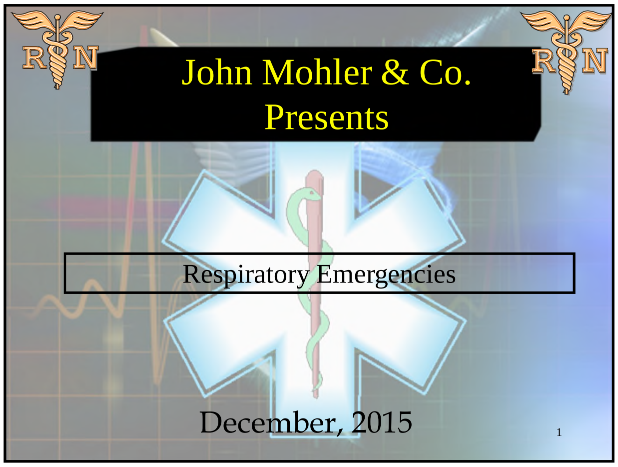
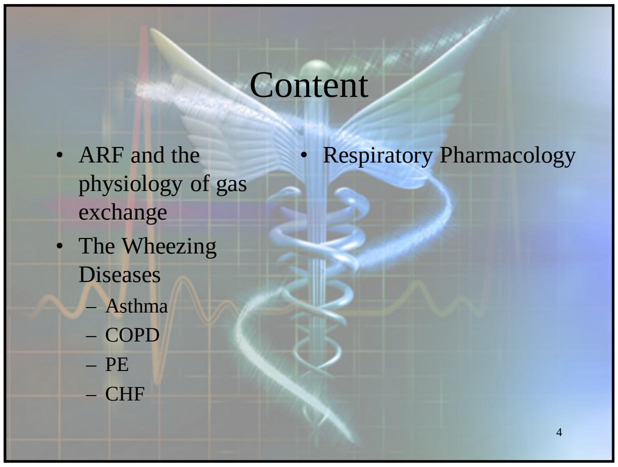

John Mohler & Co.
Presents
Respiratory Emergencies
December, 2015
1

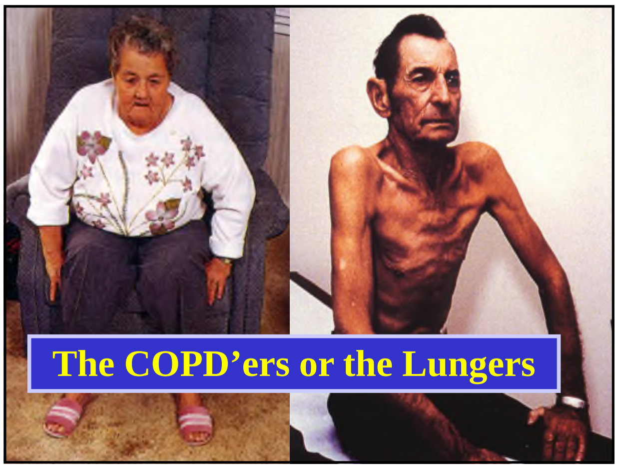

Acute Respiratory Emergencies
For NLCFPD's Paramedic Refresher
John Mohler, RN, BSN, CFRN, CCRN
REACH Air – Elko, NV

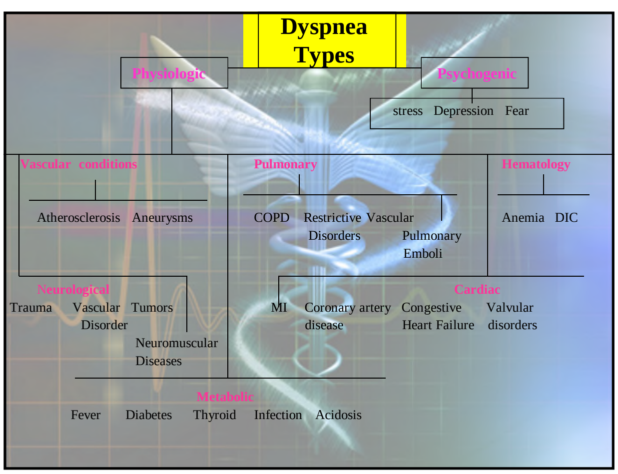

Content
• ARF and the physiology of gas exchange
• The Wheezing Diseases
– Asthma
– COPD
– PE
– CHF
• Respiratory Pharmacology
4

Physiology of Gas Exchange

- Respiration
  - Oxygenation
  - Ventilation
  - Diffusion
  - Transport

5





Oxygen Assessment

- AHA Guidelines

8

9

Oxygen Profiles

- A-a gradient (PAO_2 – PaO_2)
  - Normal gradient is < 10 mmHg on room air
  - A large A-a gradient indicates that there is abnormal transfer of gas from the lung to the bloodstream
- ABGs

Component	Normal
pH	7.4
PaO_2	90 mmHg
SaO_2	> 92 %
$PaCO_2$	40 mmHg
HCO_3	24 mEq/L

10

Oxygenation Assessment

- PaO_2
- SaO_2
- Mixed venous oxygen saturation and PO_2

Component	Normal
pH	7.4
PaO_2	90 mmHg
SaO_2	> 92 %
$PaCO_2$	40 mmHg
HCO_3	24 mEq/L

11

A-a Gradients

- The difference in partial pressure of O_2 in alveoli and partial pressure O_2 in areterial blood
- A-a gradient = $PAO_2 – PaO_2$
- Normal A-a gradient is < 10 mm Hg in young healthy adults and increases with age
- Clinical significance
  - A-a gradient > 10 mm Hg is an abnormal transfer of gas
    - Ventilation-perfusion (V/Q) mismatch
    - Shunting
    - Diffusion abnormalities

