Capnography

the ventilation vital sign

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Introduction

Upona rrival

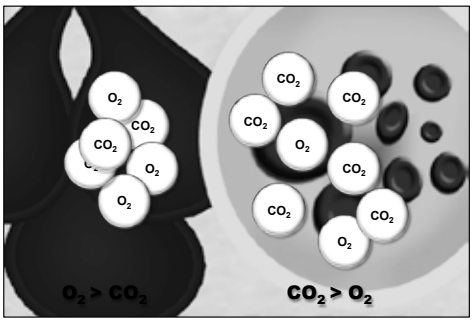
Introduction

Manage airway

Capnography

Gold standard

Diffusion



Movement of gases

Diffusion

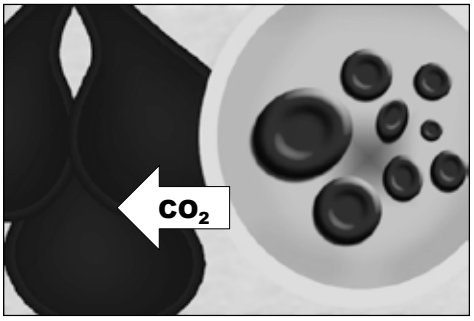
Capnography vs. Pulse Ox

Measurement of gases

Capnography vs. Pulse Ox

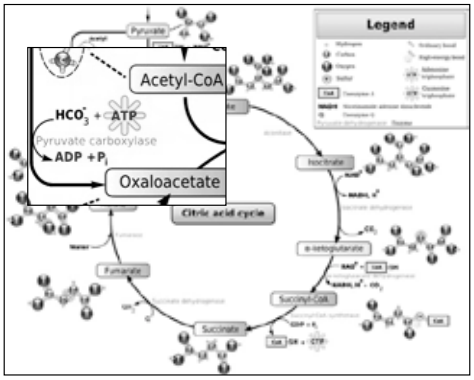
Delayed v. Immediate

Oxygenation vs. Ventilation

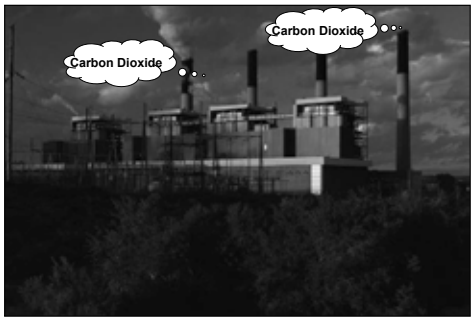


Transport of oxygen v. Elimination of CO_2

Cellular Metabolism

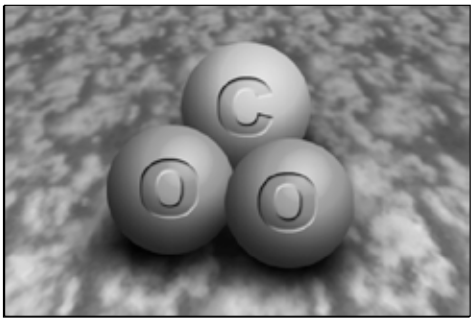


Cellular Metabolism

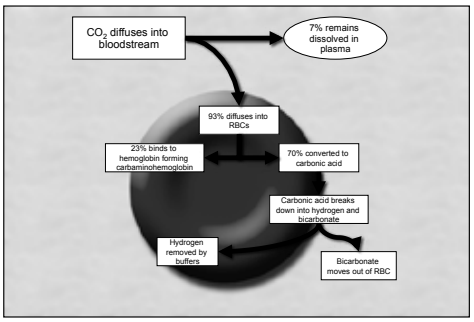


Product of metabolism: a waste

What is Carbon Dioxide?



