This PowerPoint file is a supplement to the video presentation. Some of the educational content of this program is not available solely through the PowerPoint file. Participants should use all materials to enhance the value of this continuing education program.

Capnography

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EMS/Nursing I 80813/318313

Objectives

1. Identify capnography and related terms.
2. Recognize physiological mechanisms behind capnography.
3. Recognize a normal capnogram and normal end-tidal CO_2 ($ETCO_2$) values.
4. Identify normal and abnormal capnographic waveforms.

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- **Undergrad. @ UT Permian Basin**
- **Medical School @ TTUHSC**
- **Residency in Emergency Medicine**
  - **Methodist Hospital-Indianapolis, IN**
- **Returned back to UMC's EC—now in my 21st year**
- **Medical Director since 2005**
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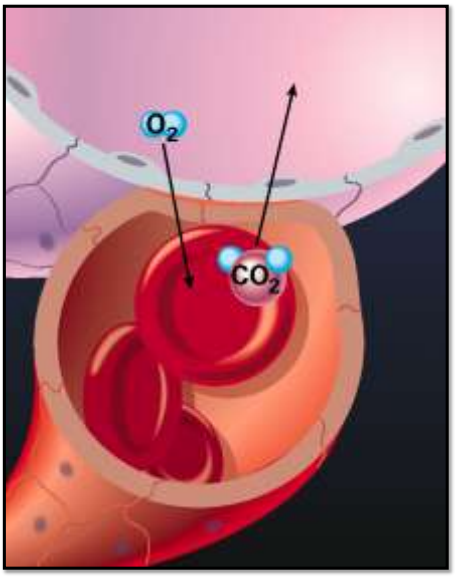
Capnography

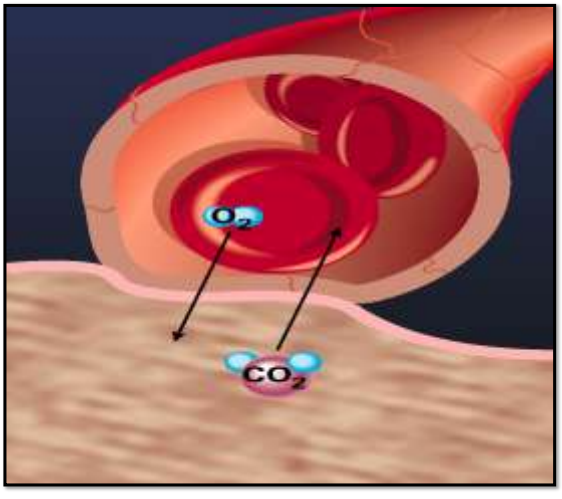
A powerful tool to objectively monitor your patient's ventilatory status

Goals

- **Define capnography and related terms**
- **Compare capnography to other monitoring parameters**
- **Describe the physiology behind capnography**
- **Identify a normal capnogram and normal end-tidal CO_2 ($EtCO_2$) values and normal and abnormal waveforms**
- **List the basic clinical applications in EMS**
- **No matter what your training level – capnography is something you can use**

CO_2 is transported and exhaled via the respiratory system – "SMOKE"





"FIRE" is the utilization of O_2 and creation of CO_2 that occurs at the cellular level

What is End-Tidal CO_2?

- The non-invasive measurement of CO_2 exhaled at the airway at the end of a breath
- Normal values are 33-42 mmHg (35-45 mmHg to make it easy)

What is End-Tidal CO_2?

"capnos" = smoke

Where there's smoke, there's fire

Why capnography?

- Capnography is an insight to the dynamic interface of the cardiovascular and respiratory systems
- It is the EKG (electrocardiogram) of the respiratory system
- Provides absolute confirmation of tube placement
- Constant monitoring of the (1) airway, (2) ventilation, and (3) perfusion
- It has close correlation with arterial levels of CO_2 (usually within 1-5 mmHg)

Why capnography?

- Normal values
  - 35-45 mmHg
  - 3 dependent variables
    - CO_2 production (fire)
    - blood flow to lungs
    - ventilation (smoke)

Why capnography?

- Why a color change device isn't enough
  - only confirms the presence of CO_2, not the amount
  - can't monitor changes in the patient condition

Why capnography?

- Why a quantitative device is not enough – while a number is better than just a color change, you miss the information available in the waveform, which is <u>invaluable</u>

Clinical Applications: Airway

- **"I KNOW THE TUBE WAS IN BUT…"**
  - **moved to gurney**
  - **moved to/from ambulance**
  - **moved to ER (emergency room)**
  - **CPR (cardio pulmonary resuscitation)**
  - **seizures**
  - **agitation**

Clinical Applications: Airway

- **Stated simply and clearly – CAPNOGRAPHY SHOULD BE REQUIRED FOR ALL INTUBATED/COMBITUBE/KING AIRWAY PATIENTS!!**

Terminology

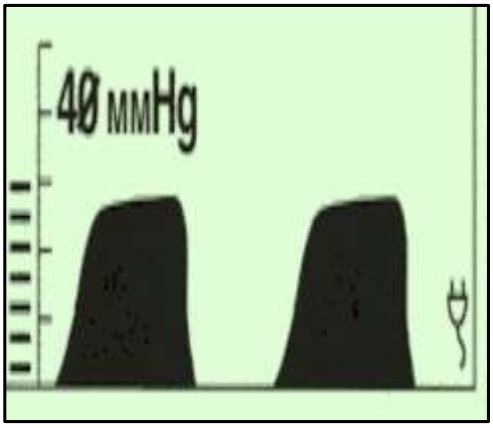
- ***Colorimetric***
  - disposable detector
  - litmus paper
  - color changes in the presence of CO_2
  - looks like this…

