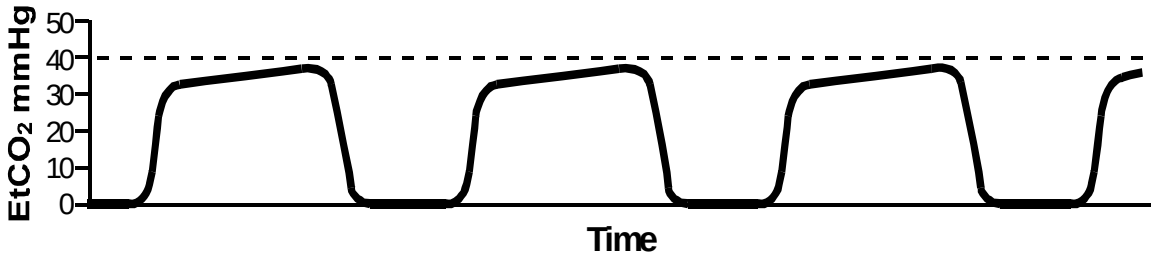
The ABC's of Waveform Interpretation!

A – Airway: Look for signs of obstructed airway (steep, upsloping expiratory plateau)

B – Breathing: Look at $EtCO_2$ reading. Look for waveforms, and elevated respiratory baseline.

C – Circulation: Look at trends, long and short term for increases or decreases in $EtCO_2$ readings

NORMAL CAPNOGRAPHY



This is a normal capnogram that has all of the phases that are easily appreciated. Note the gradual upslope and alveolar "Plateau"

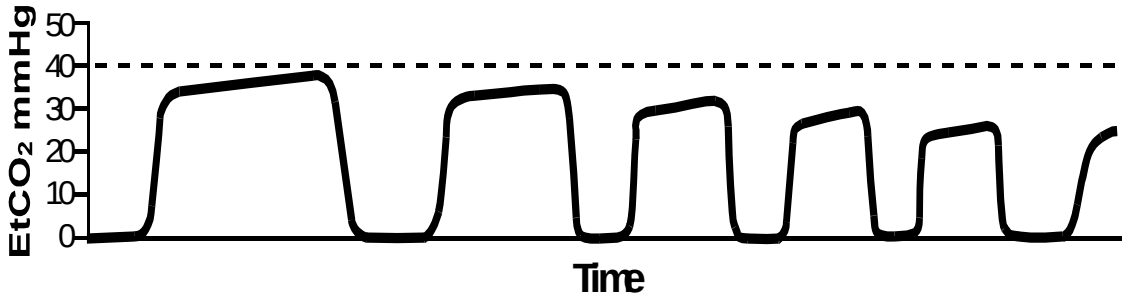
Point for thought:

List the things a normal capnogram tells you .

