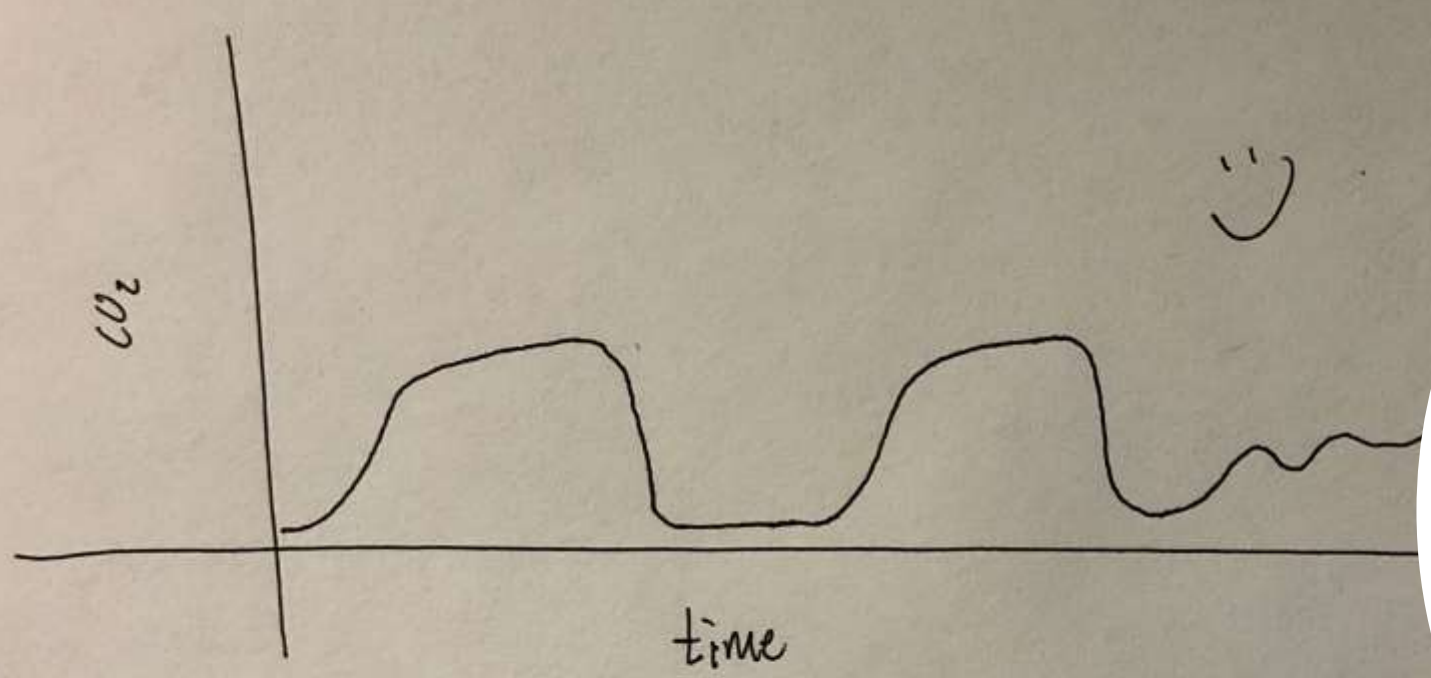


Waveform Capnography

Application for the prehospital provider

Maika Dang, MD CMTE
University of Washington EMS Fellow



Overview

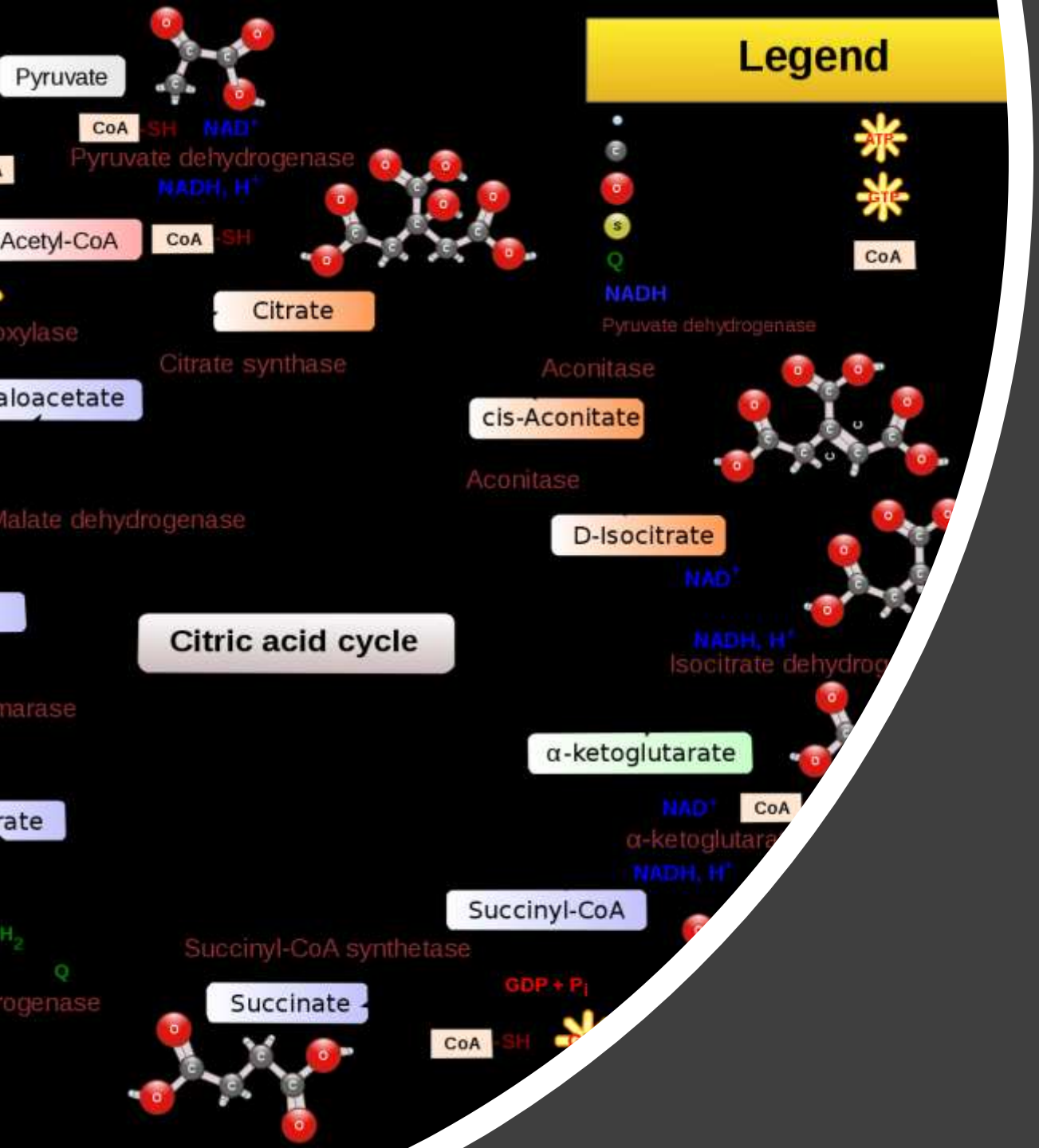
- Carbon Dioxide
- Waveform Capnography
- Physiology and Pathophysiology