Terminology

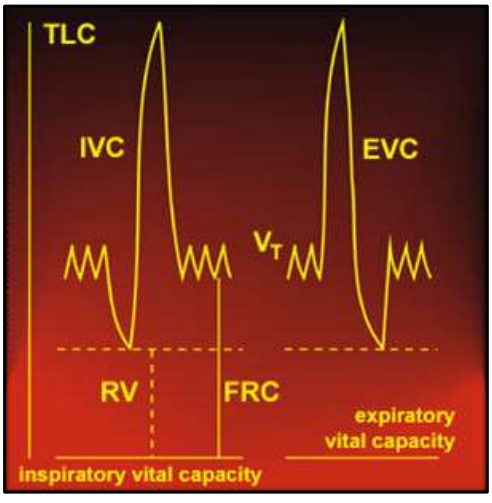
- **Capnometer**
  - an instrument
  - a monitor that provides a number *AND* a waveform

Terminology

- **Capnogram**
  - a graphical tracing or representation of exhaled CO_2 at the airway
  - called a **waveform…**



Physiology of Breathing

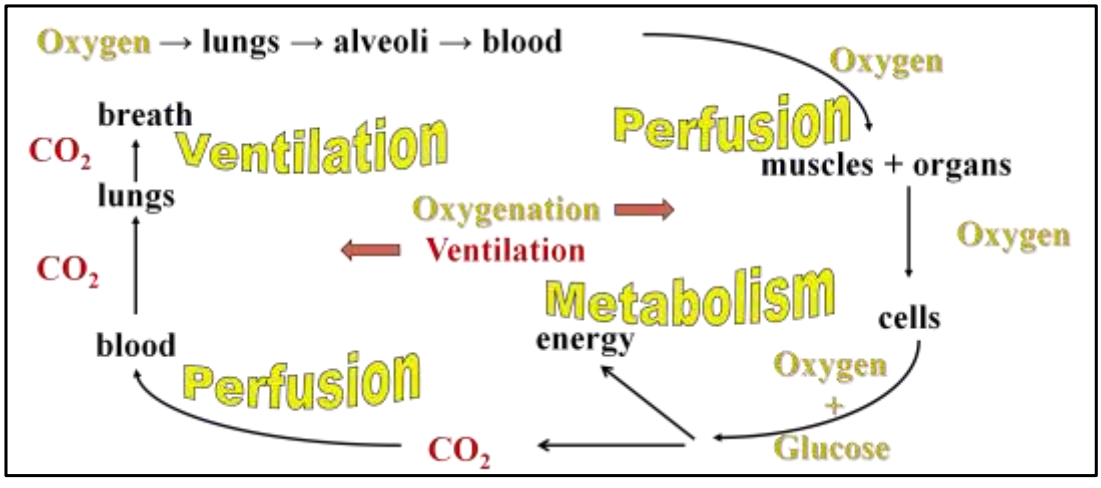


TLC – total lung capacity
IVC – inspiratory vital capacity
V_T – tidal volume
EVC – expiratory vital capacity
RV – residual volume
FRC – functional residual capacity

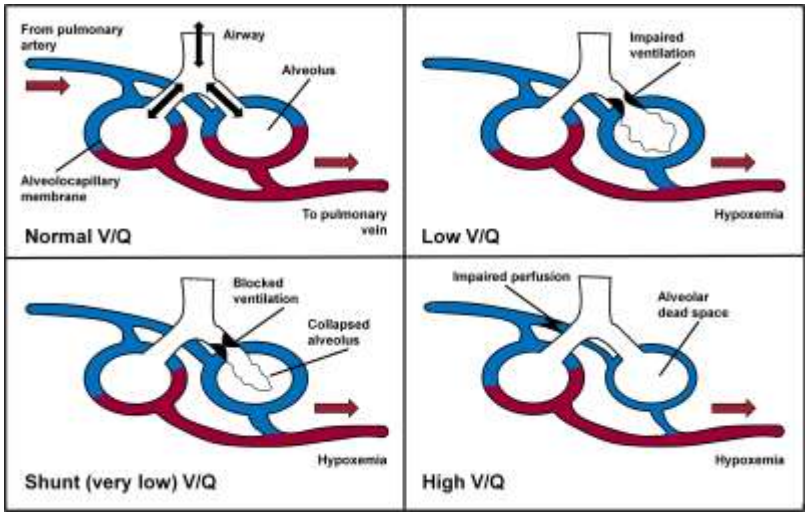
Definitions

- ***Oxygenation***: process of getting oxygen into the body and to the tissues for metabolism; monitored with pulse oximetry
- ***Ventilation***: process of eliminating CO_2 from the body; monitored with capnography

Physiology of Breathing



Physiology of Breathing



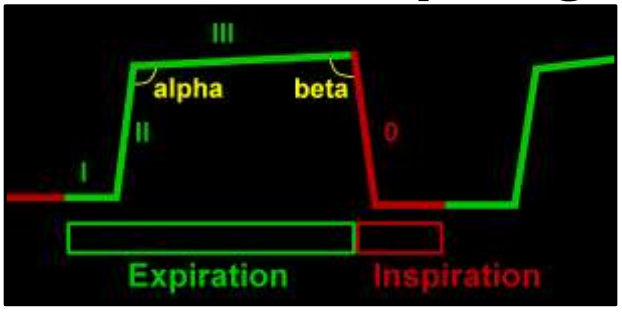
Physiology of CO_2

- Capnography can provide information about the perfusion status
- Example: low cardiac output caused by cardiogenic shock or hypovolemia won't carry as much CO_2 per minute back to the lungs, therefore…$EtCO_2$ will be reduced
- <u>Reduced perfusion to the lungs causes a low $EtCO_2$ reading</u>