12

Room Air Calculation

- A-a gradient = $P_AO_2 – P_aO_2$

$P_AO_2 = P_IO_2 – (PaCO_2/0.8)$

$P_IO_2 = (P_B – 47) \times F_IO_2$

Therefore A-a = $F_IO_2 (P_B – 47) - (PaCO_2/0.8) - P_aO_2$

47mmHg = vapor press of water @ 37^0 C
P_IO_2 = press of inspired air
F_IO_2 = fraction of inspired air
0.8 = the assumed resp quotient

13

Partial Pressures and Percentages

Altitude (ft)	PP(mmHg)/% of total gas			Total PP (mmHg)
	Oxygen	Nitrogen	Other gases	
Sea level	160.21%	593/78%	7/1.1%	760
10,000	110/21%	408/78%	5.2/1.1%	522.6
18,000	80/21%	296/78%	3.8/1.1%	379.4
34,000	40/21%	148/78%	1.9/1.1%	190

14

Pt. has a SpO2 of 90%, breathing RA, at sea level

Example

$$A\text{-}a = F_IO_2 (P_B - 47) - (PaCO_2/0.8) - P_aO_2$$

$$= 0.21(760\text{-}47) - (40/0.8) - 90 = 10$$

15

A-a Gradient

- Normal gradient in young adult is < 10 mmHg on room air
- Provides index of how efficient lung has been in equilibrating pulmonary capillary O_2 with alveolar O_2; indicates if gas transfer is normal
- Large A-a gradient generally indicates lung is the site of dysfunction except when true R-L shunting is present
- Normally, values for A-a gradient increases with age and with increased FiO_2

16

The poor man's A-a gradient calculation

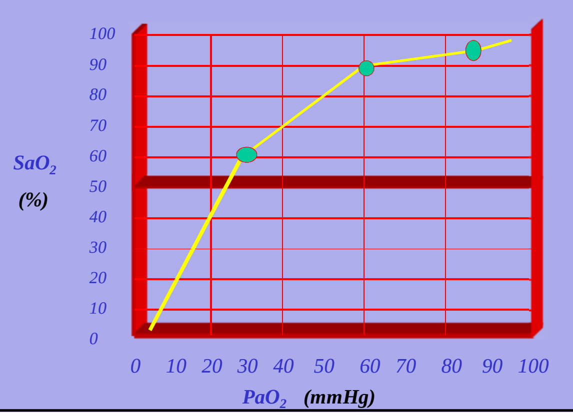
- At sea level you're breathing 21% O_2 and your PaO_2 is 90 mmHg (95% SpO_2)
  - Now we put a NRB mask on you (100% O_2) and your PaO_2 (SpO_2) should be ???? *360-450 mmHg*
  - But….

17

Oxygen Profiles

- Pulmonary shunting – unoxygenated blood is delivered to the arterial circulation
  - Normal shunting is 3-5% of the CO
  - Only cause of acute respiratory failure not corrected by 100% oxygen administration

18



Oxygenation Assessment

- PaO_2
- SaO_2
- Mixed venous oxygen saturation and PO_2

Component	Normal
pH	7.4
PaO_2	90 mmHg
SaO_2	> 92 %
$PaCO_2$	40 mmHg
HCO_3	24 mEq/L

22

A Little Test

	Pt. #1
B/P	118/74
Pulse	82
Color of mucous membranes	Pink
PaO2 (mm Hg)	80
SaO2	0.94
Hgb (gm/dl)	12
CO (L/min)	4.5
Oxygen consumption (cc/min)	250

23

Answers

- The patient with the best balance between oxygen transport and consumption is patient #2, who has an oxygen extraction rate of 0.31.
- The worst oxygen balance is that of patient #3, who has an oxygen extraction balance of 0.43

24

Oxygen Content

Oxygen Content = O_2 dissolved in plasma + O_2 attached to the Hgb

= (.003) x PaO_2 + 1.34 x Hgb x SaO_2

Where .003 is the solubility coefficient for oxygen

About 15 ml/min of oxygen is delivered by the plasma

25

Oxygen Delivery

- Clinically arterial saturation becomes a threat to O_2 transport if it falls below 90%
- Given normal Hgb (15 gm), CO, and SaO2 – oxygen delivery will be adequate (985 ml/min)

Hgb levels are more important than SaO_2

A low CO will cause low oxygen transport despite adequate Hgb and PaO2 levels

26

Calculation of the PaO_2 Role in Oxygen Transport

- ABGs and determine the PaO_2
- Figure the amount of oxygen carried per ml of pressure exerted by dissolved oxygen

0.003 x PaO2

Where 0.003 is the solubility coefficient for oxygen

- Now correct for the total blood volume

$$(0.003 \times PaO2) \times \frac{\text{Cardiac output}}{100}$$

27

Example of Oxygen carried by the plasma

- PaO_2 = 100 torr
- CO = 5 L/min

1. 0.003 x 100 = 0.3 ml/dl
2. 0.3 x 5000/100 = **15 ml** **of oxygen carried by a PaO_2 of 100 torr**

- PaO_2 = 60 torr
- CO = 5 L/min

1. 0.003 x 60 = 0.18
2. 0.18 x 5000/100 = **9 ml** **of oxygen carried by a PaO_2 of 60 torr**

Normal PaO_2 is 80 – 100 torr

28

Example of Oxygen carried by the plasma

- PaO_2 = 400 torr
- CO = 5 L/min

1. 0.003 x 400 = 1.2 ml/dl
2. 1.2 x 5000/100 = **60 ml** **of oxygen carried by a PaO_2 of 400 torr**