"Capnos" = Greek for smoke

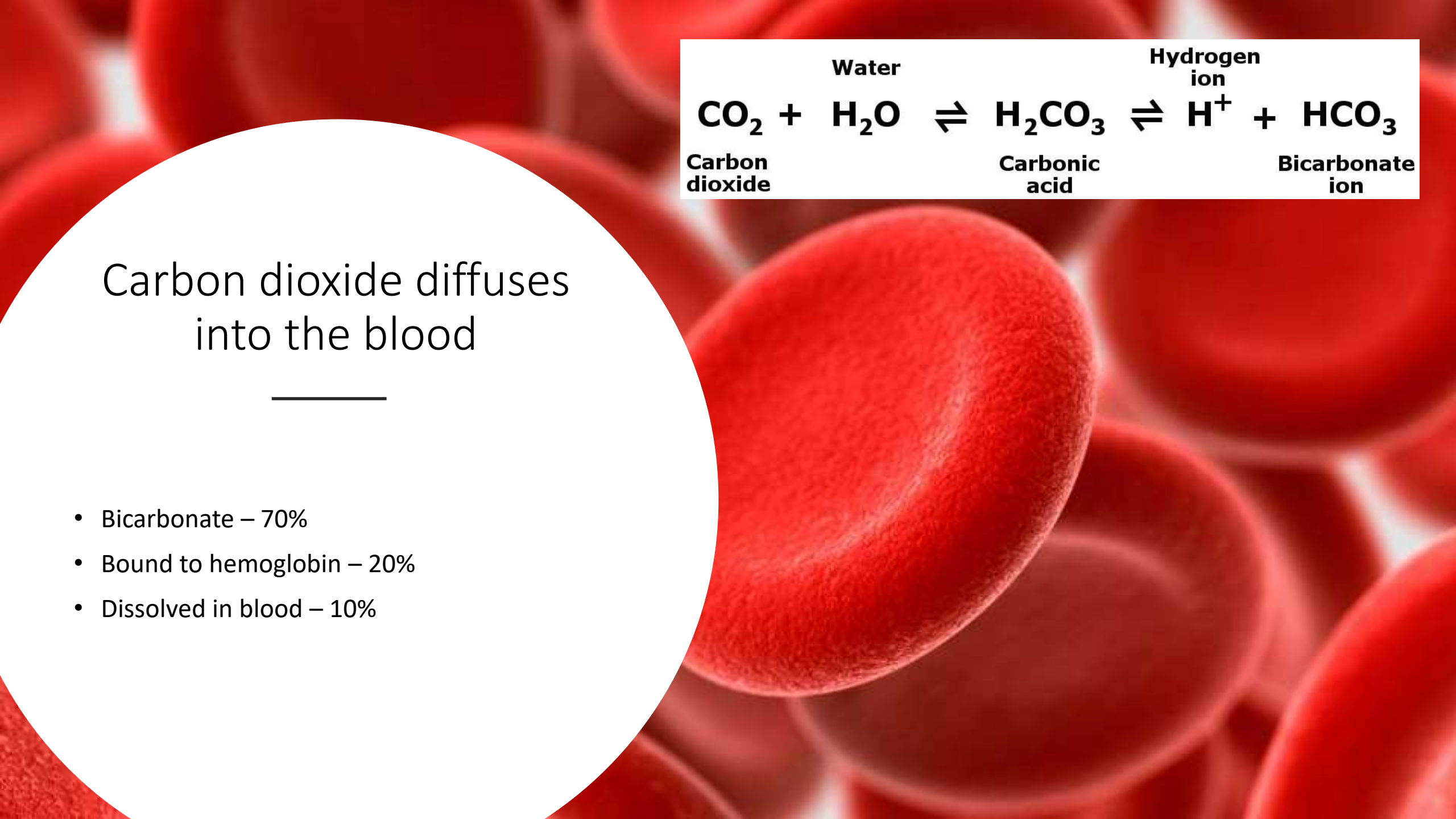
"CO_2 is the smoke from the flames of metabolism"

- Raymond Fowler, MD



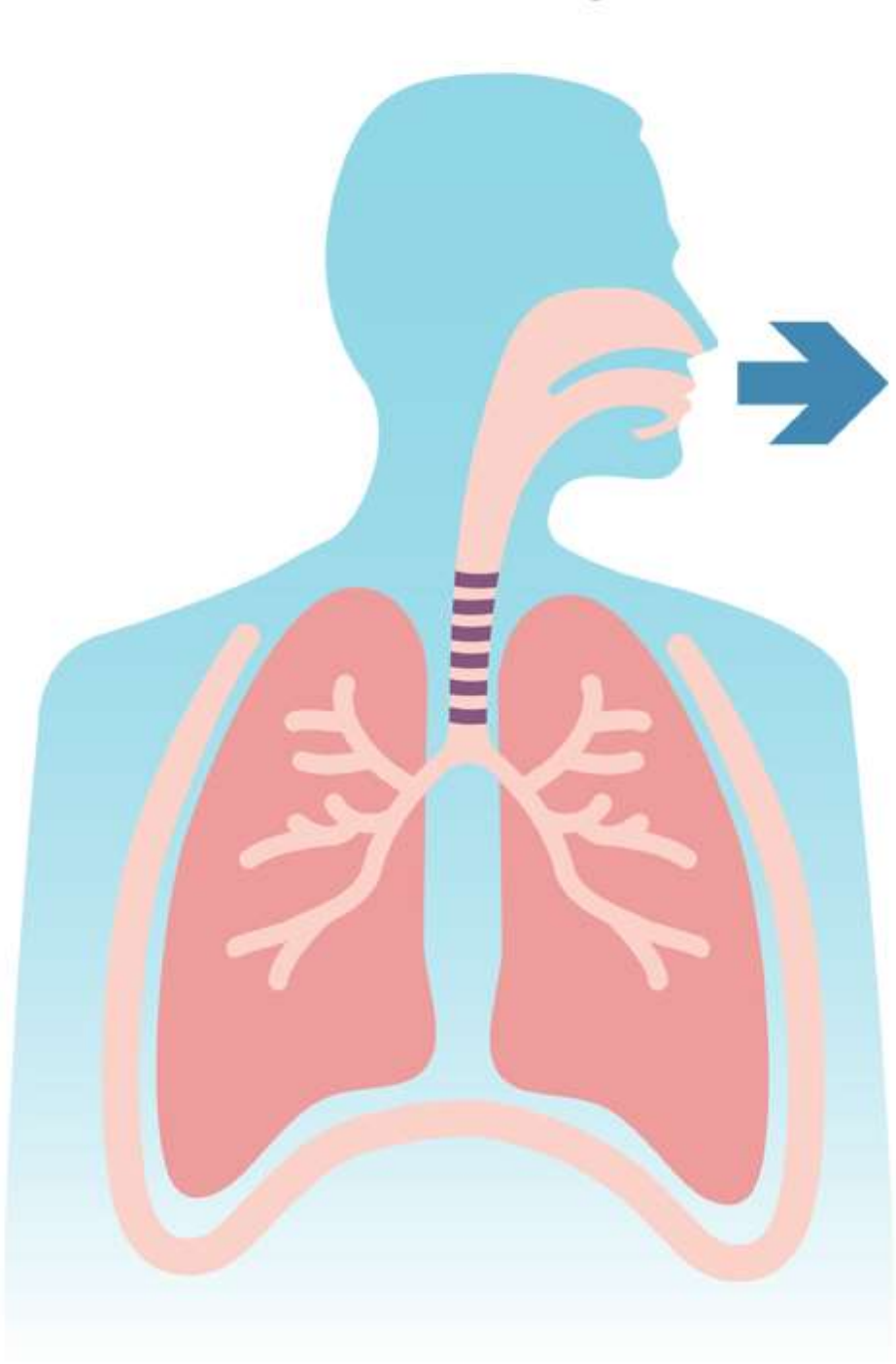
Carbon dioxide byproduct of cellular metabolism

Glucose + O_2 → CO2 + H_20



Carbon dioxide diffuses into the blood

- Bicarbonate – 70%
- Bound to hemoglobin – 20%
- Dissolved in blood – 10%



Carbon dioxide is eliminated through the lungs





The Evolution of CO_2 Detection

Is there a pulse?

