"CO^2 is the smoke from the flames of metabolism"

-Ray Fowler, MD

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History of capnography

Introduced in 1943 for anesthesia monitoring

In 1979, Unrecognized esophageal intubation *(in the OR)* was found to be the most common cause of brain damage and death among surgical complications.

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How it Works

Metabolism creates $ETC0^2$ for excretion

ETC02 and Oxygen are exchanged at the alveolar level in the lungs with each breath.

The higher the metabolic rate = the more ETC02

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CPR Prognostic Indicator

<By Using ETC02> Cardiac Output and Pulmonary Blood Flow can be detected even without palpable pulses.

Annals of Emergency Medicine 1994

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AHA Guidelines (2015)

"Continuous waveform capnography …. Most reliable method of confirming… placement of ET Tube"

"High quality chest compressions are achieved when the ETC02 value is at least 10-20 mmHg"

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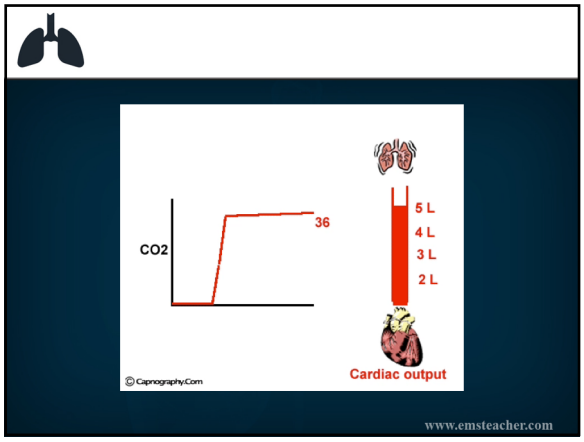

ETC02 is used most often in EMS settings for Respiratory Depression and ETT confirmation

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Respiratory Depression Risks

Sleep Apnea / Sleep Disorder / Snoring

Head Injury

Morbid Obesity

No recent opioid usage hx OR Chronic opioid Use

Pre-existing cardiac or resp. dysfunction

Additional sedation drugs*

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Other common indications

Assessing effectiveness of Rt. Tx.

Effectiveness of CPR

Effectiveness of BVM ventilation

Assess Circulatory Status

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Less Common Applications

Seizure Activity ☺

Magnesium Drips (OB World)

Propofol Drips (non-intubated)

Conscious Sedation

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Joint Commission Recommendations

Pulse oximetry to monitor oxygenation BUT
"not to rely on pulse Oximetry alone"

Capnography used to monitor Ventilation

"Continuous use of both rather than intermittently. "

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Oxygenation vs. Capnography

Oxygen for metabolism	Carbon Dioxide from metabolism
Sp02 changes take 1-5 minutes	ETC02 changes take seconds
Waveform may remain normal even if pt. is NOT	Waveform will not be normal when the pt is NOT.
Influenced by Supp. O^2	Not affected by Supp 0^2

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"Without proper circulation a normal capnogram is **not possible**"

Recording and analysis of the C02 waveform and its use in differential diagnosis

Professor B. Smalhout, MD, Ph.D.

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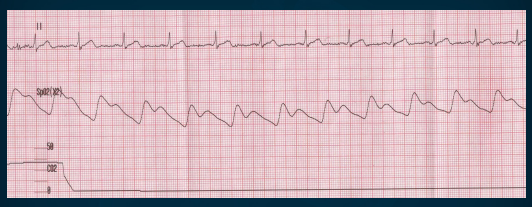

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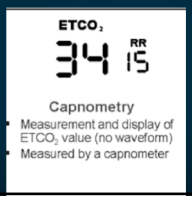
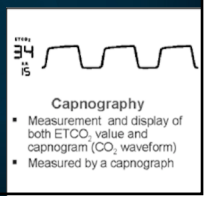
Types of ETC02 Detectors

Colorimetric: positive color change w/ ETC02

Capnometer: the numeric measurement of ETC02

Capnograph: an expired waveform + a numeric value.





Side Stream vs. Mainstream

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Sidestream vs Mainstream

- Takes a sample of gas and interprets into waveform
- Can be used on non-intubated pts
- Handheld capability
- Can get clogged with gunk
- Disposable

- Infrared absorbs gas and interprets into waveform
- ONLY intubated patients
- No portability
- No worries with gunk
- RE-usable.