- PaO_2 = 200 torr
- CO = 5 L/min

1. 0.003 x 200 = 0.6 ml/dl
2. 0.6 x 5000/100 = **30 ml** **of oxygen carried by a PaO_2 of 200 torr**

Normal PaO_2 is 80 – 100 torr

29

Oxygen Carrying Capacity of Hgb

- Oxygen carried by hemoglobin in 100 ml of blood is calculated

$$1.34 \times Hgb \times SaO_2$$

Where 1.34 is the maximal amount of O_2 carried per gram of Hgb

- To account for total blood volume:

$$(1.34 \times Hgb \times SaO2) \times \frac{\text{Cardiac output}}{100}$$

30

Role of Hgb Examples

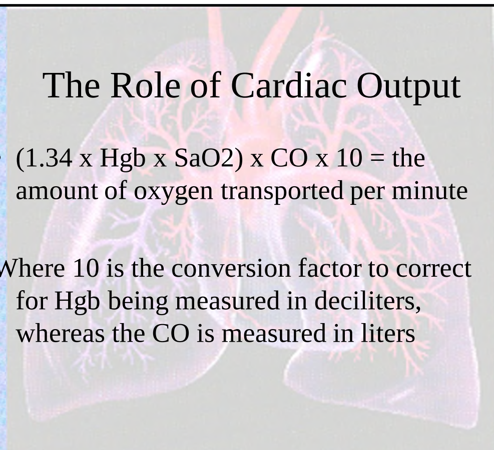
- Hgb = 15 gm/dl
- SaO_2 = 0.98
- CO = 5 L/min
- PaO_2 = 60 torr

1. 1.34 x 15 x 0.98 = 19.7 cc O2/dl
2. 19.7 x 5000/100 = **985 ml of oxygen transported per minute in the blood**

- Hgb = 10 gm/dl
- SaO_2 = 0.98
- CO = 5 L/min
- PaO_2 = 100 torr

1. 1.34 x 10 x 0.98 = 13.1
2. 13.1 x 5000/100 = **655 ml of oxygen transported per minute**

31



The Role of Cardiac Output

- (1.34 x Hgb x SaO2) x CO x 10 = the amount of oxygen transported per minute

Where 10 is the conversion factor to correct for Hgb being measured in deciliters, whereas the CO is measured in liters

CO examples

- CO = 3 L/min
- Hgb = 13 gm/dl
- PaO_2 = 100
- SaO_2 = 0.98

(1.34 x 13 x 0.98) x 3 x 10 = **512 ml O_2 transported per minute**

- CO = 6 L/min
- Hgb = 10 gm/dl
- PaO_2 = 59
- SaO_2 = 0.89

(1.34 x 10 x 0.89) x 6 x 10 = **718 ml O_2 transported per minute**

33

Putting it all Together

- PaO_2 rises from 60 torr to 90 torr with the addition of PEEP

Did a benefit to oxygenation occur?

? Did the CO fall with the addition of PEEP, thereby decreasing total oxygen transport, or did the work of breathing increase indicating an increase in oxygen consumption?

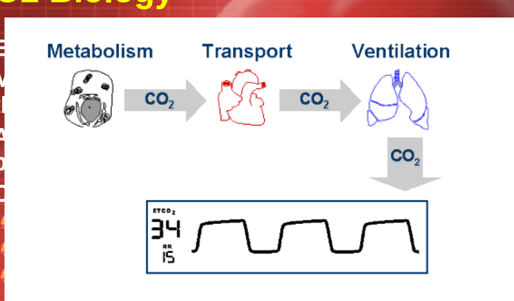
34

The In's and Out's of End Tidal CO_2 Monitoring

John Mohler, RN
REACH Air Ambulance, Elko, NV
John Mohler & Co.

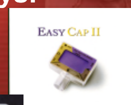
A special thanks to Casey Quinlan and Bob Page for their inputs

CO2 Biology



End Tidal Carbon Dioxide

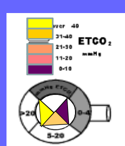
- CO_2 present in the airway at the end of exhalation – $PETCO_2$
- $PETCO_2$ measured two ways:
  - Colorimetric detection
  - Infrared spectroscopy



Types of Capnometry

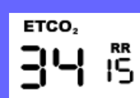
"The Gold Standard"

- Qualitative $ETCO_2$



- Provides a range
- Uses chemically treated paper that changes color when exposed to CO_2

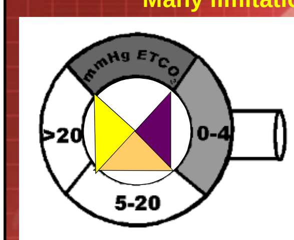
- Quantitative $ETCO_2$



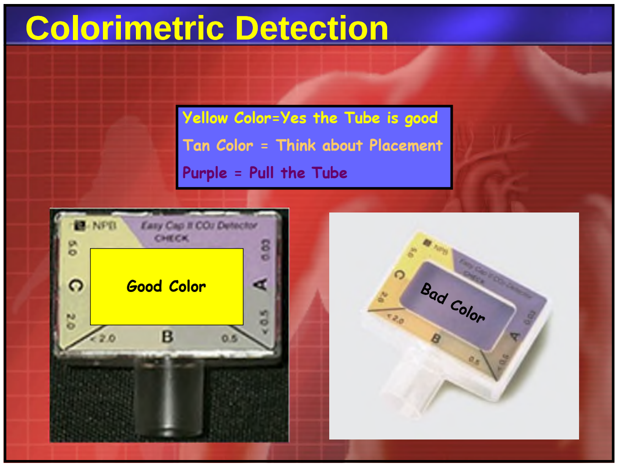
- Gives a numerical value
- Found in capnographs and capnometers