Colorimetric



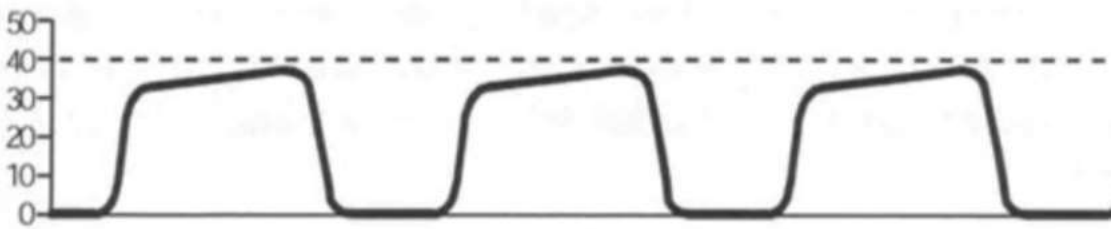
What is the rate?

Capnometry



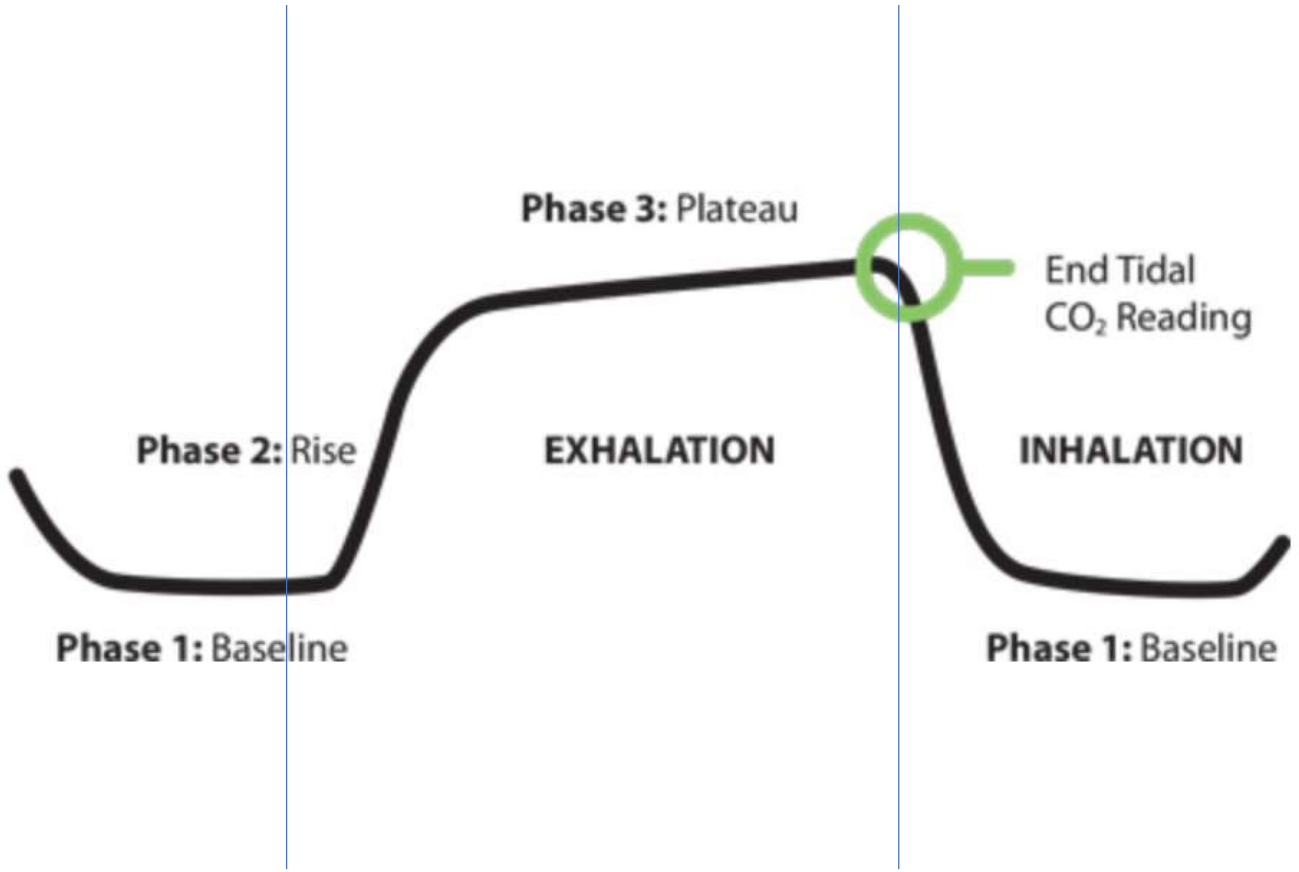
What is the rhythm?