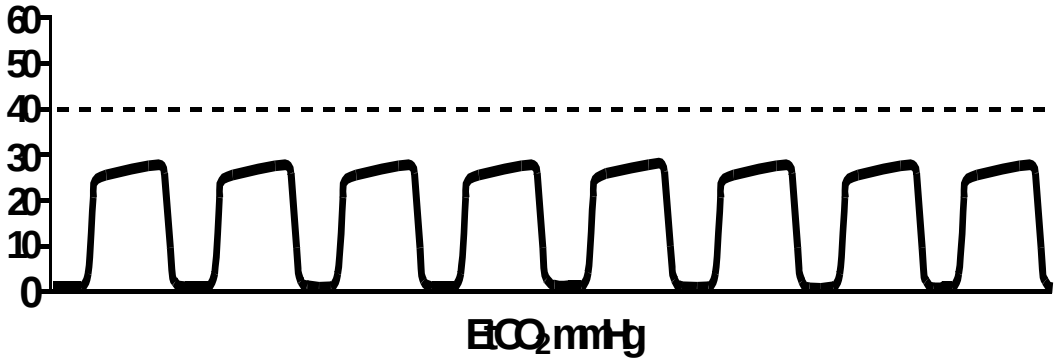
ABNORMAL CAPNOGRAPHY

- **Hyperventilation**

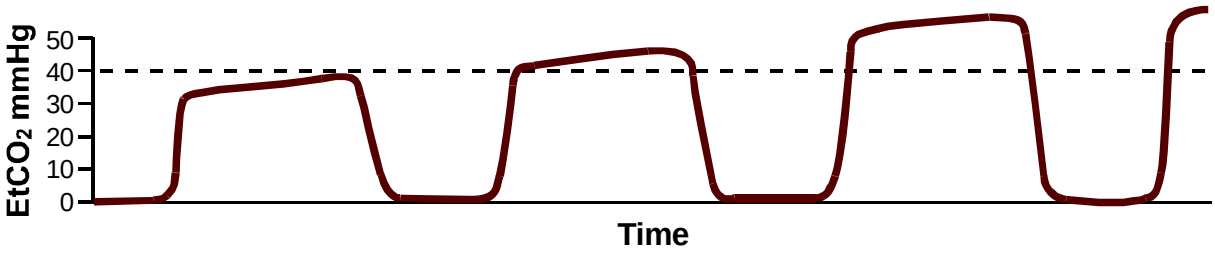
This capnogram starts slow and has an $EtCO_2$ reading that is normal. Notice as the rate gets faster, the waveform gets narrower and there is a steady decrease in the $EtCO_2$ to below 30mm/hg. Causes of this type of waveform include:



- Hyperventilation syndrome
- Overzealous bagging
- Pulmonary embolism



- **Hypoventilation**

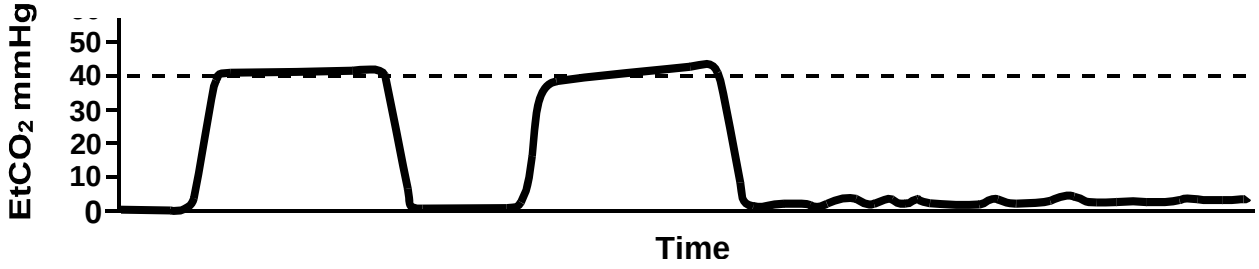


In this capnogram, there is a gradual increase in the $EtCO_2$. Obstruction is not apparent. Causes of this may include:

Respiratory depression for any reason

- Narcotic overdose
- CNS dysfunction
- Heavy sedation

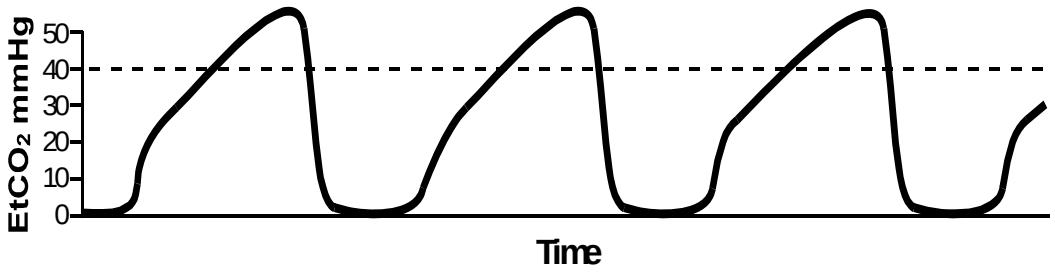
- **Apnea**



This capnogram shows a complete loss of waveform indicating no CO_2 present. Capnography allows for instantaneous recognition of this potentially fatal condition. Since this occurred suddenly, consider the following causes:

- Dislodged ET Tube
- Total obstruction of ET Tube
- Respiratory arrest in the non-intubated patient
- Equipment malfunction (If the patient is still breathing) Check all connections and sampling chambers