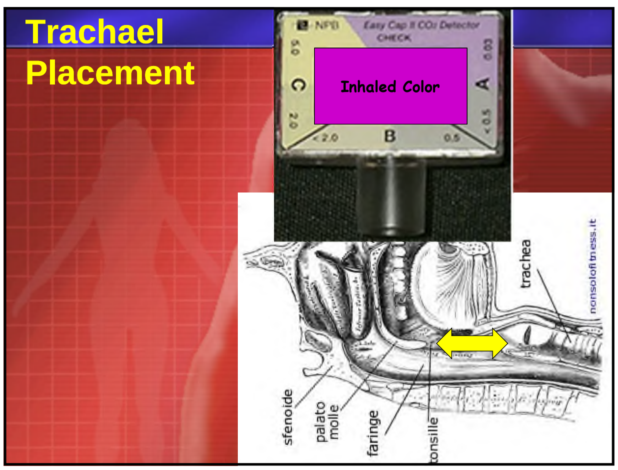
Colorimetric Detection

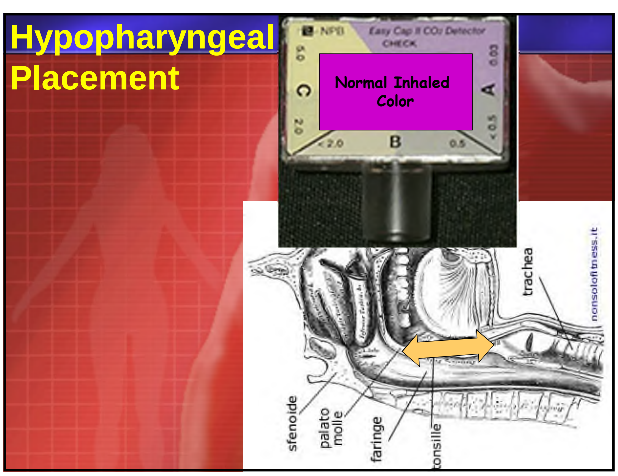
Many limitations:



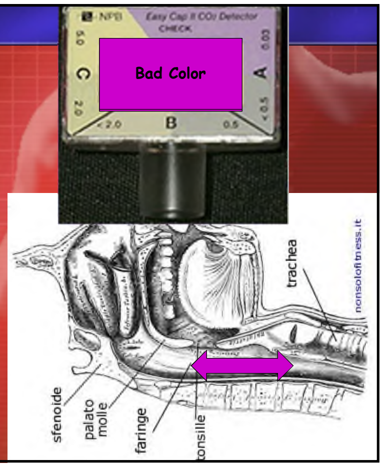
- A detector only, not a monitor
- Gives a range
- Low threshold for CO_2
- Can only be used for several minutes
- Has expiration date


Colorimetric Detection
Yellow Color=Yes the Tube is good
Tan Color = Think about Placement
Purple = Pull the Tube
Good Color
Bad Color


Trachael Placement
Inhaled Color
trachea
sfenoide
palato molle
faringe
tonsille
nonsolofitness.it


Hypopharyngeal Placement
Normal Inhaled Color
trachea
sfenoide
palato molle
faringe
tonsille
nonsolofitness.it

Esophageal Placement

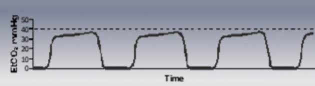


Quantitative

- Capnometry

- Gives you a respiratory rate and $PETCO_2$ value

- Capnography



- Gives you a waveform along with a respiratory rate and $PETCO_2$ value

Infrared Technology

- Shines infrared light through exhaled gas, measures how much is absorbed on the other side
  - Mainstream
  - Sidestream
    - Microstream (low-Flow)

Why is $ETCO_2$ Useful?

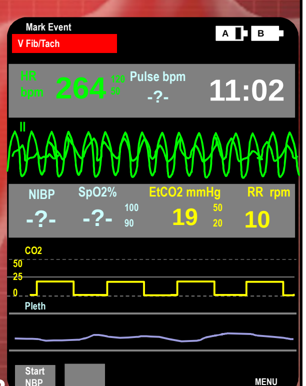
- Verifies ETT placement
- And monitors ETT placement
- But can also detect:
  - Respiratory Depression & Apnea
  - Hypo / Hyperventilation
  - Bronchospasm & Severity of Asthma
  - Perfusion Status
    - ROSC
    - Cardiac output
    - Quality of CPR

ETCO2 and Cardiac Arrest

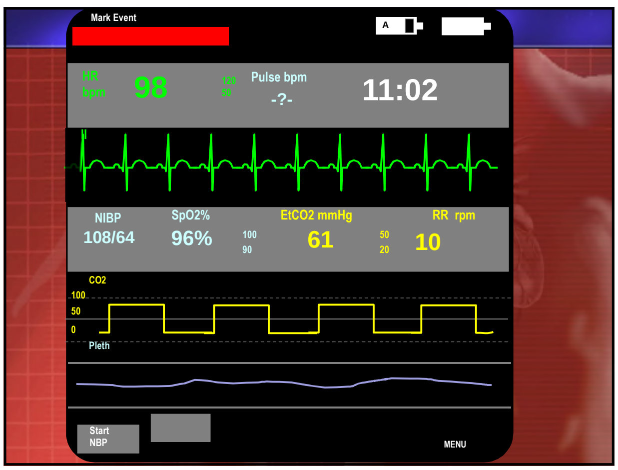
And other “nice to know stuff”