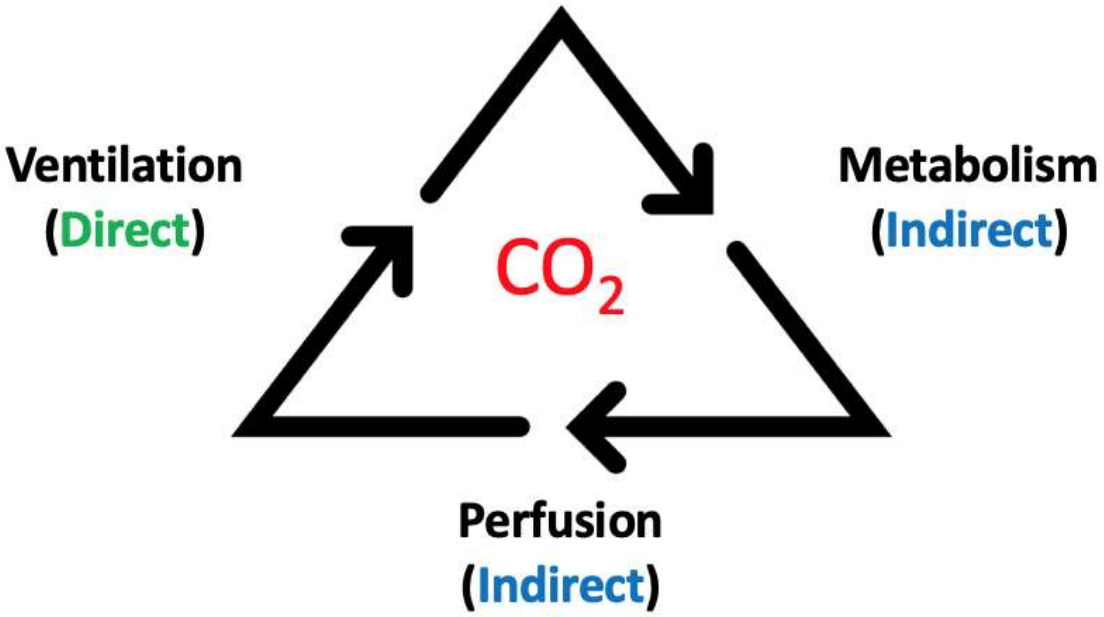
Capnography

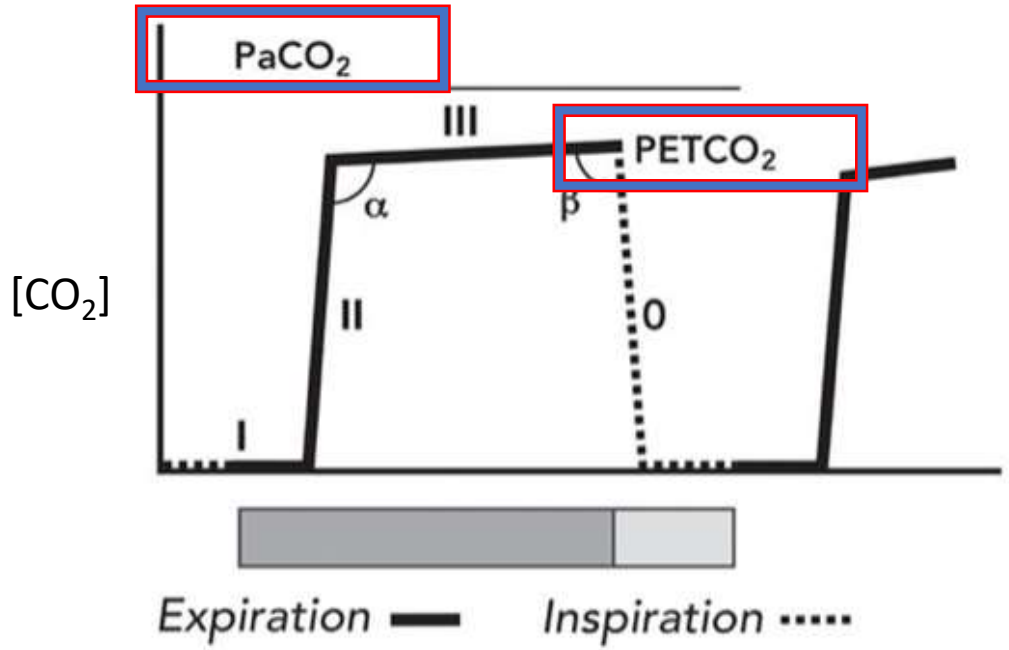


Capnography

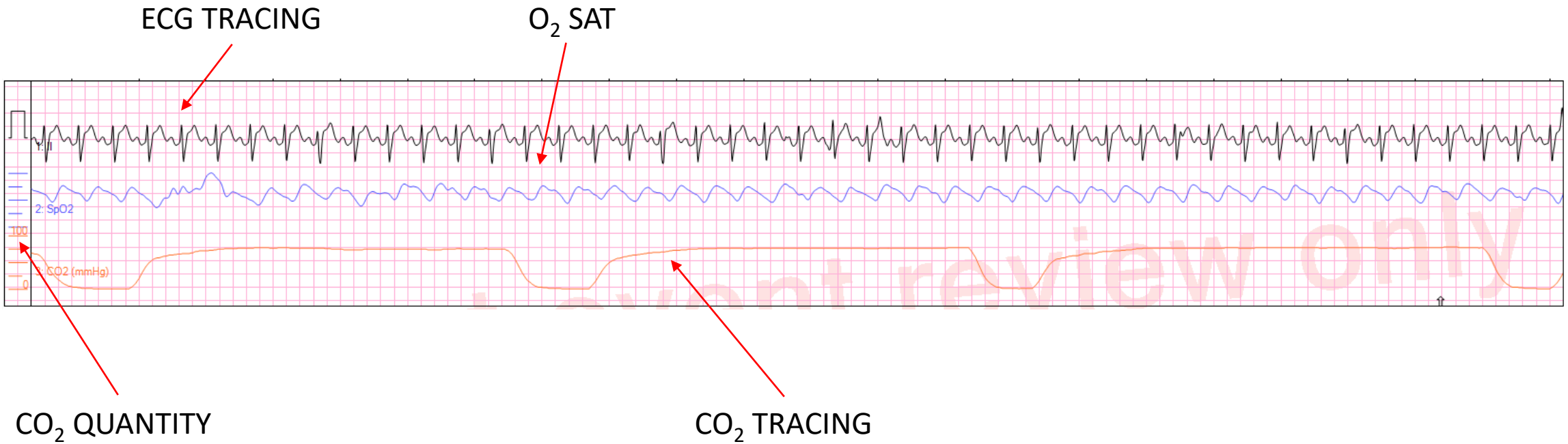
- Continuous numerical and waveform measurement of exhaled CO_2 concentration




Ventilation
(Direct)
Metabolism
(Indirect)
CO_2
Perfusion
(Indirect)


$[CO_2]$
$PaCO_2$
$PETCO_2$
III
II
I
α
β
0
Expiration
Inspiration

Lets Get Oriented

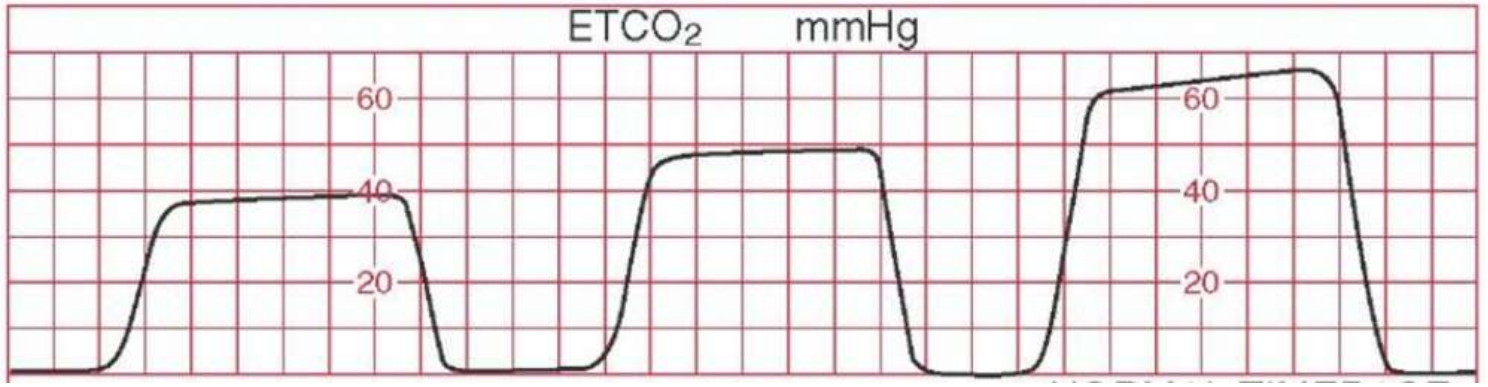


exam review only



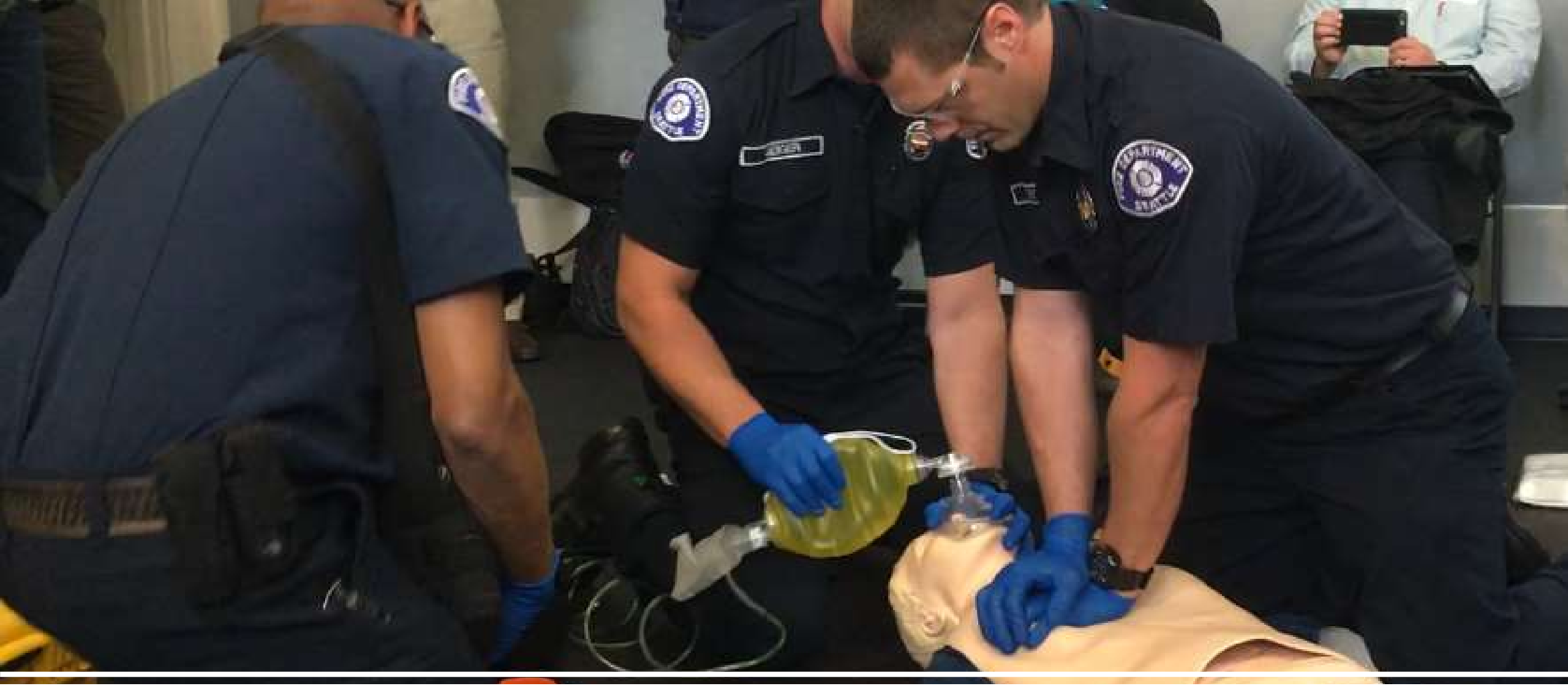
Capnography is not just for the ALS provider