Phases of Exhalation

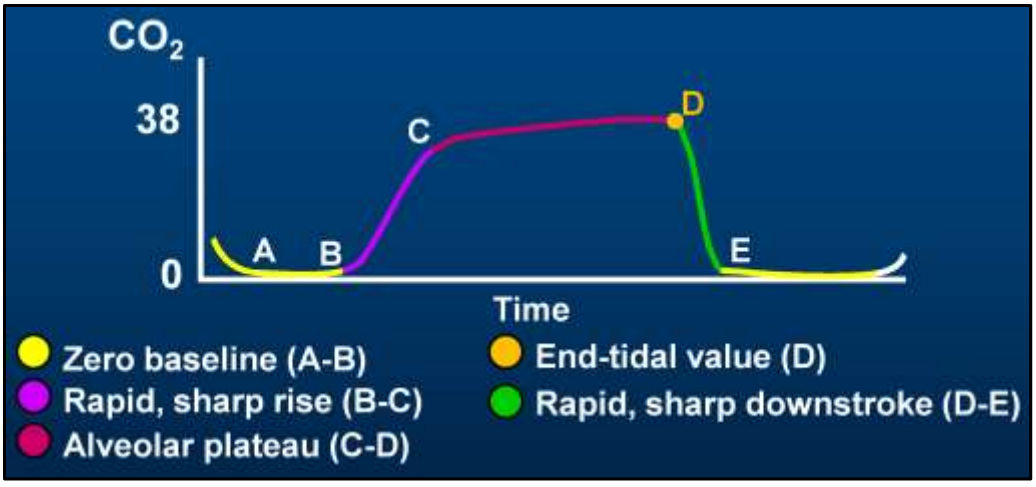
- Beginning exhalation = no CO_2 in breath
- Middle exhalation = rapid rise in CO_2
- End exhalation
  - CO_2 levels continue to gradually rise (alveolar plateau)
  - peak just before inspiration ($EtCO_2$)

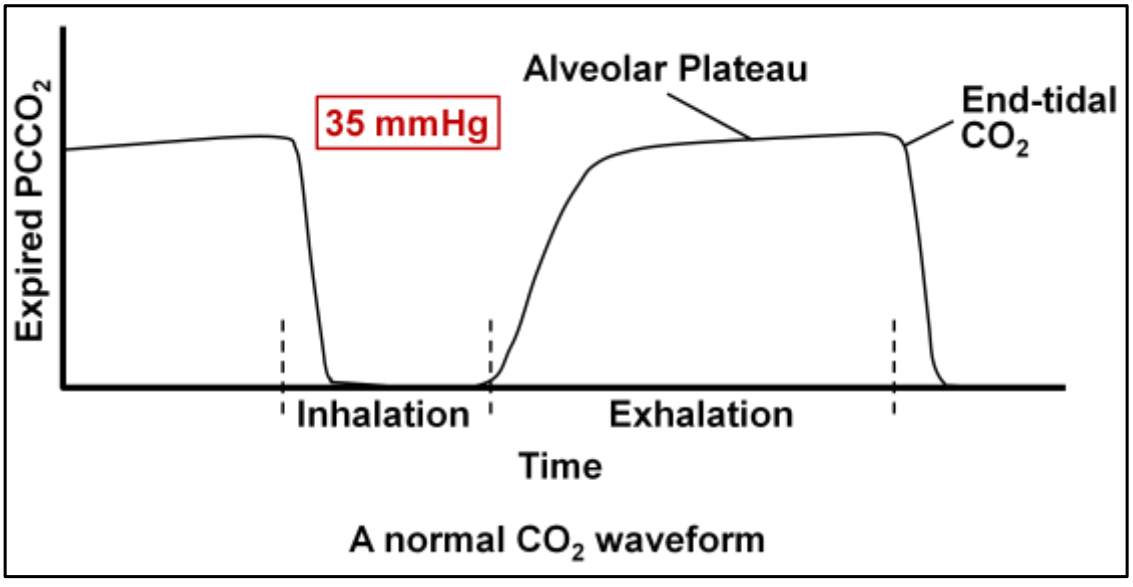
The Normal Capnogram



A time capnogram can be divided into INSPIRATORY (phase 0) and expiratory segments. The EXPIRATORY SEGMENT, is divided into phases I, II and III, and occasionally, phase IV, which represents the terminal rise in CO_2 concentration. The angle between phase II and phase III is the alpha angle. The nearly 90 degree angle between phase III and the descending limb is the beta angle.

Capnographic Waveform





Clinical Applications

- Verification of endotracheal tube (ETT) placement – The American Heart Association 2000 Guidelines state: "confirm ETT placement with non-physical examination techniques including capnography"
- Controlled ventilation for those sensitive to fluctuation – neonates and mild hyperventilation for head injuries: 30 mm
- Continuous monitoring of ETT position during transport (tube vigilance)

Clinical Applications

- CPR
  - assesses effectiveness of cardiac compression/pacing
  - is the earliest sign of return of spontaneous circulation (ROSC)
  - predictor of survival – $EtCO_2$ of 10 mm or less at 20 minutes = little chance of survival

The ABCs of Waveform Interpretation

- **A – Airway**
  - ***Is the tube in the trachea*?**
  - **Is CO_2 present for *several* breaths?**

The ABCs of Waveform Interpretation

- **B – Breathing**
  - **evaluates $EtCO_2$ number**
  - **evaluates the waveforms and trend lines**

The ABCs of Waveform Interpretation

- **C – Circulation**
  - **looks at trends, long- and short-term, for increases or decreases in $EtCO_2$ readings**
  - **looks at the morphology of waveforms**