Removal of CO_2

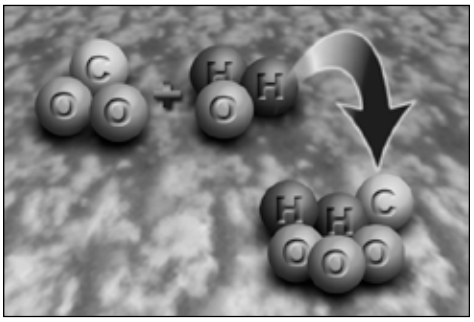


Adapted from Anatomy and Physiology for Emergency Care

Oxygenation vs. Ventilation

Capnography measures ventilation

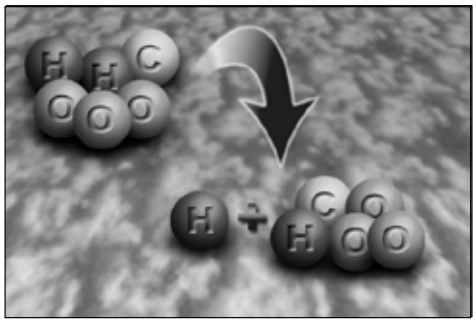
Breakdown of CO_2



$$CO_2 + H_2O = H_2CO_3$$

Carbon Dioxide Water Carbonic Acid

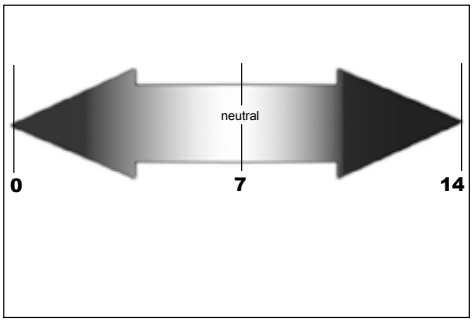
Breakdown of CO_2



$$H_2CO_3 = H + HCO_3$$

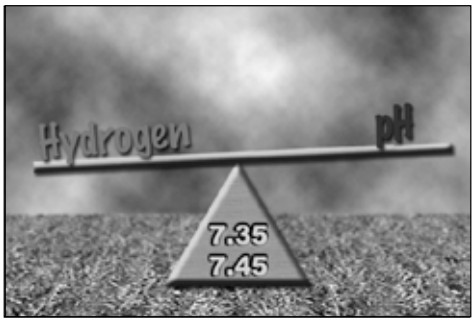
Carbonic Acid Hydrogen Bicarbonate

Concentration of Hydrogen



pH

Acid-Base Balance



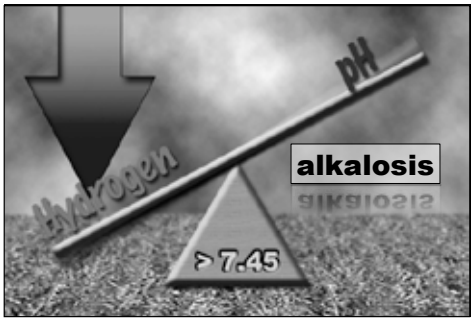
Acid-Base Balance

Rising CO_2 and pH

$\uparrow CO_2 + H_2O \rightleftharpoons \uparrow H_2CO_3 \rightleftharpoons \uparrow H + HCO_3$

Rising CO_2, pH, and *You*

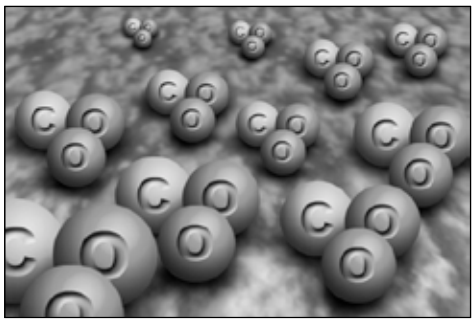
Falling CO_2 and pH



$\downarrow CO_2 + H_2O \rightleftharpoons \downarrow H_2CO_3 \rightleftharpoons \downarrow H + HCO_3$