Capnography
Most sensitive for detecting hypoventilation



Emergency Department

Airway Monitoring
AMS
Procedural Sedation



Let’s talk bagging





Effective Bagging

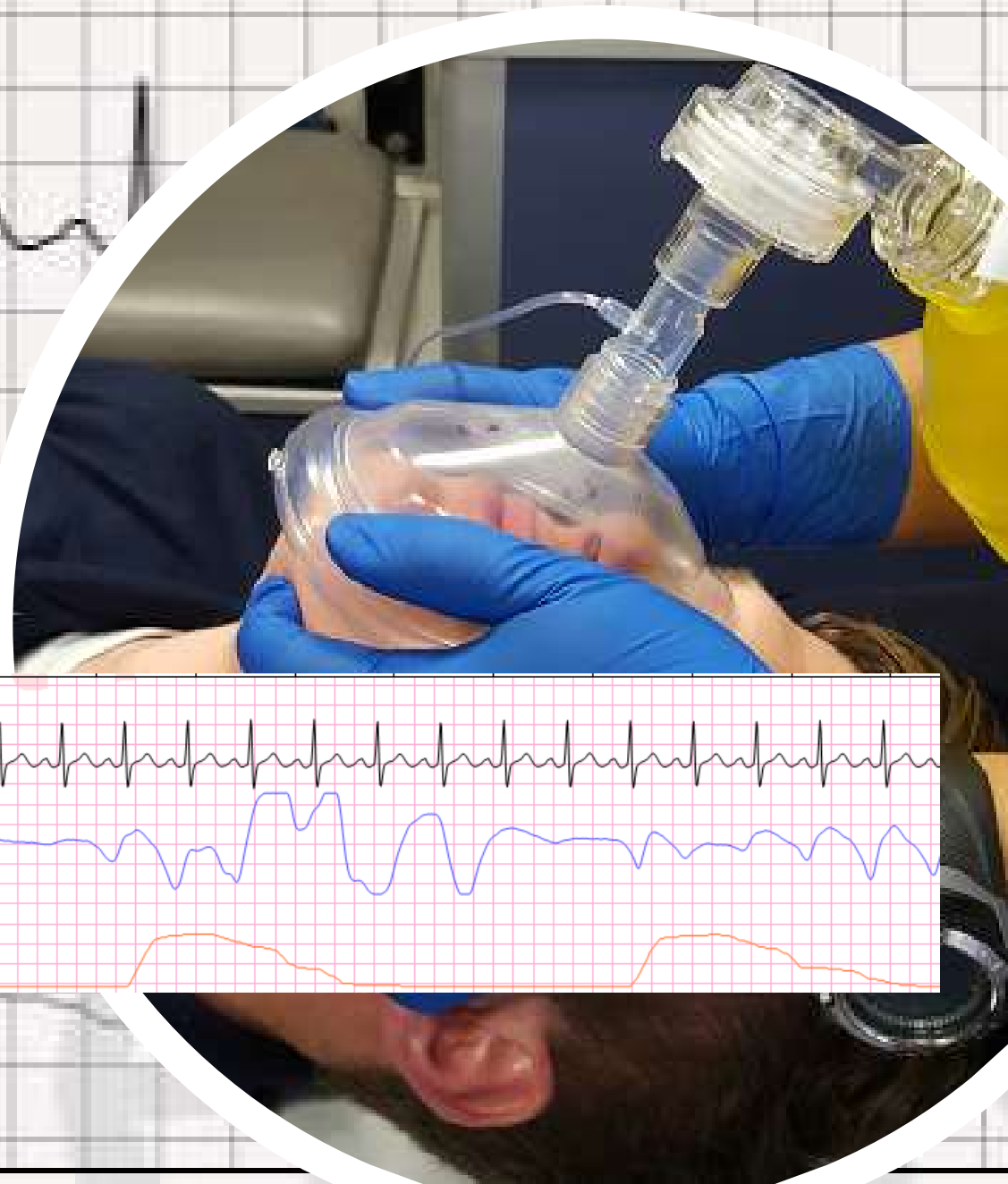
Effective Bagging

- Two person bagging better than one
- Jaw Thrust
- Face into the mask
- Light downward pressure with thumbs
- Bring face into mask with upward pressure



$EtCO_2$

- Quality of the mask seal
- Current ventilator status
- Potential $EtCO_2$ target





For post review


22 yo male reportedly took MDMA found seizing and hyperthermic
Requiring airway management
EXAMPLE USING EtCO2 with BVM
FREAKNIGHT

Prior to intubation



End tidal ~ 25

Intubation

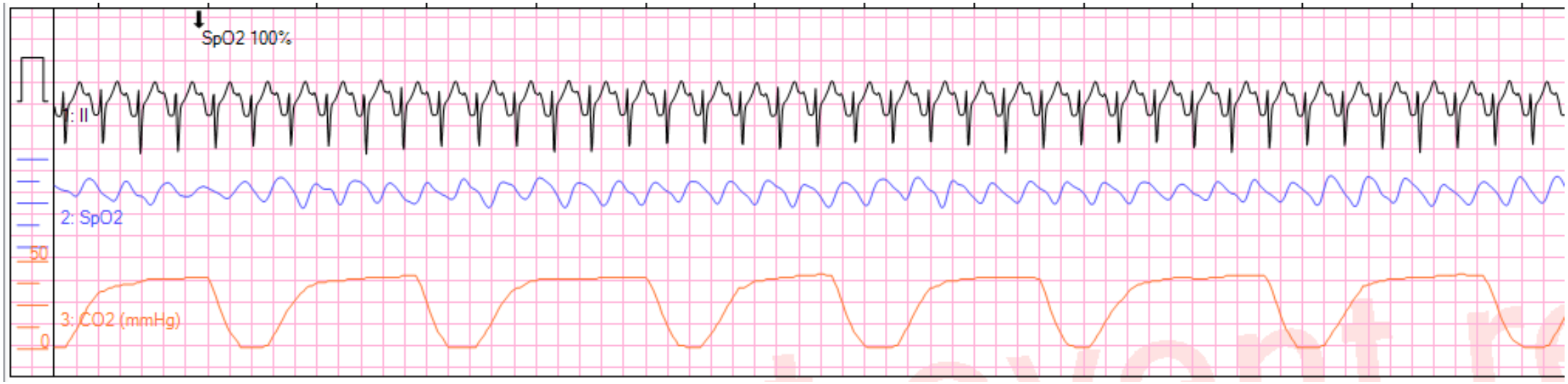
Approximately 45 seconds no ventilations during intubation