Smoking Zone

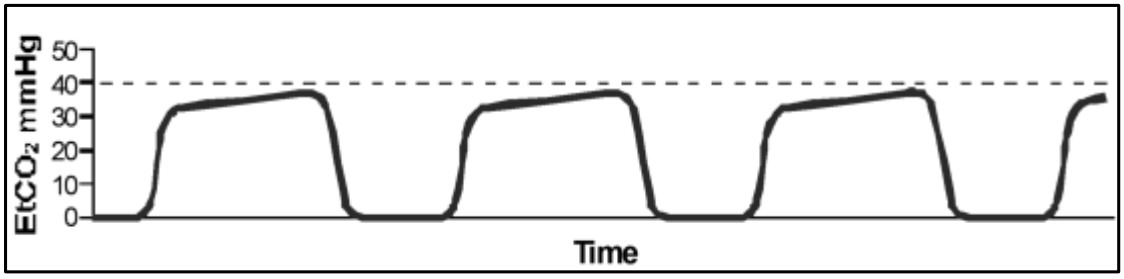
- **Causes of elevated $EtCO_2$ come from <u>increased production or decreased elimination</u>…such as (think this way):**
  - **hypoventilation (too little CO_2 removed)**
  - **hyperthermia (too much CO_2 produced)**
  - **seizure (too much CO_2 produced)**
  - **bicarb administration (CO_2 produced by the Henderson-Hasselbalch equation)**

No Smoking Zone

- **Causes of low/absent $EtCO_2$ are less production or higher elimination**
  - **hyperventilation**
  - **hypothermia**
  - **hypoperfusion**
    - **pulmonary embolus**
    - **shock with low cardiac output**
  - ***ETT dislodged or occluded (the one to remember)***

How about a right mainstem intubation?

No, NORMAL CAPNOGRAPHY



You need >50% lung impairment to affect ventilatory capnogram.
Question: Which is the larger lung?

QUIZ

ANSWER – TUBE DISPLACEMENT

- The $EtCO_2$ will respond quickly to the displacement
- $EtCO_2$ is a monitor of ventilation, SPO_2 is oxygenation

Non-intubated Applications

- Bronchospastic disease (wheezing)
- Hypoventilation states
- Shock states (hypoperfusion)
- The list goes on…

Phases of Acute Asthma Exacerbation

Phase	Clinical Assessment	$EtCO_2$ Levels
Mild	Hyperventilating	<35
Moderate	Tiring	40-50
Severe	Tired	>50

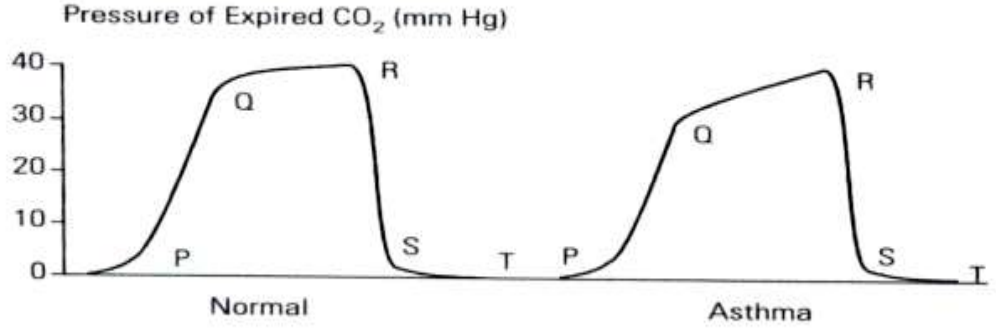
Acute Respiratory Disease

- May be a bronchospastic disease [asthma, COPD (chronic obstructive pulmonary disorder)]

Acute Respiratory Disease

- You can ~~diagnose~~ INFER presence of bronchospasm
  - great to assess response to treatment
  - The diagnosis is made by physical exam…listening!!

Capnogram of data from a normal subject and a subject with asthma.



P, onset of expiration; **segment PQ**, mixing of dead space and alveolar gases; **segment QR**, plateau phase representing alveolar gas delivery; **R**, end of expiration; **segment RS**, beginning of inspiration; **ST**, low CO_2 concentration in the airway during the remainder of inspiration.

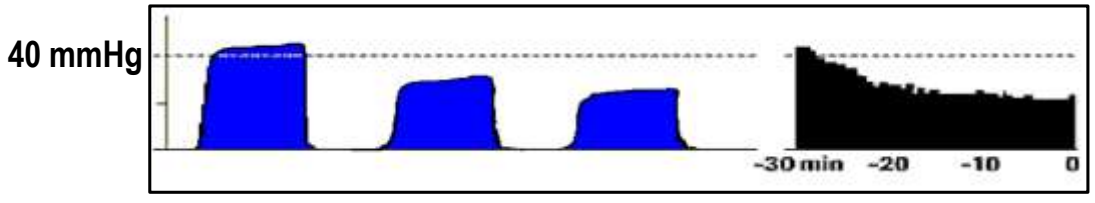
Clinical Application

- **Drug overdose**
- **Alcohol overdose**
- **Metabolic acidosis**
- **DKA (diabetic ketoacidosis): metabolic acidosis forces the Henderson-Hasselbalch equation**

Shock States

- *Give a precipitous drop or downward trending in the $EtCO_2$*
- Cardiogenic shock
- Septic shock
- Hemorrhagic shock (trauma)
- Hypovolemic shock