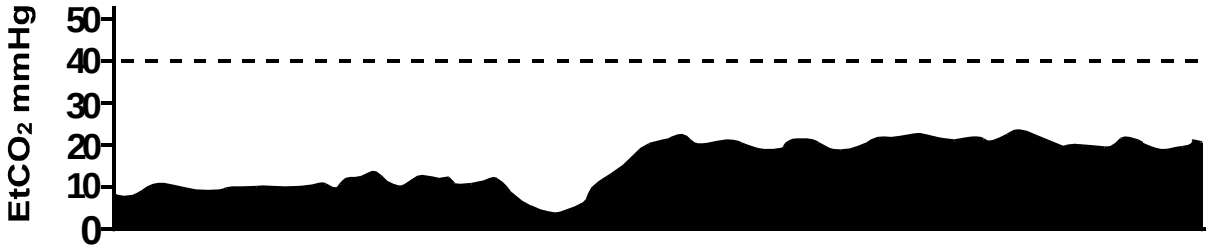
Loss of Alveolar Plateau



This capnogram displays an abnormal loss of alveolar plateau meaning incomplete or obstructed exhalation. Note the "Shark's fin" pattern. This pattern is found in the following Bronchoconstriction

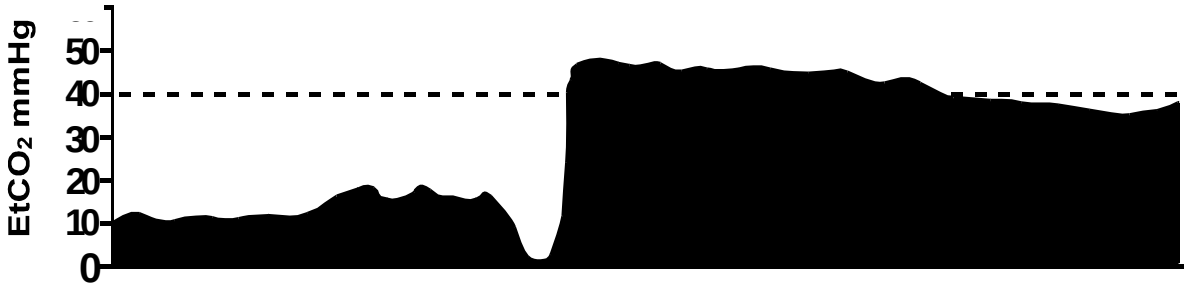
- Asthma
- COPD
- Incomplete airway obstruction
- Upper airway
  - Tube kinked or obstructed by mucous

- **Poor perfusion (cardiac arrest)**



Time: 30 minute

The capnogram can indicate perfusion during CPR and effectiveness of resuscitation efforts. Note the trough in the center of the capnogram. During this time, there was a change in personnel doing CPR. The fatigue of the first rescuer was demonstrated when the second rescuer took over compressions.



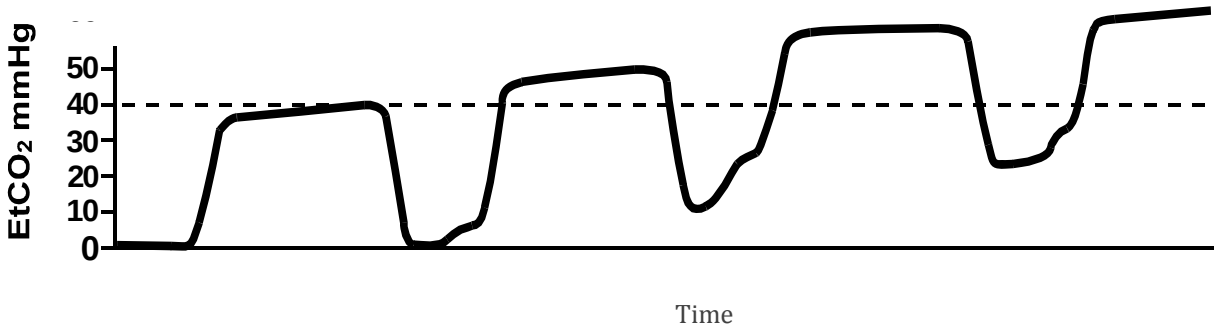
Time: trend 30 minutes

This patient was defibrillated successfully with a return of spontaneous pulse.

Notice the dramatic change in the $EtCO_2$ when pulses were restored.

Studies have shown that consistently low readings (less than 10mm) during resuscitation reflect a poor outcome and futile resuscitation.