End tidal ~ 70

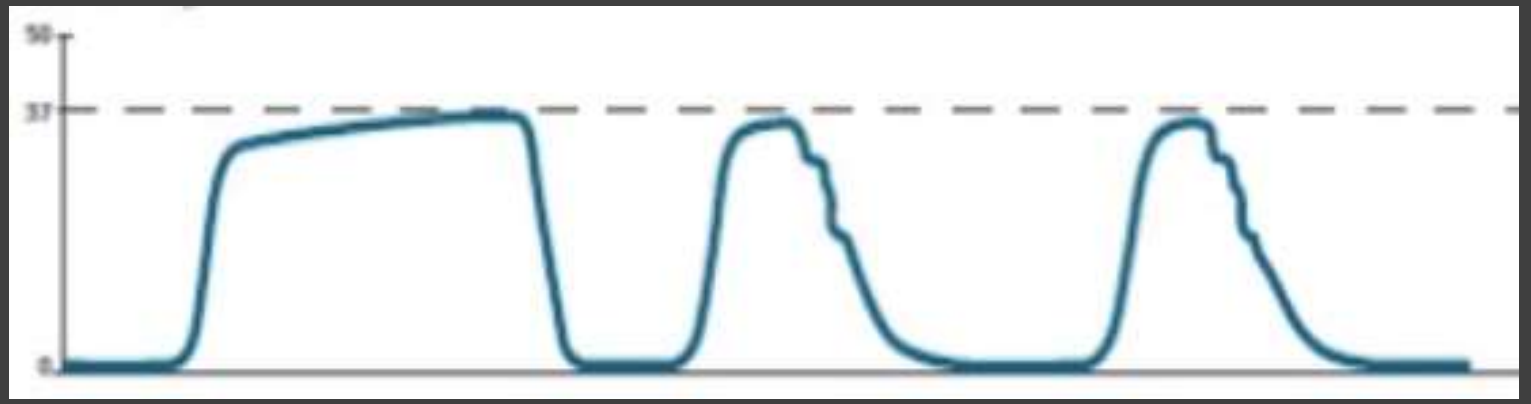
Arrival to hospital

What do you think of this patient's metabolic state?
How to you want to ventilate this patient?



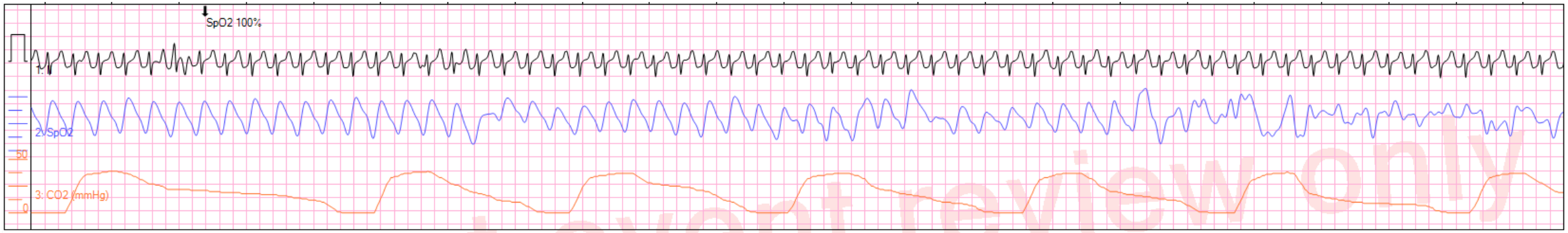

02:13:01
02:13:03
02:13:17
02:13:19
02:13:20
02:13:34
02:13:36
Physio-Control, Inc

The Second Attempt



- Second pass attempt a success!
- What is happening here?