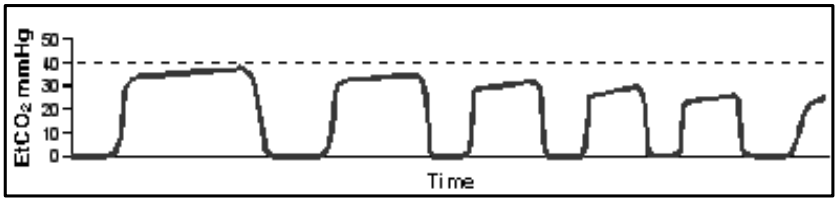
Pulmonary Embolism



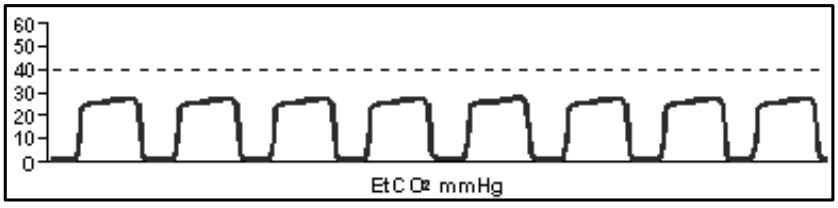
Pulmonary Hypoperfusion

- Low $EtCO_2$ with small waveform
- Low SpO_2

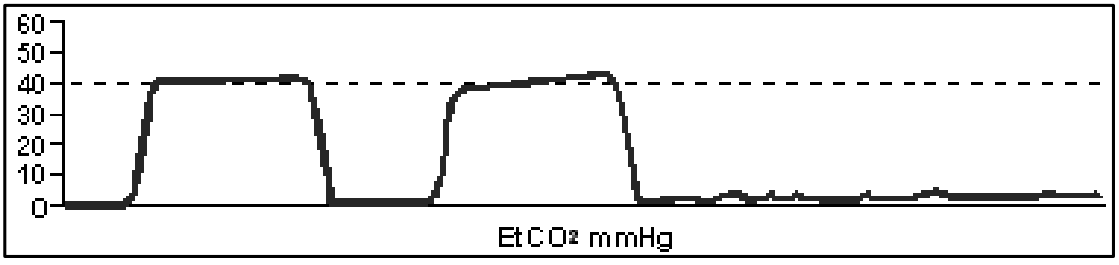
What's happening here?



Overly Aggressive/Hyperventilation

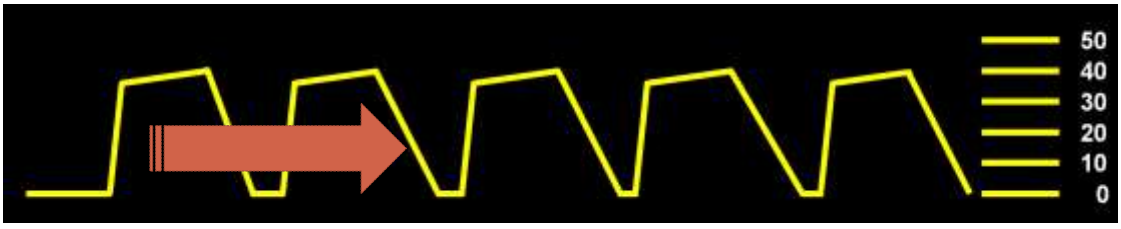


What's happening here?



Dislodged tube

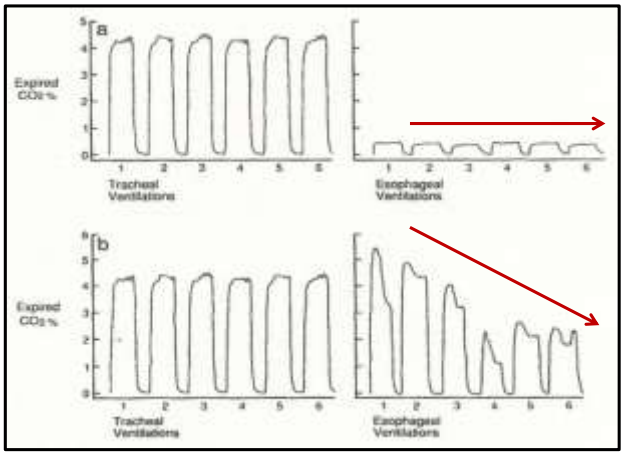
What's happening here?



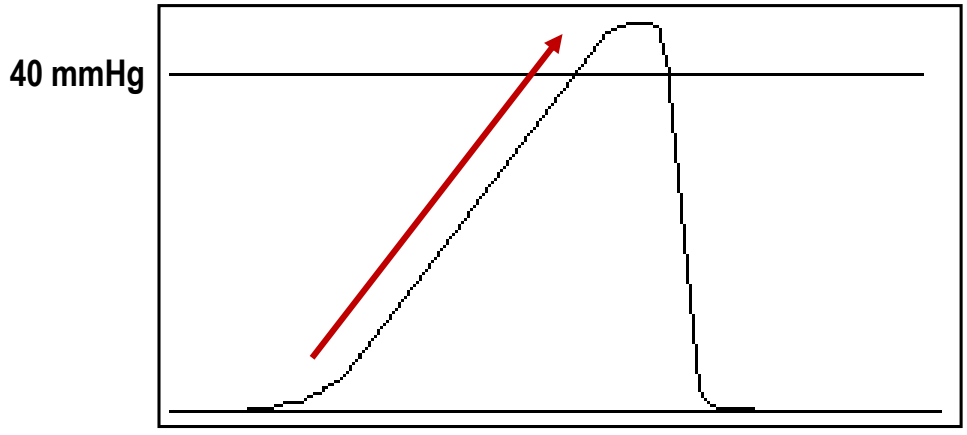
Ventilating around the tube
(i.e., tube too small, tube leak, or broken cuff)

How about esophageal intubations?