- **Elevated Baseline**



This capnogram demonstrates an elevation to the baseline. This indicates incomplete inhalation and or exhalation. CO_2 does not get completely washed out on inhalation. Possible causes for this include:

- Air trapping (as in asthma or COPD)

- CO_2 rebreathing (ventilator circuit problem)

What other condition(s) might produce this type of waveform?

CASE SIMULATIONS AND EVALUATION

CASE # 1

Presentation

Patient is a 65 year old male complaining of crushing substernal chest pain. He rates the pain as a 10 on a scale of one to ten. He denies and shortness of breath or any other complaints. He has a history of cardiac disease and asthma.

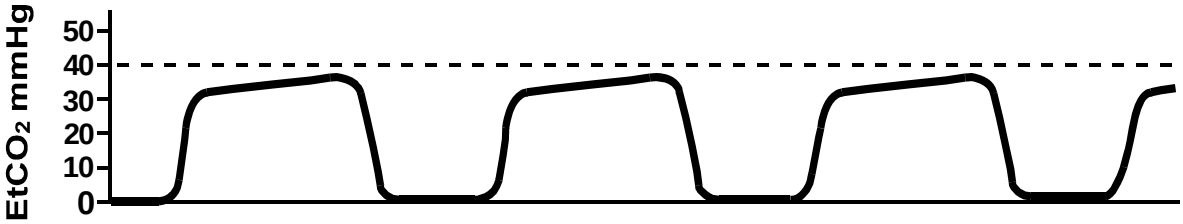
Clinical Situation

V/S: 130/80, Pulse is 100, RR is about 20

SpO_2 is 96%, $EtCO_2$ is 40

Cardiac Monitor shows Sinus Tachycardia

His capnogram is as follows.



Questions:

Is the $EtCO_2$ within normal limits?

Is the waveform normal or abnormal? Why or Why Not?

What can you deduce about the ventilation status?

A

B

C

CASE #2

Presentation

Patient is a 25-year-old male patient with a history of asthma. He has been compliant with his medications until he ran out of albuterol. Today, while at a basketball game, he suddenly gets short of breath. He does not have his albuterol inhaler with him. He presents sitting in the bleachers, in minor respiratory distress. It is noisy and hard to hear lung sounds.

Clinical Situation

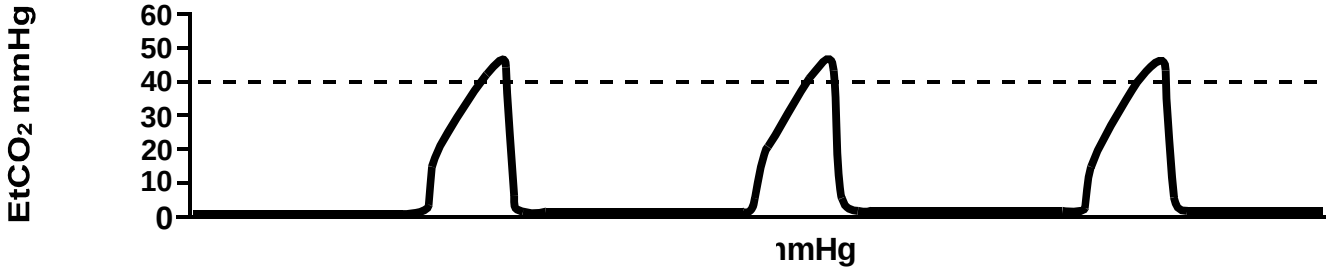
B/P 120/76

Pulse 100

RR – 14

SpO_2 94

$EtCO_2$ is 50



Questions:

Is the $EtCO_2$ within normal limits?

Is the waveform normal or abnormal? Why or Why Not?

What can you deduce about the ventilation status?