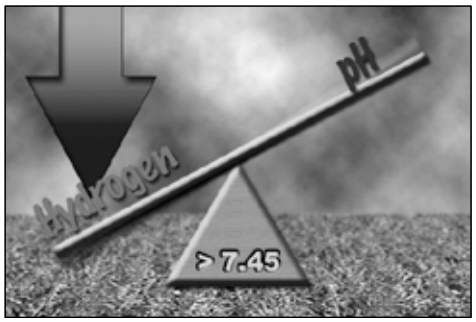
Falling CO_2, pH, and *You*

Alterations in Hydrogen

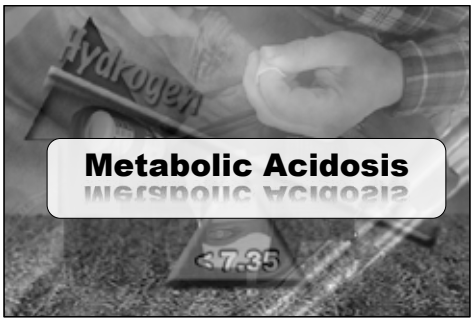


$\uparrow H + HCO_3 \rightleftharpoons \uparrow H_2CO_3 \rightleftharpoons \uparrow CO_2 + H_2O$

Hydrogen and pH



Rising Hydrogen and pH

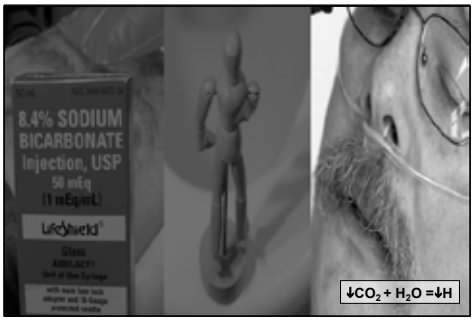


Lowered Hydrogen and pH

Maintaining Balance

Taking the garbage out

Maintaining Balance

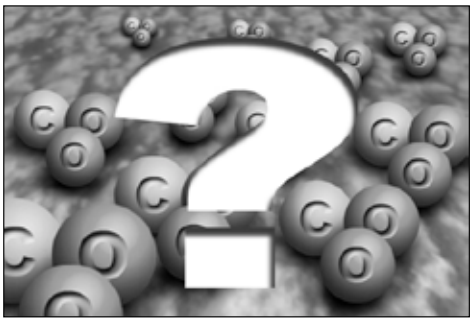


Buffer system

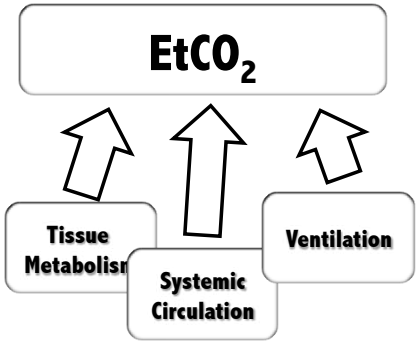
Maintaining Balance

Metabolic acidosis w/ respiratory alkalosis

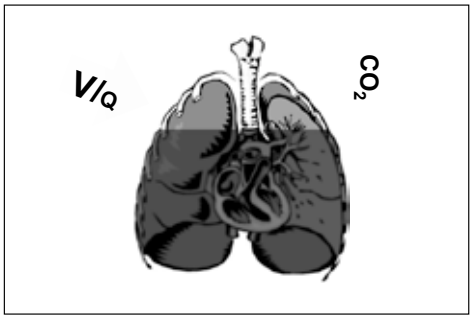
How does this relate?