Expired CO_2 waveforms during tracheal and esophageal ventilations before (a) and after (b) addition of a carbonated beverage in the stomach



Kinking, biting, or partially occluded tubes can also be detected

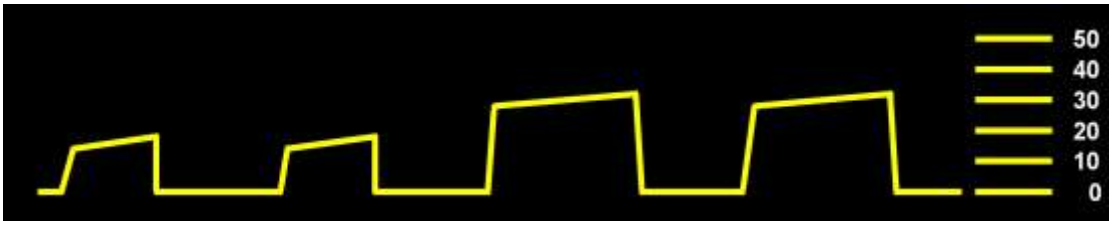


Perfusion

- Capnography can, over time, trend out an $EtCO_2$ graph and give insight to global perfusion
- ***<u>It is a proven predictor of those who do not survive resuscitation</u>***
- Gives you feedback of the effectiveness of your resuscitation efforts

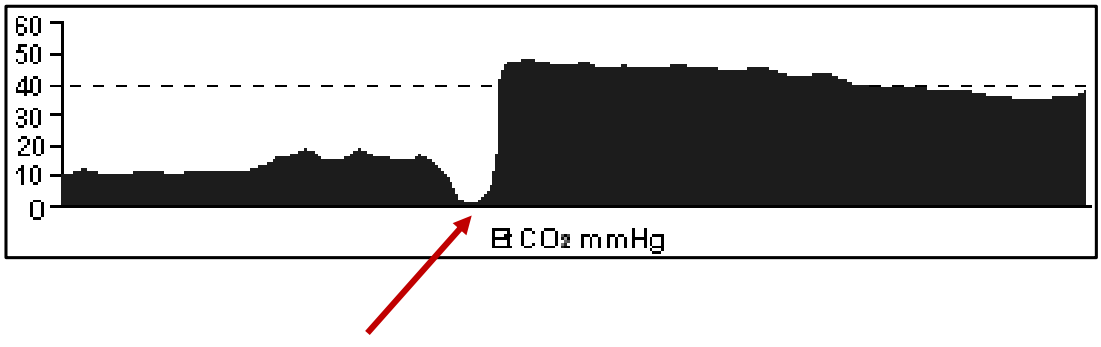
$EtCO_2$ and Cardiac Output

Sudden increase in value = ROSC



- **Cardiac arrest survivors had an average $ETCO_2$ of 18 mmHg, 20 minutes into an arrest, while non-survivors averaged 6**
- **In another study, survivors averaged 19, and non-survivors 5**

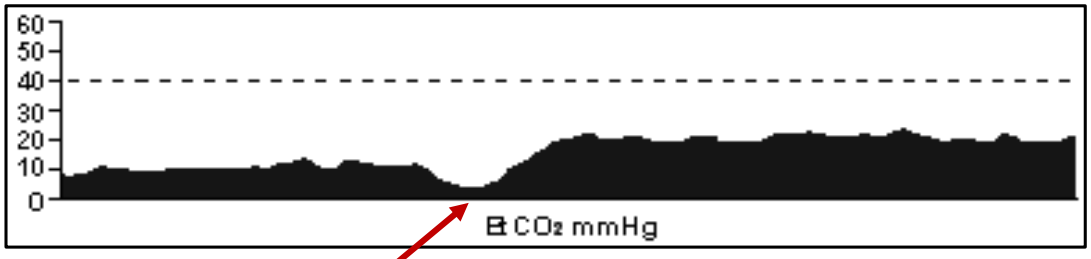
Successful Defibrillation



- **Trend line with defibrillation (note the significant and sudden increase in the $ETCO_2$ – this signifies an effective ROSC)**

$EtCO_2$ and Cardiac Output

Because $EtCO_2$ reflects cardiac output, rescuer fatigue during CPR will show up as decreasing $EtCO_2$



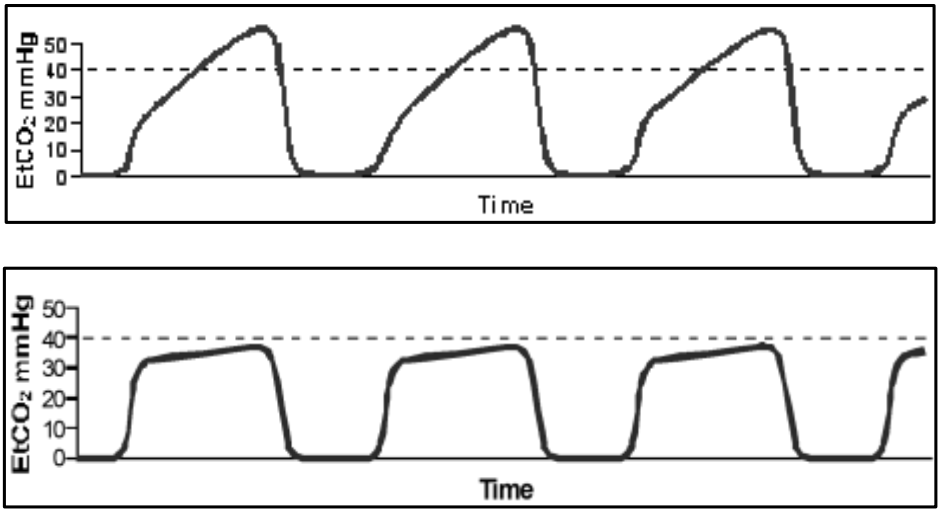
Change in rescuers (note ↑ values with non-fatigued compressor)