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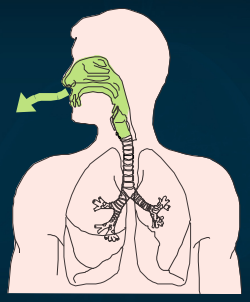
Dead Space



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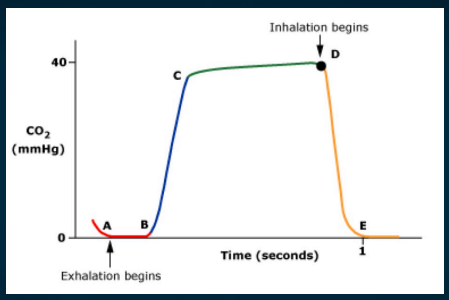

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Waveform Interpretation

Height = amount of ETC02

Length = length of exhalation

Rate = Resp. Rate

Baseline = does it trend up?

Shape = squares, shark fins, dips, camel humps, icebergs?

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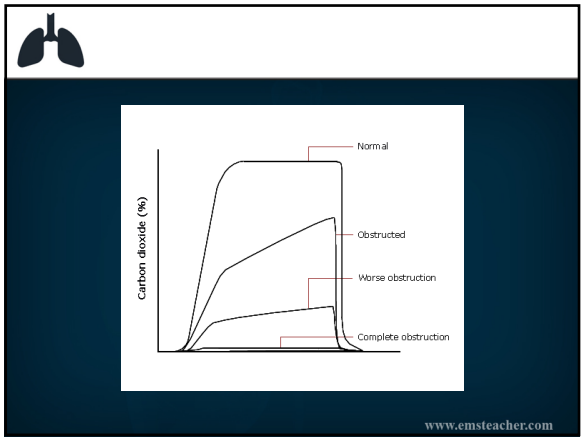
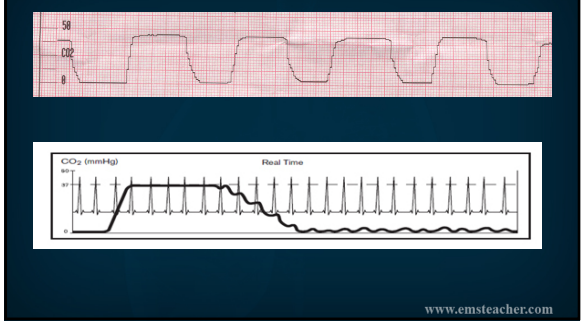


Normal Waveform



Hypoventilation

When ETC02 is retained, it builds up in the body and alters the pH of the blood.

This pH alteration hits the chemoreceptors in the brain.

The brain senses a decrease in pH and tells the lungs to “Breathe More”

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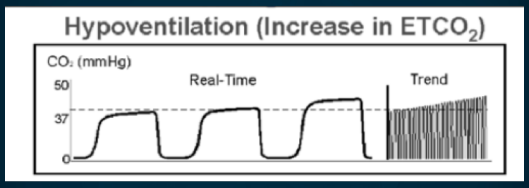
Hypoventilation



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$C0^2$ Narcosis

When the lungs fail to breathe as instructed, ETC02 continues to build up.

If nothing is done about the increasing C02 the brain starts getting sleepy

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Increased ETC02 Causes

Hypoventilation
Decrease in Tidal Volume
Malignant Hyperthermia
Early stage sepsis
Rebreathing
Fever*
Bicarb administration

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Hyperventilation

As the patient hyperventilates, the carbon dioxide is breathed off.

ETC02 decreases with every breath.

ETC02 causes vasospasms ➔ decrease in perfusion to the brain, chest discomfort, tingly lips, fingertips, etc.

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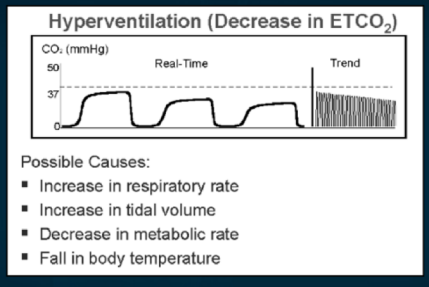
Hyperventilation



Possible Causes:
- Increase in respiratory rate
- Increase in tidal volume
- Decrease in metabolic rate
- Fall in body temperature

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Decreased ETC02 Causes

Hyperventilation

Anxiety Attacks

Pulmonary Edema

Hypotension / Circulatory Collapse

Hypothermia

Apnea

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Sudden Drop to Zero

Cardiac Arrest? – Check a PULSE!!