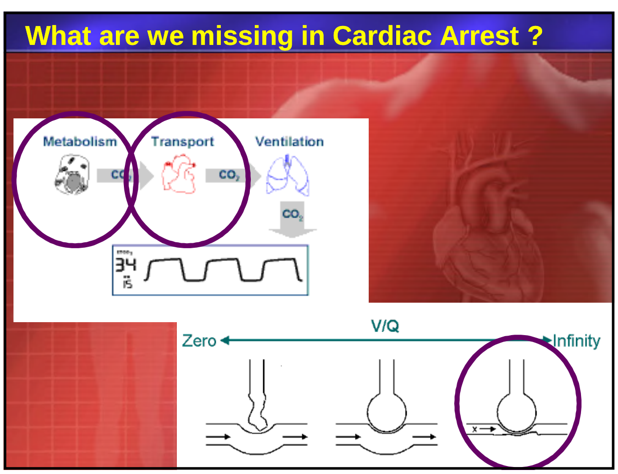
Case Study

- Cardiac Arrest
- CPR in progress, and you have just intubated patient
- You “slap the cap” and your initial $EtCO_2$ is 19 mmHg
- What do you know now? Do you wish any other info? What?




Mark Event
V Tach
A
B
HR bpm
104
120
50
Pulse bpm
-?-
11:02
II
So what just happened?
NIBP
-?-
SpO2%
-?-
100
90
EtCO2 mmHg
50
20
RR rpm
10
CO2
50
25
0
Pleth
Start NBP
MENU


Mark Event
A
HR bpm
98
120
50
Pulse bpm
-?-
11:02
II
NIBP
108/64
SpO2%
96%
100
90
EtCO2 mmHg
61
50
20
RR rpm
10
CO2
100
50
0
Pleth
Start NBP
MENU


What are we missing in Cardiac Arrest ?
Metabolism
Transport
Ventilation
CO2
34
Zero
V/Q
Infinity

SCA Values

- Expect readings well below the normal
  - It's a perfusion monitor
- Need a value >5 mmHg to confirm tube
- Make sure to get reading immediately after ETI and continuously monitor

Assessing Efficacy and Predicting Outcome in Cardiac Arrest

- Look at the numbers – if wave form is too sloppy and low
- Most cardiac arrests with chest compressions are between 10 and 16 mmHg (AHA says shoot for 20 mmHg)
- If < 10 mmHG, chest compressions aren't doing anything and ROSC won't happen
- If equal to or greater than 30, you may have a perfusing rhythm!

What are We Measuring?

- Ventilation status?
- Perfusion status?
- Acid-base status?
- Or all of the above?

PETCO2 and PaCO2

- In healthy patients (with normal v/q) $PaCO_2$ is 2 – 5 mmHg higher than PETCO2
- Normal $PaCO_2$ = 35 – 45 mmHg
- Normal $PETCO_2$ = 30 - 43 mmHg
  - AHA uses 35-40 mmHg
- In diseased lungs, the gradient will increase due to ventilation/perfusion mismatch

Managing Ventilator Settings

Must have adequate Cardiac Output

- Aim for $PETCO_2$ of 35 – 40 mmHg (AHA)
  - Many use 35-45 mmHg
- Adjust rate and/or volume
- Normal volume is 10-15 cc/kg
  - Resuscitation volumes are suggested at 6-8 cc/kg
- Normal rate is 10-12 bpm with Pulse
- Vent rate without a pulse is 8-10 bpm
- Avoid hyperventilation, but……

Things that Affect ETCO2

Increase in $ETCO_2$

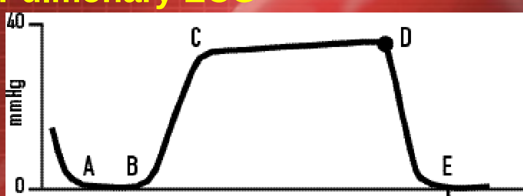
- Decrease Minute Ventilation
- Bicarb Infusion
- Shivering
- Albuterol during early Bronchospasm
- Increased Cardiac Output

Decrease in $ETCO_2$

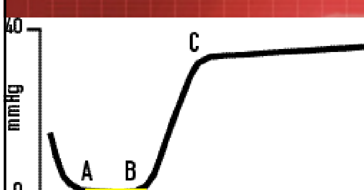
- Increase Minute Ventilation
- Hypothermia
- PE
- Early Bronchospasm
- Decreased Cardiac Output
- Metabolic acidosis

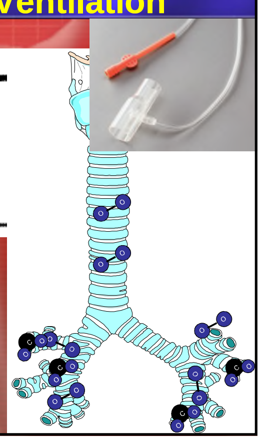
What should it look like ?