Nero or Head Injuries

- **Avoid hypoxemia and hypotension – this (and the following) results in brain ischemia**
- **Avoid hypercarbia and hypocarbia**
- **Control CO_2 levels near normocarbia – goal of 35-40 mmHg**

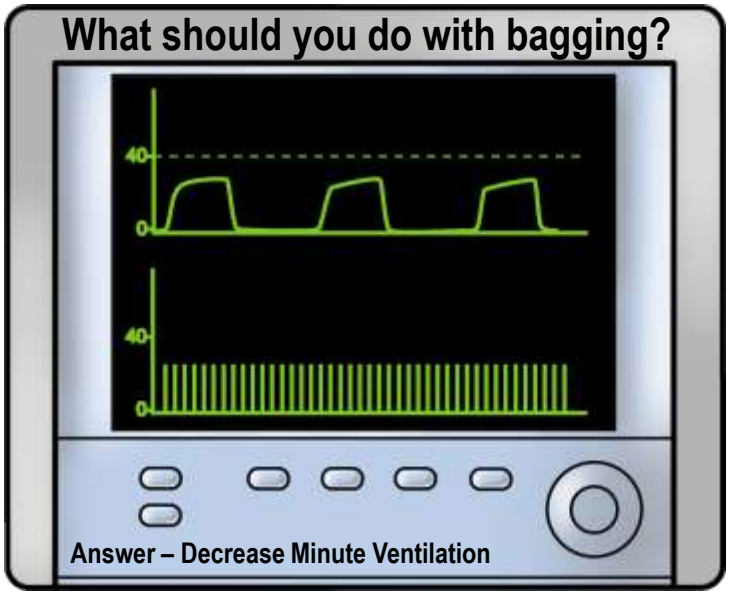
Obstructive Pulmonary Diseases

- With asthma and COPD…
  - the waveform can indicate bronchoconstriction where wheezes might not be heard and…
  - you can monitor the effectiveness of bronchodilator therapy



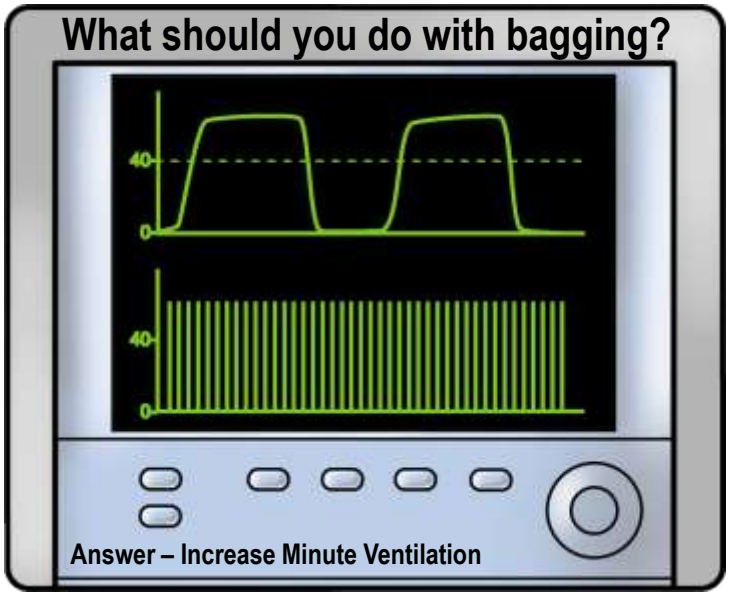
Before and after bronchodilator therapy

What should you do with bagging?



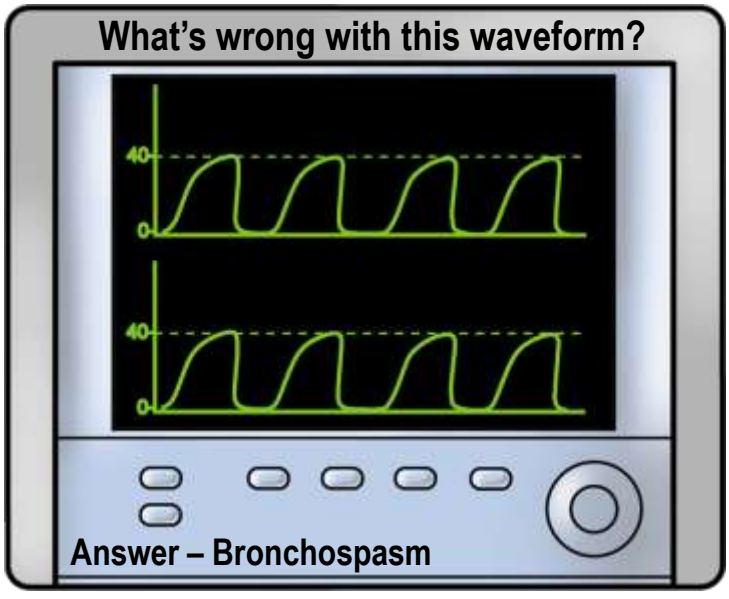
Answer – Decrease Minute Ventilation

What should you do with bagging?