A

B

C

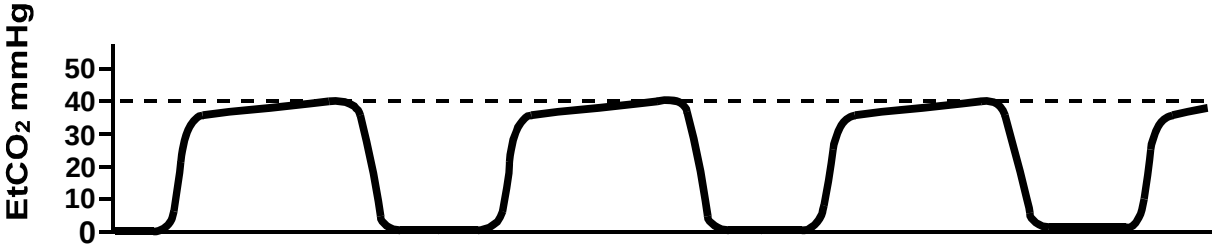
CASE #3

Presentation

You and your partner are working a cardiac arrest and are successful in resuscitation. The Patient is still unstable and the decision is made to load and go because of the very short transport time to the ED. He is intubated and $EtCO_2$ confirmed with good waveform and an $EtCO_2$ of about 42mm/hg.

The patient is not breathing on their own.

Clinical Situation:



B/P is 100/70

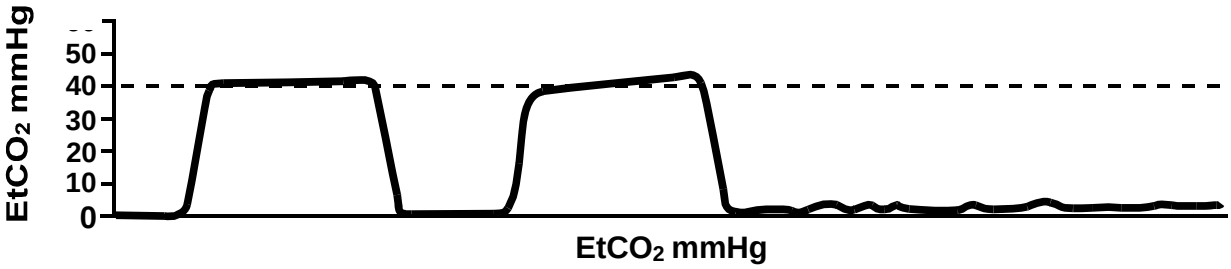
Pulse is 88

RR assisted

SpO_2 is 100% on 15lpm via NRB mask

$EtCO_2$ is 40-42

After loading him into the ambulance, the first responders resume ventilation. The capnography alarm sounds and the following waveform is seen:



CASE # 3 Continued

Questions:

Is the $EtCO_2$ within normal limits?

Is the waveform normal or abnormal? Why or Why Not?

What can you deduce about the ventilation status?
A
B
C

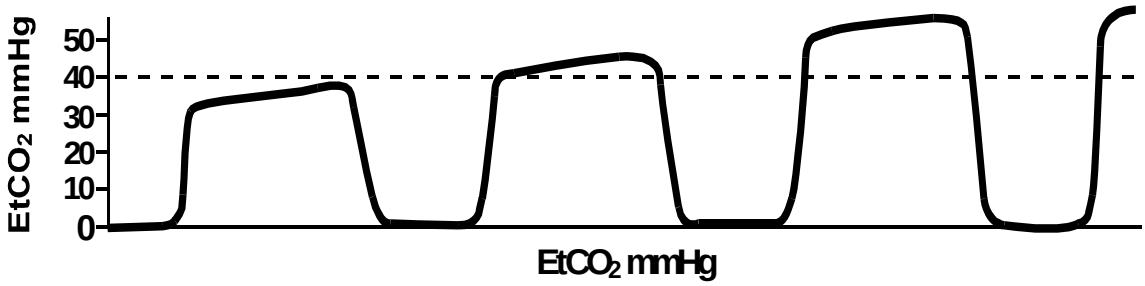
CASE # 4

Presentation

You have a 30-year-old female who was in status seizures. Your partner administers Valium to halt the seizures. The patient appears to be post-ictal but is slow to respond fully.

Clinical Situation

B/P is 114/68
Pulse is 96
RR is 12
SpO_2 is 98 on 6 lpm nasal cannula
Glucose is 100
$EtCO_2$ is as follows



Questions:

Is the $EtCO_2$ within normal limits?

Is the waveform normal or abnormal? Why or Why Not?