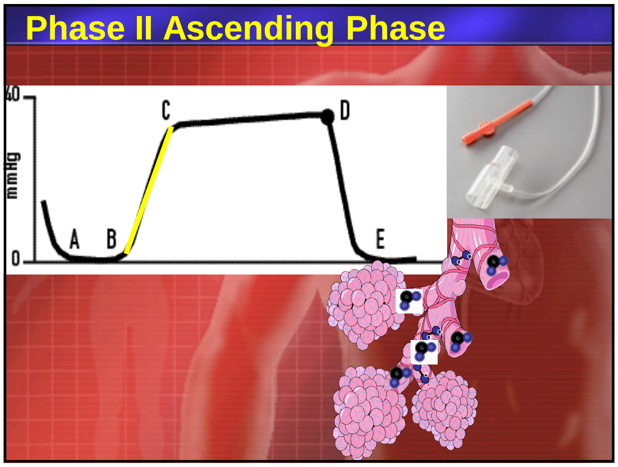
"Pulmonary ECG"

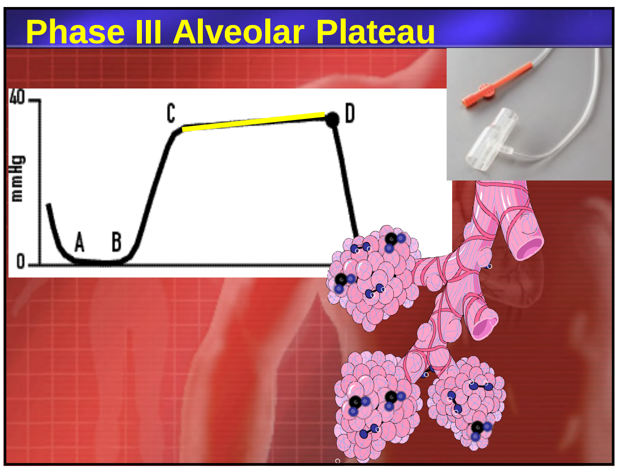


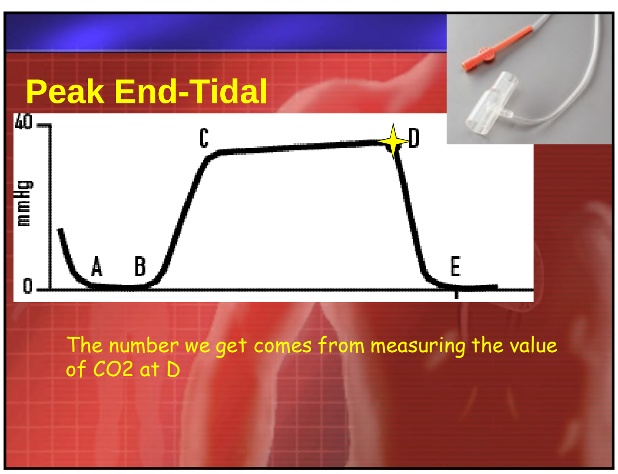
Phase I Dead Space Ventilation

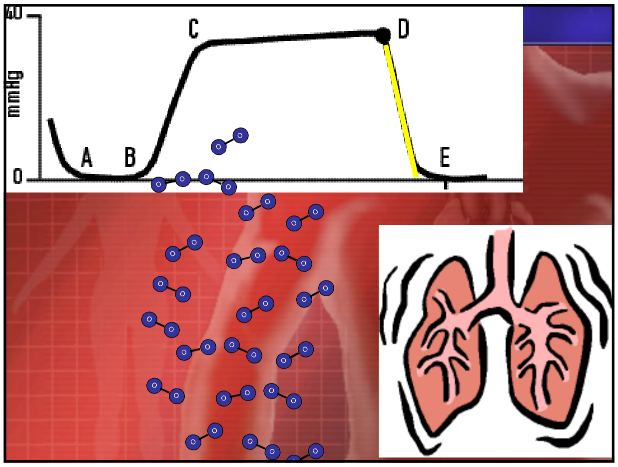


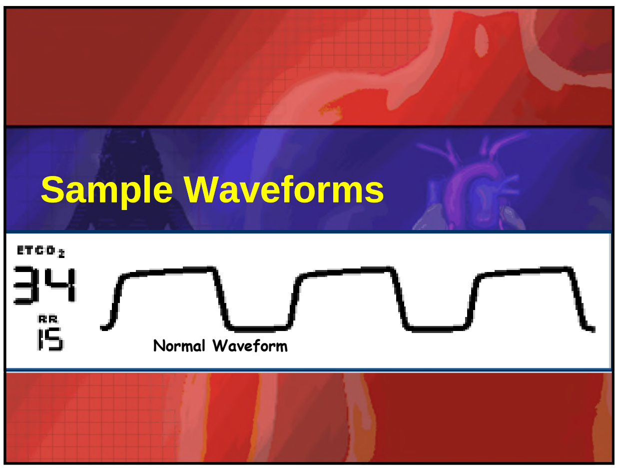


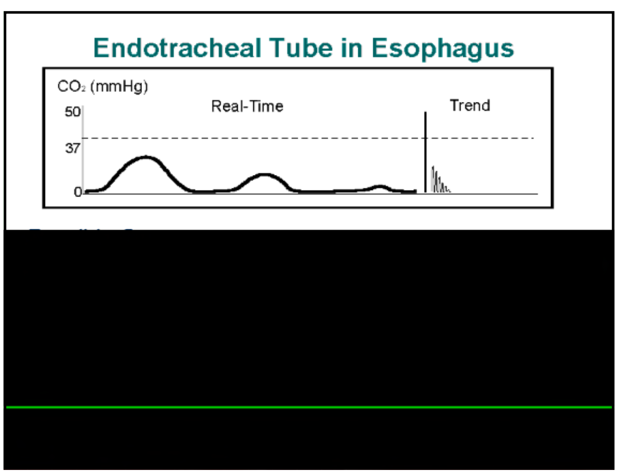

Phase II Ascending Phase
40
mmHg
0
A
B
C
D
E


Phase III Alveolar Plateau
40
mmHg
0
A
B
C
D

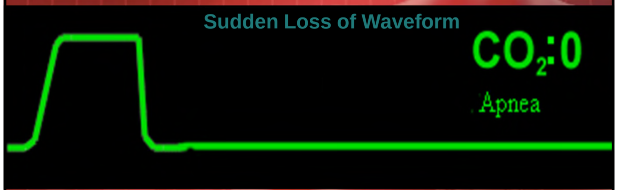

Peak End-Tidal
40
mmHg
0
A
B
C
D
E
The number we get comes from measuring the value of CO2 at D