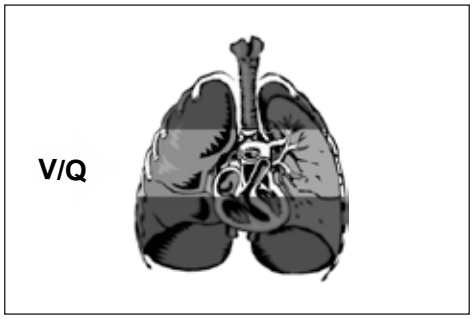
CO_2 Concentration



Ventilation:Perfusion



Ventilation:Perfusion

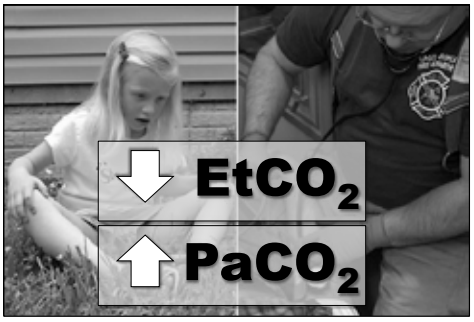


Ventilation:Perfusion

Ventilation:Perfusion

Physiological mismatch

Ventilation:Perfusion



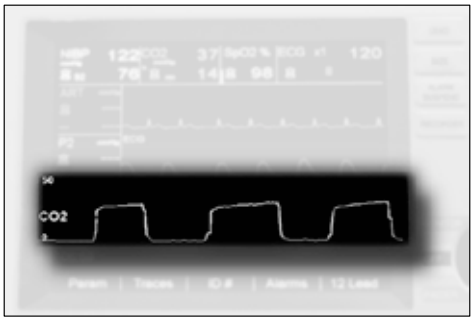
Pathological mismatch

Measuring $EtCO_2$

colors, numbers, waves

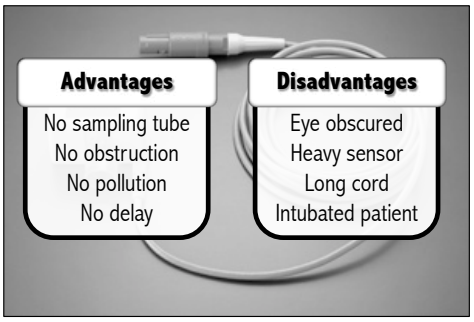
General Types

Waveform Capnography



Graphical display

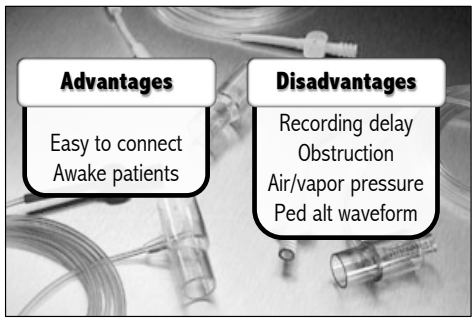
Sampling Methods



Advantages	Disadvantages
No sampling tube	Eye obscured
No obstruction	Heavy sensor
No pollution	Long cord
No delay	Intubated patient

Mainstream

Sampling Methods

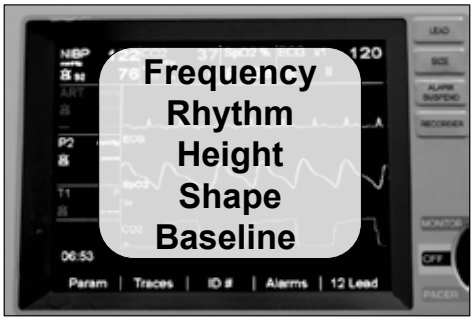


Advantages	Disadvantages
Easy to connect	Recording delay
Awake patients	Obstruction
	Air/vapor pressure
	Ped alt waveform