What can you deduce about the ventilation status?
A
B
C

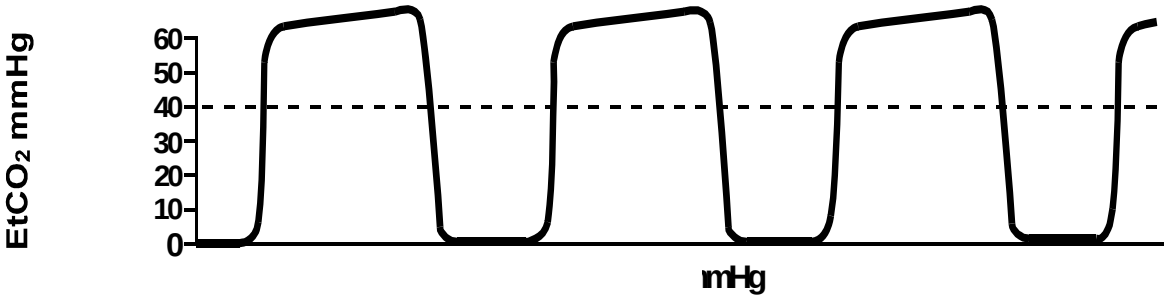
CASE # 5

Presentation

It's 3 am and you are called to a residence for a 60 year old man that is in respiratory distress. You find the gentleman sitting up on his bed with feet dangling off the end. He presents in obvious distress and cannot speak words due to the distress. His lung fields are very diminished with crackles heard. He is pale and diaphoretic and appears to be getting weaker. Family members tell you that he has a bad heart and takes a "heart pill", and a "water pill". Pt becomes obtunded with labored breathing. They still have a gag reflex.

Clinical Presentation

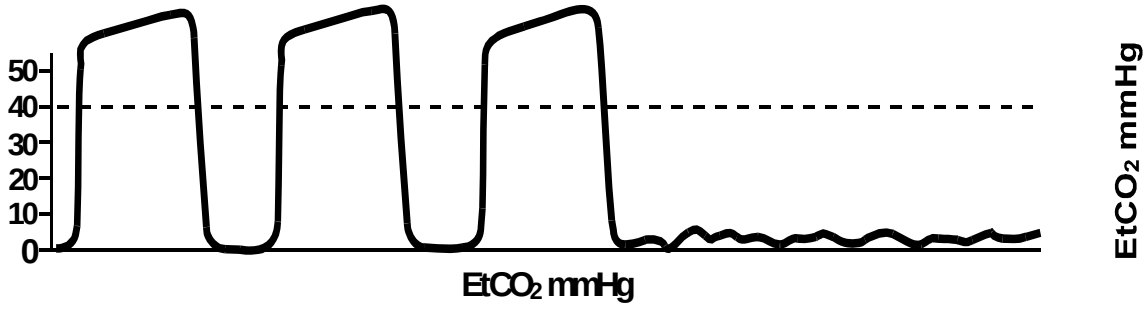
BP is 158/90
HR is 130
RR is labored
SpO_2 is 88%
$EtCO_2$ as follows



A
B
C

Case #5 Continued

The decision is made to nasally intubate this patient. The tube is passed although the lung sounds are so diminished they are hard to hear. The Pulse Ox offers no change, however, the capnogram shows the following:



Questions: Scenario 5

Is the $EtCO_2$ within normal limits?

Is the waveform normal or abnormal? Why or Why Not?

What can you deduce about the ventilation status?

A

B

C

Closing Remarks,
…From one paramedic to another….

Capnography represents another great stride in the advances in technology and medicine that have made way into the field. Not since the cardiac monitor and paramedics manually reading ECG strips has one device had the ability to benefit such a wide variety of patients.

For years, Anesthesiologists have used waveform capnography as their standard for monitoring the vital functions of patients. Now, the technology allows a smaller version to be used by paramedics.

And now, YOU are ready to do this! Think of the incredible difference this can make in the care of your patients.

To summarize, why do you need waveform capnography?

- Ventilation Vital Sign
- Confirmation of tube placement
- Constant monitoring of airway, ventilation and perfusion
- Bronchoconstriction in Obstructive airway disease
- Any respiratory patient
- Closed head injury to guide the careful elimination of CO_2
- Progressive monitoring of perfusion and ventilation

Why a color change device isn't enough

- Only confirms the presence of CO_2 not the amount
- Can't monitor the patient

Why a quantitative device is not enough

- While a number is better than just a color change,
- It can't detect bronchoconstriction
- It can't trend the level of CO_2