40
mmHg
0
A
B
C
D
E


Sample Waveforms
ETCO2
34
RR
15
Normal Waveform

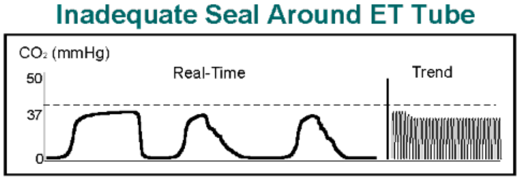

Endotracheal Tube in Esophagus
CO2 (mmHg)
Real-Time
Trend
50
37
0

Sudden Change in Readings



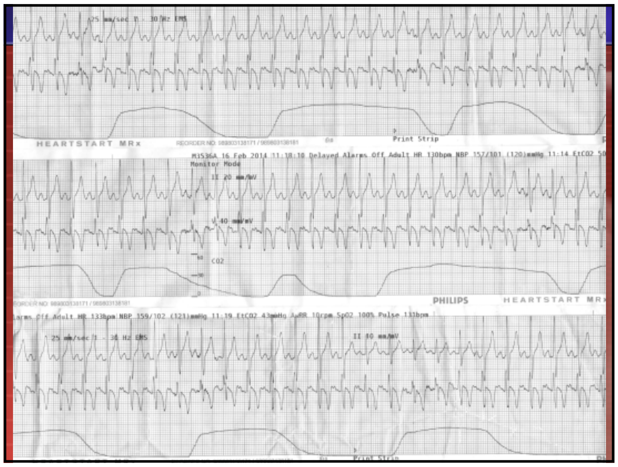
- Apnea
- Airway Obstruction
- Dislodged airway (esophageal)
- Airway circuit disconnection
- Ventilator malfunction

Inadequate Seal Around ET Tube

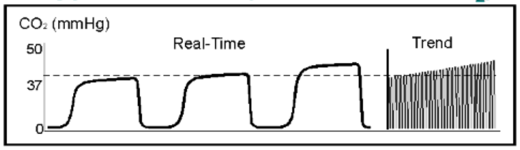


Possible Causes:

- Leaky or deflated endotracheal or tracheostomy cuff
- Artificial airway is too small for the patient



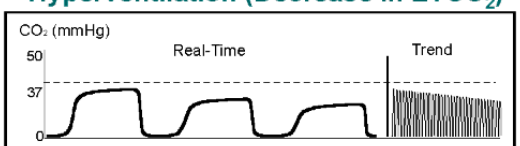
Hypoventilation (Increase in $ETCO_2$)



Possible Causes:

- Decrease in respiratory rate
- Decrease in tidal volume
- Increase in metabolic rate
- Rapid rise in body temperature (hyperthermia)

Hyperventilation (Decrease in $ETCO_2$)



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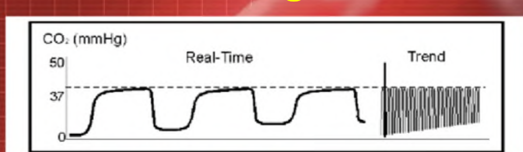
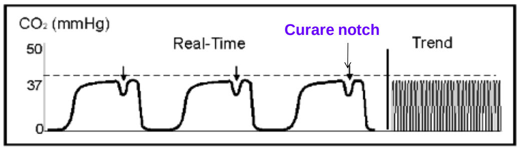
Rebreathing



Possible causes:

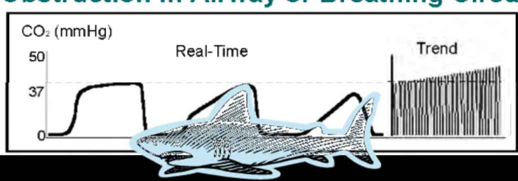
- ✓ Faulty expiratory valve
- ✓ Inadequate inspiratory flow
- ✓ Breath stacking (wrong mode, undersedated)
- ✓ Malfunction of CO_2 absorber system

Paralytics Wearing off



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

Obstruction in Airway or Breathing Circuit



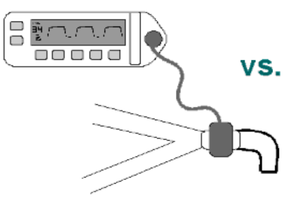
The Big Question

Intubated

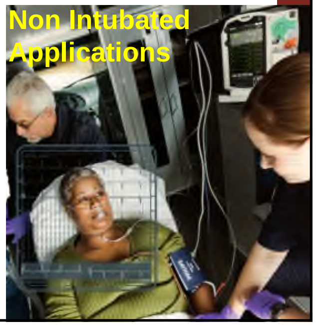
Mainstream

or

And do we really need both?

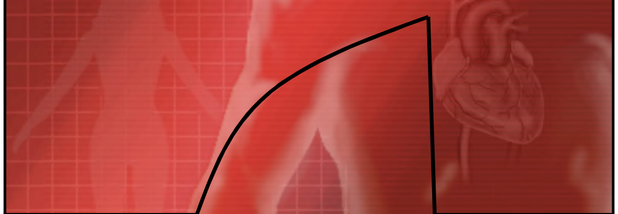


vs.



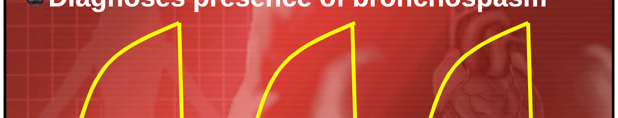
Let's Look at Some Non – Intubated Applications

Is this a Normal Waveform ?