Side stream

Waveform Analysis

Waveform Analysis



Waveform Analysis

Ventilatory Phases

Waveform Analysis

Phase 0 End Inspiration

Waveform Analysis

Phase I Start of Exhalation

Waveform Analysis

Phase II Anatomical Dead Space

Waveform Analysis

Phase III Better V/Q

Waveform Analysis

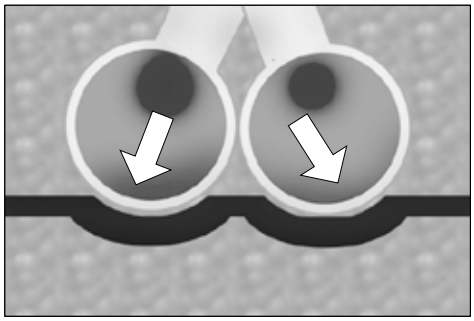
Phase 0 Start of Inspiration

Practical Capnography

pathological causes

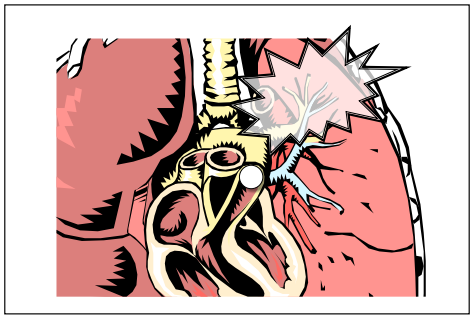
Etiologies

Dead Space Ventilation



A Perfusion Problem **(V/q)**

Dead Space Ventilation



A Perfusion Problem **(V/q)**

Dead Space Ventilation

Low Cardiac Output **(V/q)**

Dead Space Ventilation

A Perfusion Problem **(V/q)**

Shunt Perfusion

A Ventilation Problem **(v/Q)**

Practical Capnography

confirmation of ett placement

ETT Placement

Colormetric False Negative

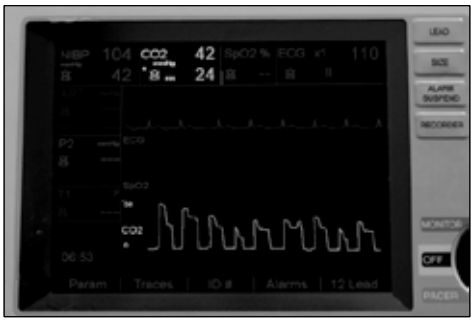
ETT Placement

Waveform Correct Placement

ETT Placement

Colormetric False Positive

ETT Placement



Incorrect placement

Practical Capnography

interpreting the readings

Hypocapnia

Hypocapnia

Look at the Numbers

Hypocapnia

Speed of Change

Hypocapnia

Sudden decrease

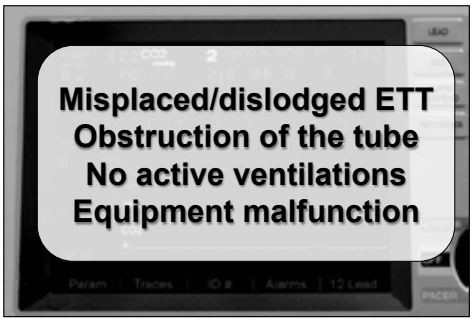
Zero/near zero without waveform

Hypocapnia

Sudden decrease

Zero/near zero without waveform

Hypocapnia



Misplaced/dislodged ETT
Obstruction of the tube
No active ventilations
Equipment malfunction