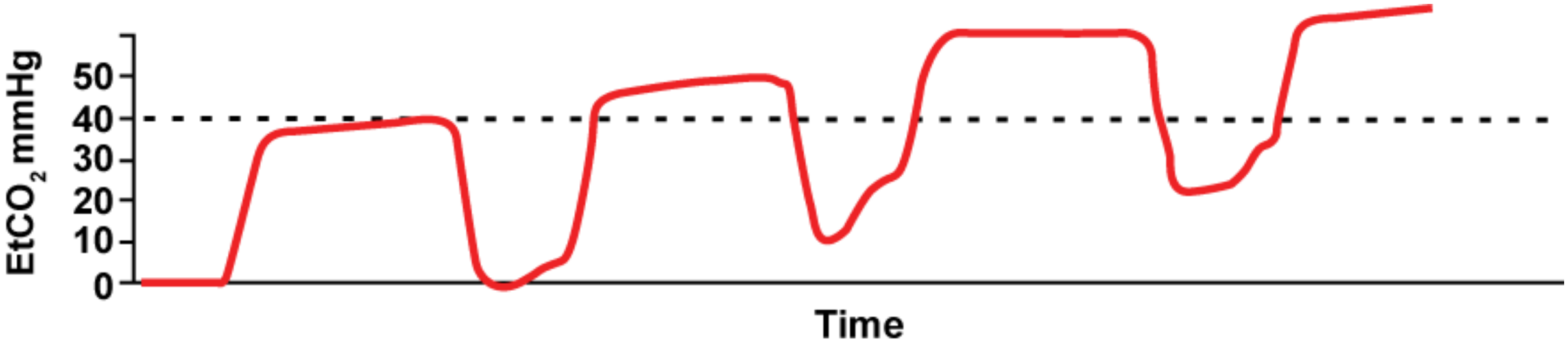
Cuff leak or hypopharyngeal ETT



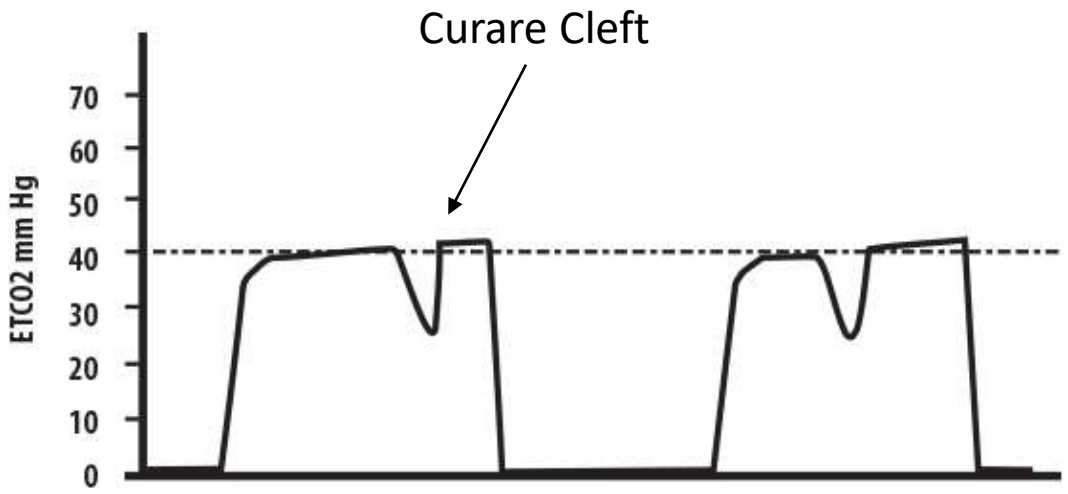
Waveform prior inflating balloon

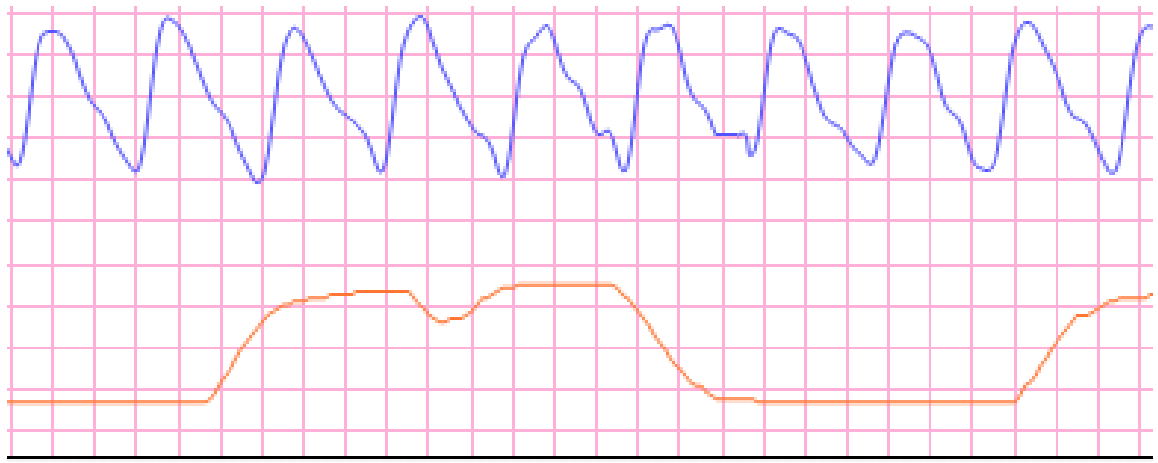
Learner review only

Rebreathing



Return of spontaneous respirations





The sixth vital sign



Front review only

$EtCO_2$

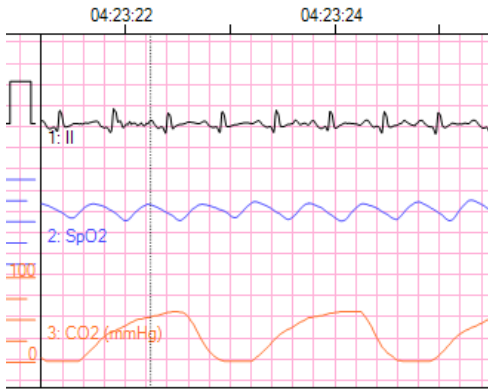
25 mmHg

DKA

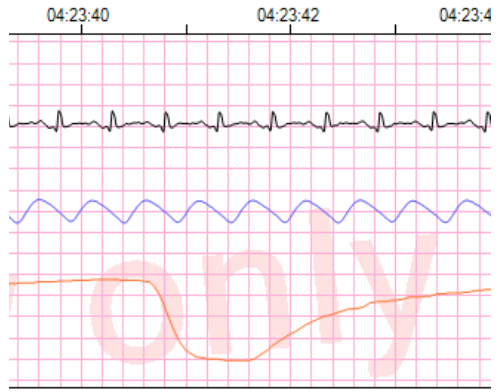
Sepsis

What is going on here?