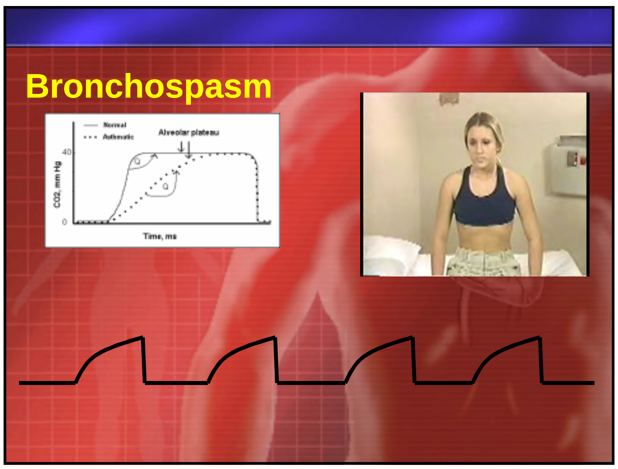
Using ETCO2 in Asthma

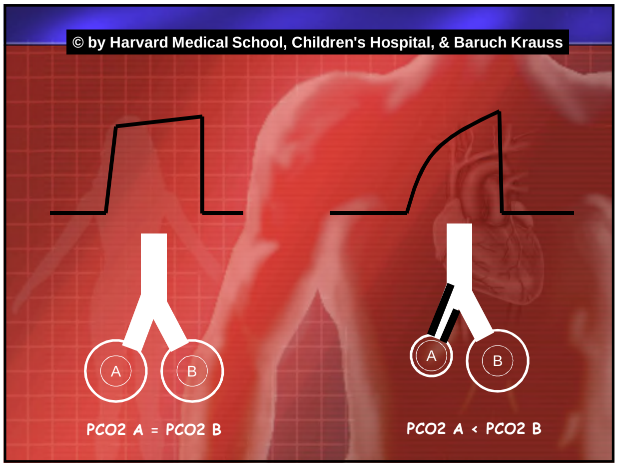
- Diagnoses presence of bronchospasm



- Assesses severity of Asthma
  - Trending
- Gauges response to treatment
  - Trending


Shark Fins = Bronchospasm

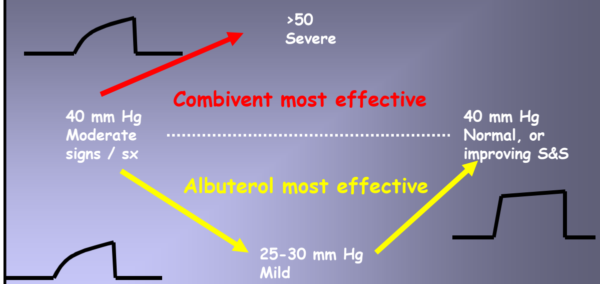

Bronchospasm
Normal
Asthmatic
Alveolar plateau
40
0
CO2, mm Hg
Time, ms


© by Harvard Medical School, Children's Hospital, & Baruch Krauss
A
B
PCO2 A = PCO2 B
A
B
PCO2 A < PCO2 B

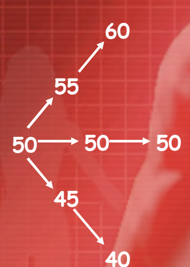
That's nice John, but why should we care about all that ?

- You can trend Asthma
- You can apply different treatment to different Asthmatics
- You can see the need to intubate often before the patient "shows you" signs

Phases of Asthma



Trending



Is CO2 staying the same, getting worse, or improving?

Do You Give Albuterol to your CHF Patients?

CHF

CHF

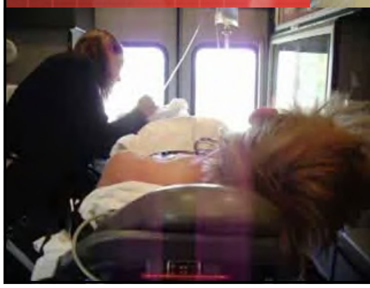
Remember…… Not all that wheezes is Asthma

Case Study

- 56 y/o male in your ambulance, intubated and in cardiogenic shock
  - 78/42, 118, RR of 10, $EtCO_2$ 25-26 mmHg
  - vented at SIMV 10, 600cc, 100%, 5 PEEP, 10 PS
- What do you wish to do first?

? $ETCO_2$?

26mmHg



Glucose	758
HCO_2	16
pH	7.15
SpO_2	100%

?Trauma Case Study

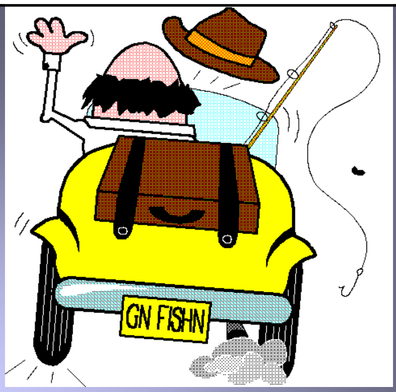
- 23 y/o F, found unconscious on side of rural road

Trauma Case Study

- 46 y/o M, MVC, multiple injuries, intubated
  - HR 118, RR on vent 14/14, B/P 78/38, SpO_2 86-96% with poor wave form, $EtCO_2$ 27mmHg

In Summary

- 3 components; metabolism, perfusion, & ventilation
- Must have adequate perfusion before you have a ventilation monitor
- $PETCO_2$ will be less than $PaCO_2$
- Intubated and non intubated applications



ANY QUESTIONS??

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