Sudden decrease

Zero/near zero without waveform

Hypocapnia

Dislodgement

Obstruction

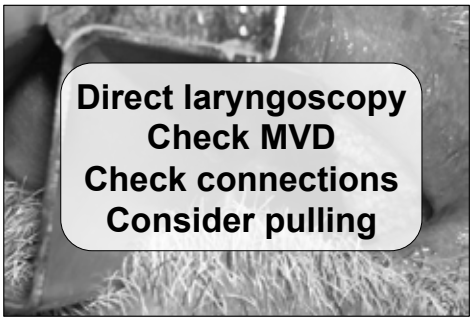
Pneumothorax

Equipment

Sudden decrease

Zero/near zero without waveform

Hypocapnia



Direct laryngoscopy
Check MVD
Check connections
Consider pulling

Sudden decrease

Zero/near zero without waveform

Hypocapnia

Sudden decrease

Low, but non-zero, with waveform

Hypocapnia

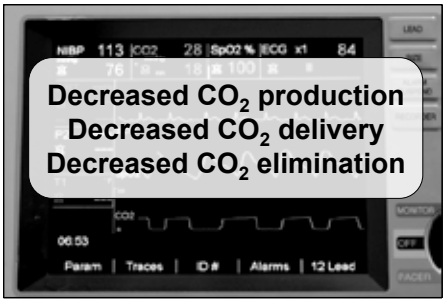
Sudden decrease

Low, but non-zero, with waveform

Hypocapnia

Exponential decrease with waveform

Hypocapnia



Gradual Decrease with Waveform

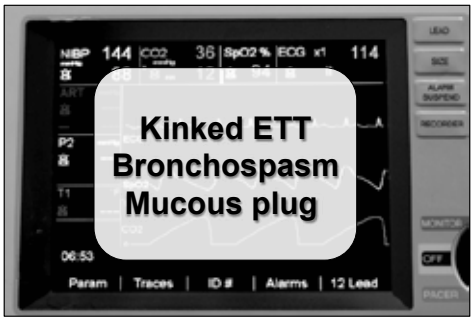
Hypocapnia

Gradual Decrease with Waveform

Hypocapnia

Organized waveform without plateau

Hypocapnia



Organized waveform without plateau

Hypercapnia

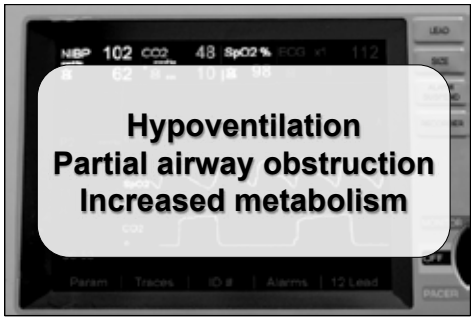
Hypercapnia

$\uparrow CO_2 + H_2O = \uparrow H_2CO_3 = \uparrow H^+ + HCO_3$

pH ↓ RR ↑

Assess & count respirations

Hypercapnia



Hypoventilation
Partial airway obstruction
Increased metabolism

Gradual Rise with Waveform

Hypercapnia

Increased CO_2 delivery
(bicarb admin, tourniquet release, seizure)
Bronchospasm relief

Acute but transient Rise with Waveform

Hypercapnia

Steady State with Waveform

Special Considerations

Cardiac Arrest

CPR effectiveness

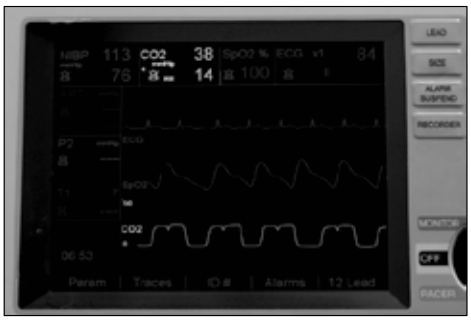
Cardiac Arrest

PEA or ROSC?

Cardiac Arrest

Termination of efforts

Cardiac Arrest



Return of spontaneous respirations

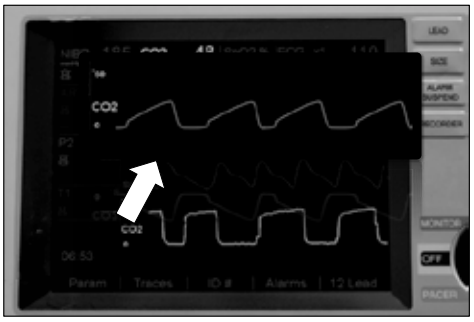
Bronchospasm

A diagnostic tool

Bronchospasm

Better or worse?

Pulmonary Edema

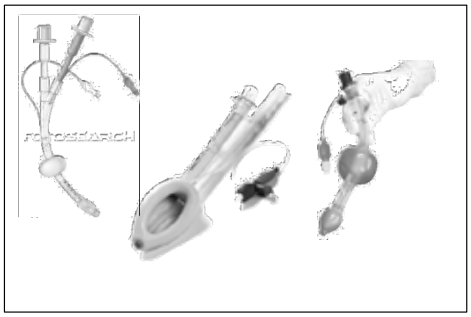


Cardiac Asthma?

Pulmonary Edema

Impending respiratory failure

Supraglottic Airways



Equipment Malfunctions

Dual Wave Capnogram

Sampling leak or loose connection

Blending of the Phases

Cuff leak

Odd Waveforms

Sampling tube leak

Rising Baseline

Rebreathing or contamination

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Thank You!

References

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