Misplaced / kinked ET Tube

C02 analyzer defective

Ventilator Defective

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Esophageal Intubation

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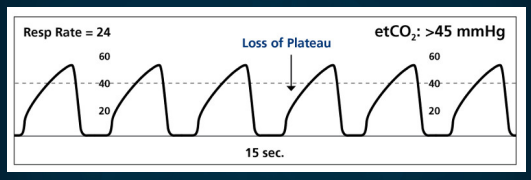
Obstructed Airway



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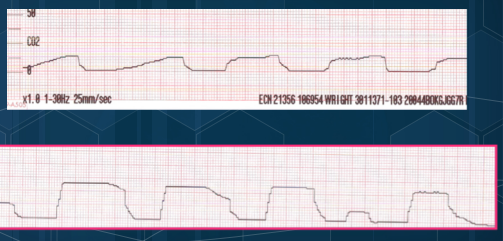
Capnography



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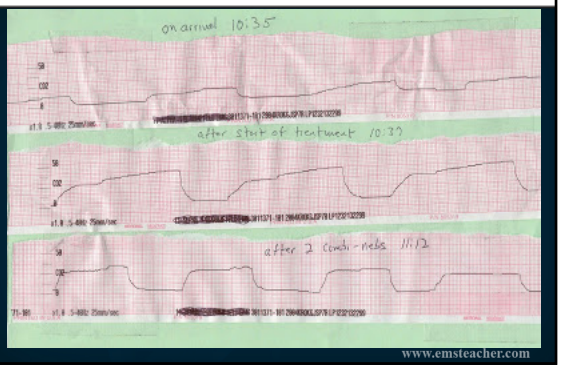

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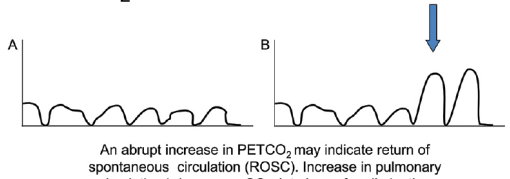
ROSC

CO_2 waveform during CPR



An abrupt increase in $PETCO_2$ may indicate return of spontaneous circulation (ROSC). Increase in pulmonary circulation brings more CO_2 into lungs for elimination

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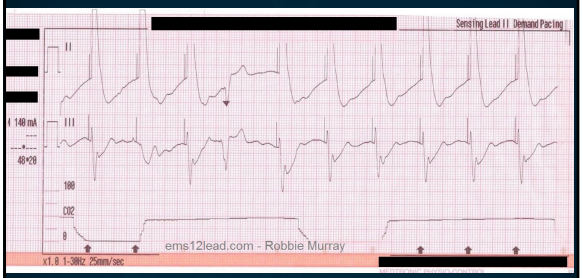
Mechanical or Electrical Capture



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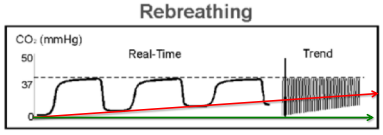
Baseline

Rebreathing



Possible Causes:

- Faulty expiratory valve
- Inadequate inspiratory flow
- Insufficient expiratory time
- Malfunction of CO_2 absorber system

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Air Leak or ETT too small

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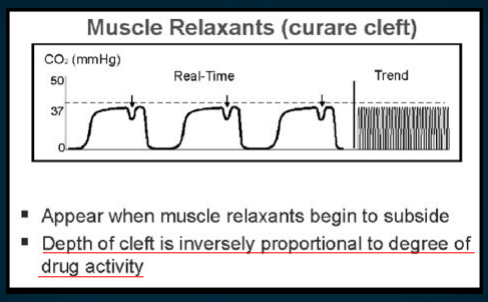
Curare Cleft



- Appear when muscle relaxants begin to subside
- Depth of cleft is inversely proportional to degree of drug activity

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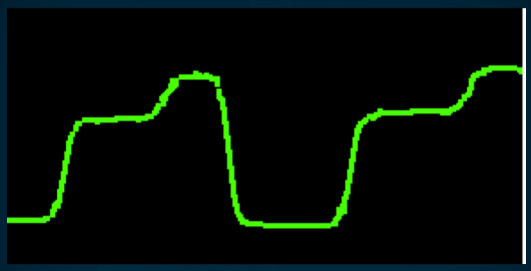
Camel Hump Waveform



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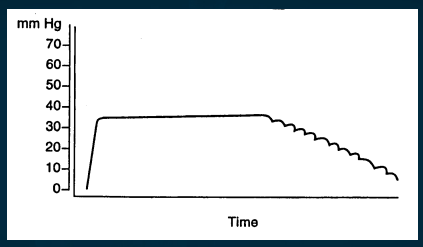
“Cardiogenic Oscillations”



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Icebergs?!