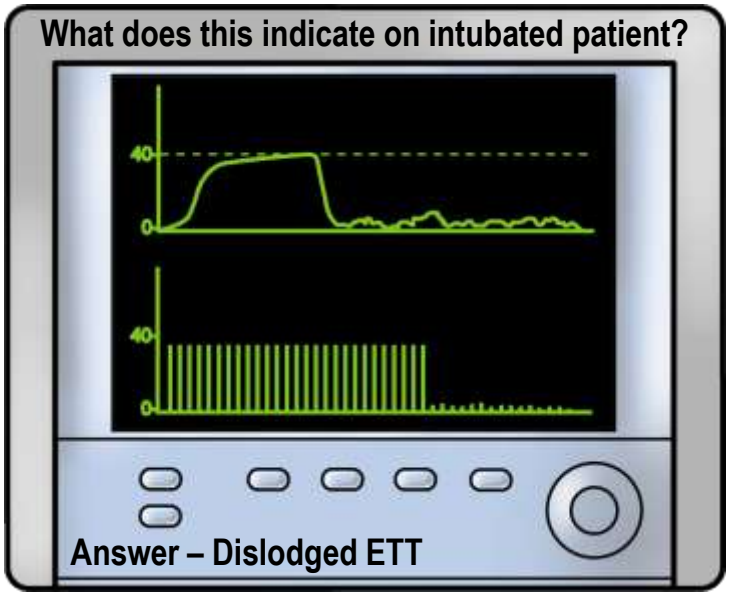
Answer – Increase Minute Ventilation

What's wrong with this waveform?



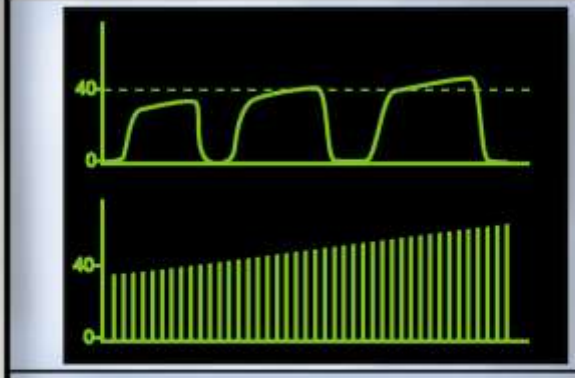
Answer – Bronchospasm

What does this indicate on intubated patient?



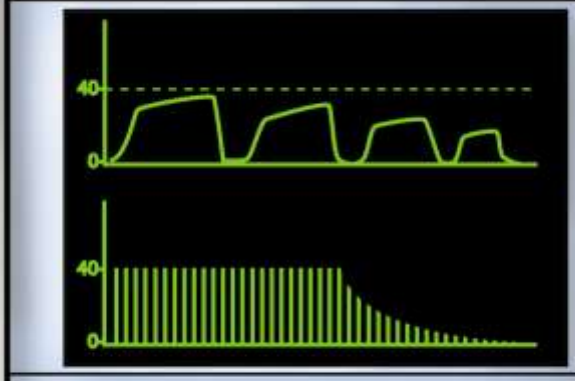
Answer – Dislodged ETT

What does this indicate on non-intubated patient?



Answer – Hypoventilation, Seizure

Is your bagging appropriate?

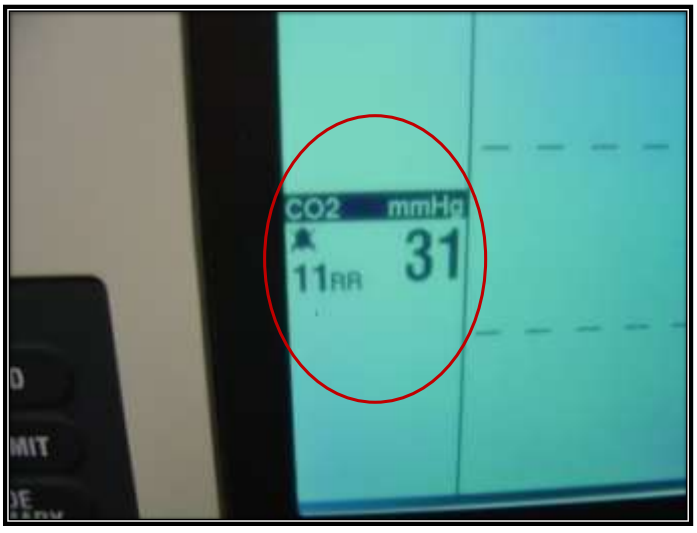


Answer – No, hypoventilation or shock

The Gear

The Gear

The Gear



The Gear

The Gear

Summary: Capnography (The Ventilation Vital Sign)

- **What can capnography monitoring do for you?**
  - **breath-to-breath monitoring via the waveform of the effectiveness and adequacy of ventilations (not oxygenation)**

Summary: Capnography (The Ventilation Vital Sign)

- What can capnography monitoring do for you?
  - allows you to make inferences as to the possible causes/diagnoses – it does not diagnose

Summary: Capnography (The Ventilation Vital Sign)

- What can capnography monitoring do for you?
  - trend lines (graphs) are a fantastic quality improvement tool for a director to, at a glance, check a medic's performance

Summary: Capnography (The Ventilation Vital Sign)

- What can capnography monitoring do for you?
  - also a great way for the medic to self-evaluate a call

Summary: Capnography (The Ventilation Vital Sign)

- Tracks the progress of the patient's condition
- Confirms with certainty tube placement
- Helps to troubleshoot ***changes*** in the patient's condition

Summary: Capnography (The Ventilation Vital Sign)

- **Non-intubated**
  - **monitor breathing status of *obtunded or sedated* patients**
  - **track progression of acute respiratory failure**

Summary: Capnography (The Ventilation Vital Sign)

- **Remember, it is a tool…it does not diagnose!!**
- **A fool with a tool…is still a fool!!**

Capnography

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- **Complete the course evaluation.**
- **Complete the posttest with a score of 80% or greater.**
- **Complete the time utilized in course completion including the posttest.**

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