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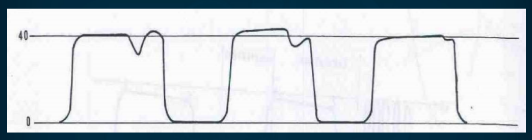
What's going on here?



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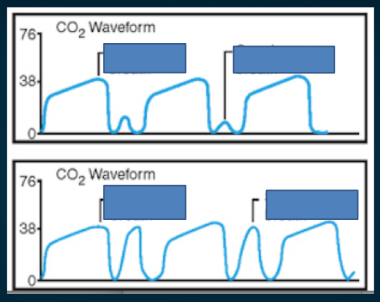

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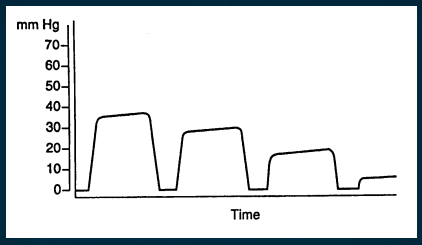

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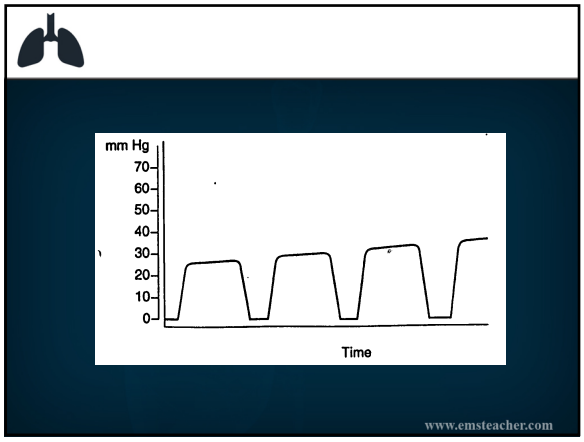
mm Hg
70
60
50
40
30
20
10
0
Time
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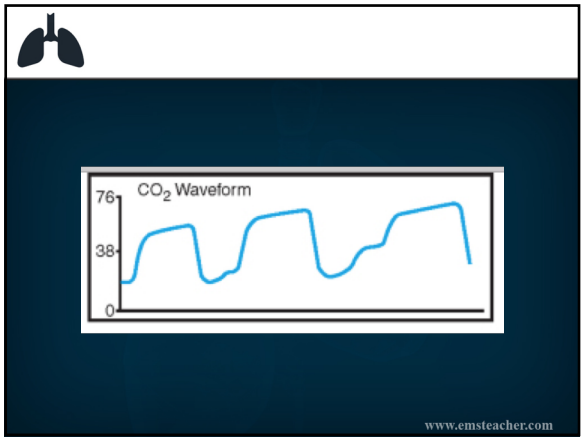
CO_2 Waveform
76
38
0
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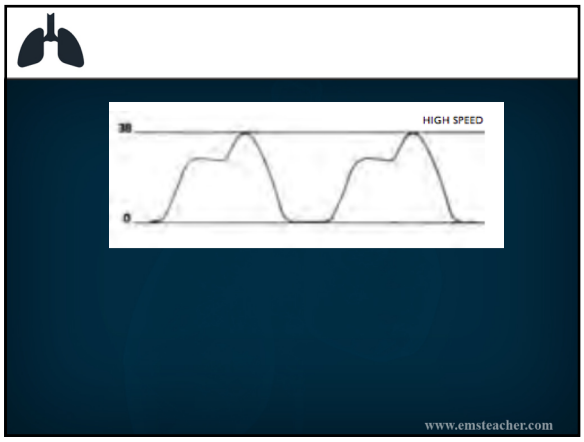
HIGH SPEED
38
0
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