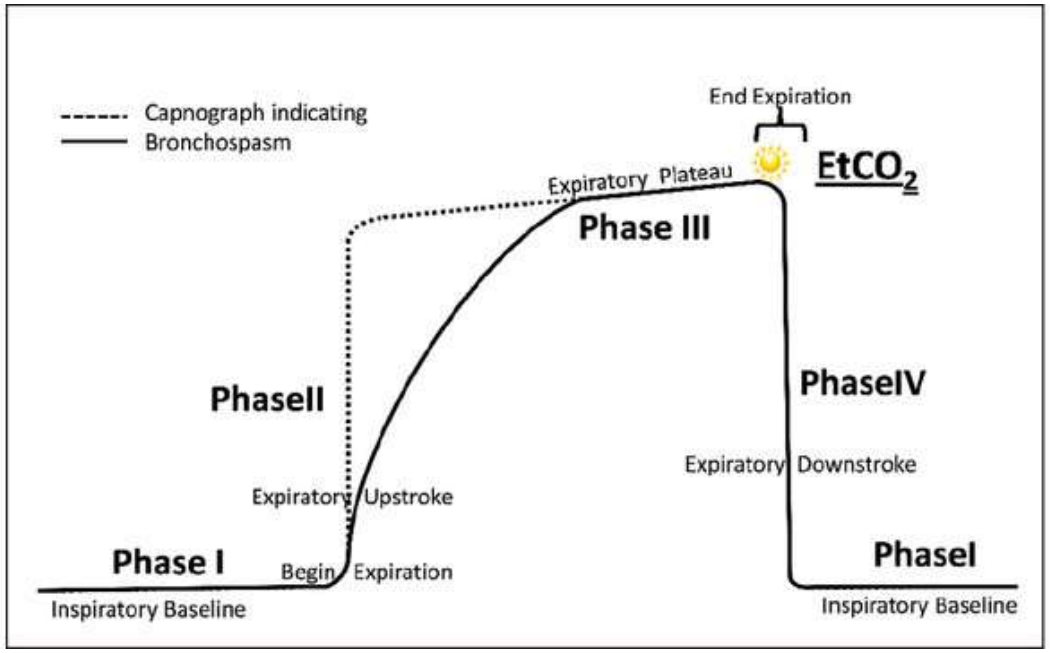
Case of difficulty breathing







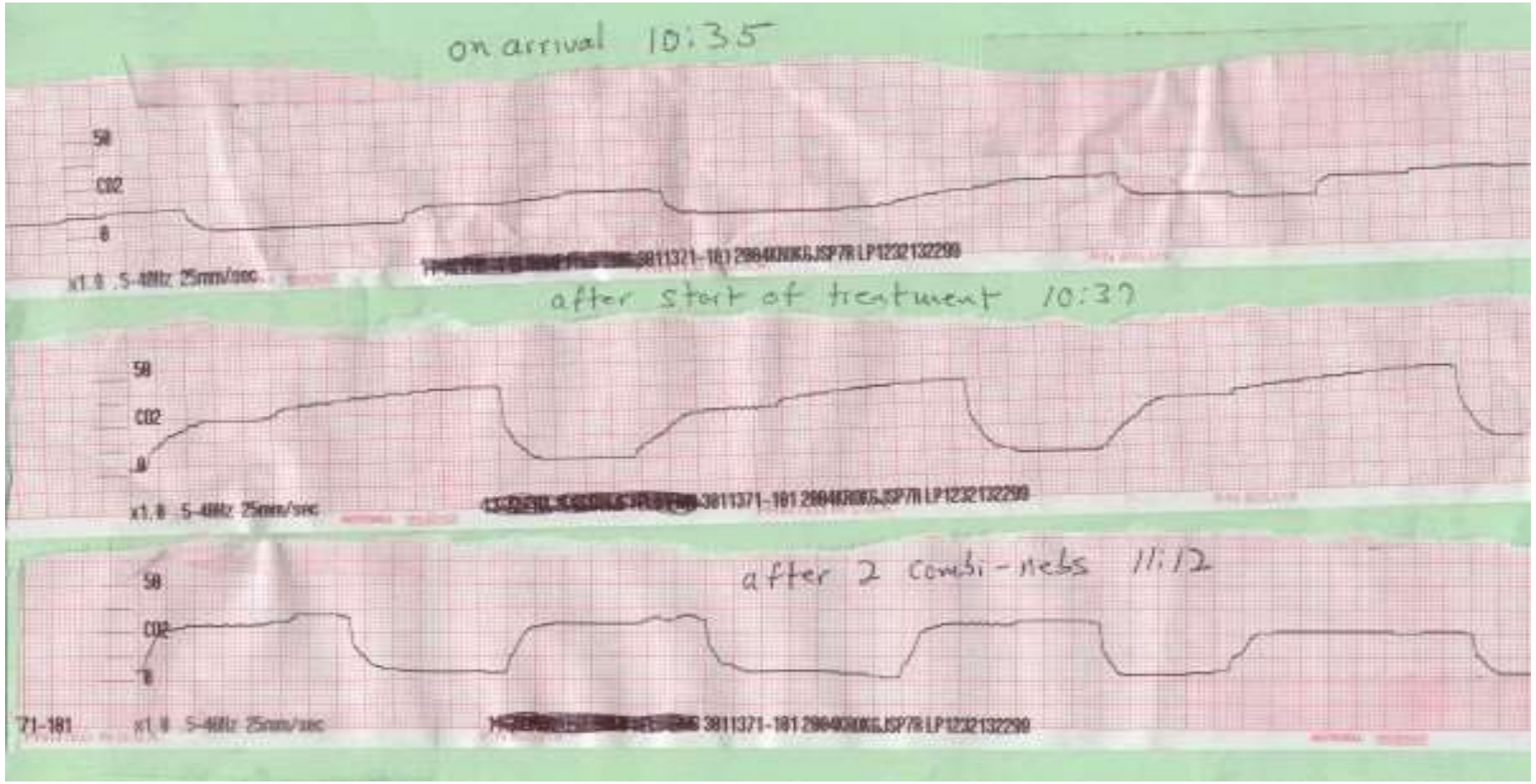
Bronchospasm







Changes with treatment

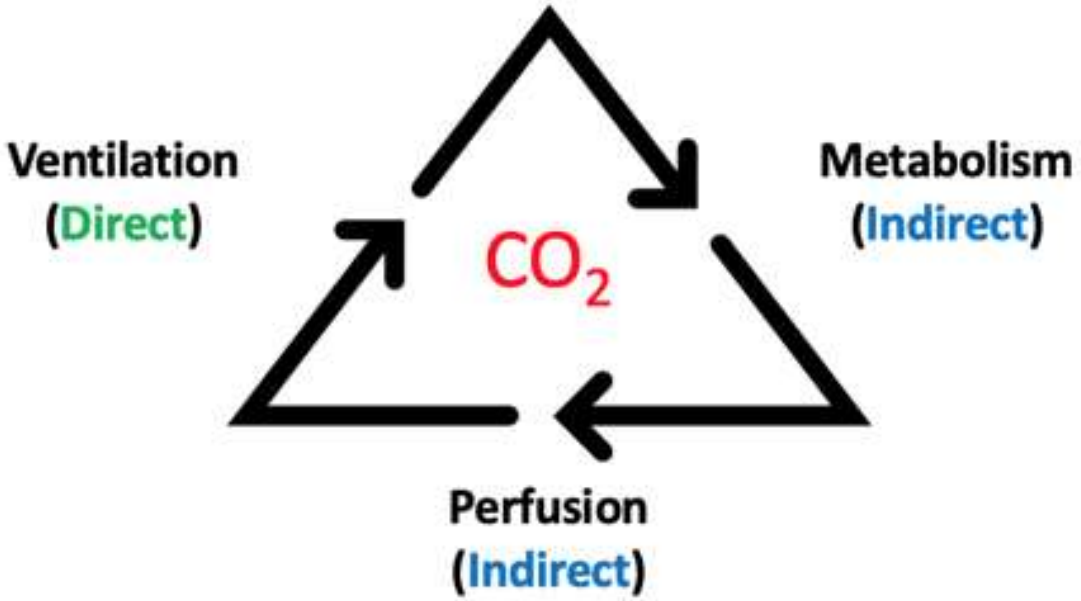


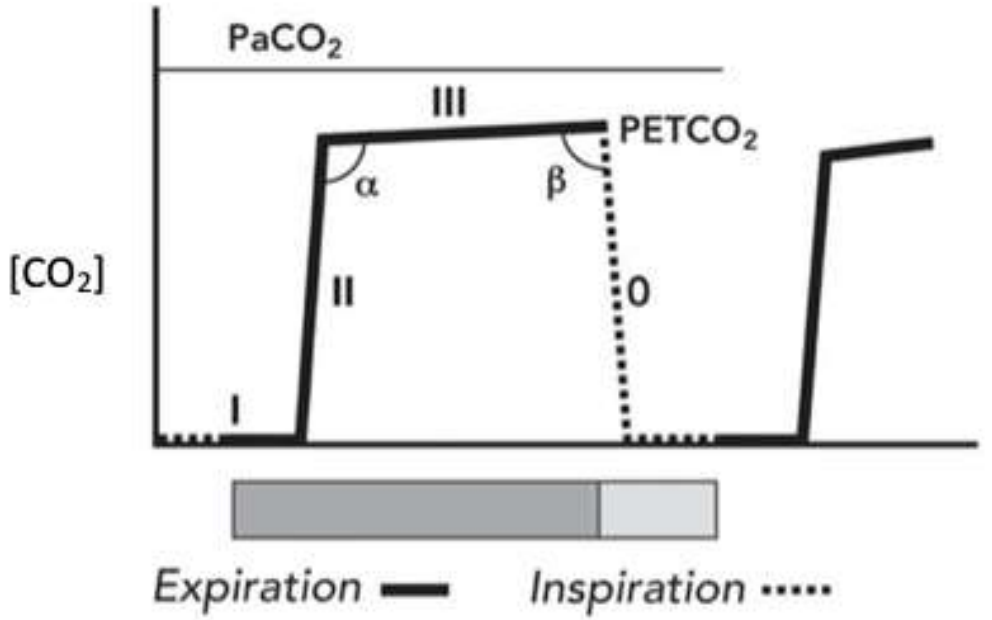


$PaCO_2$ – $EtCO_2$ gadient

When the end tidal reading does not accurately reflect the arterial CO_2

Normal $PaCO_2$ – $EtCO_2$ gradient is within 5 mmHg





$EtCO_2$ accurately reflects $PaCO_2$ when

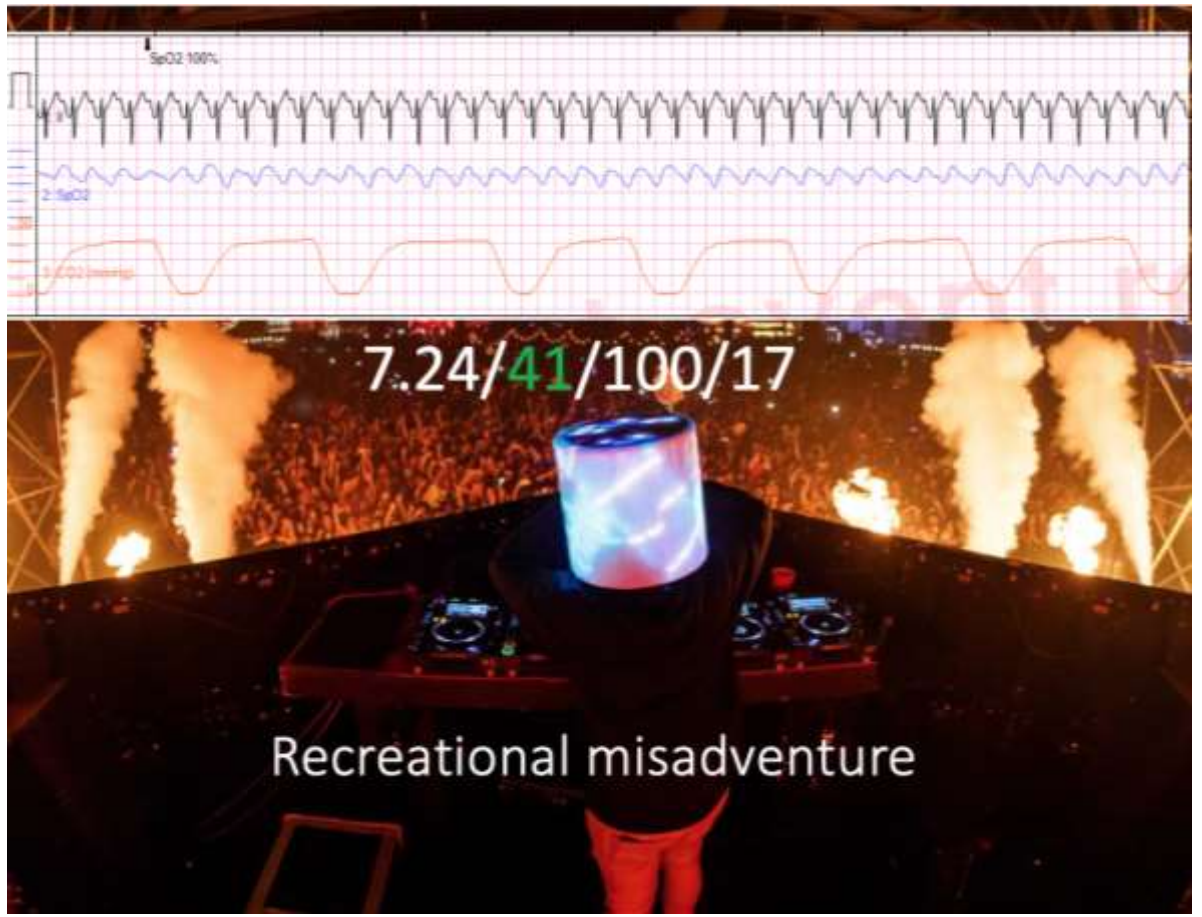
Normal <u>perfusion</u> state

(delivery)

AND

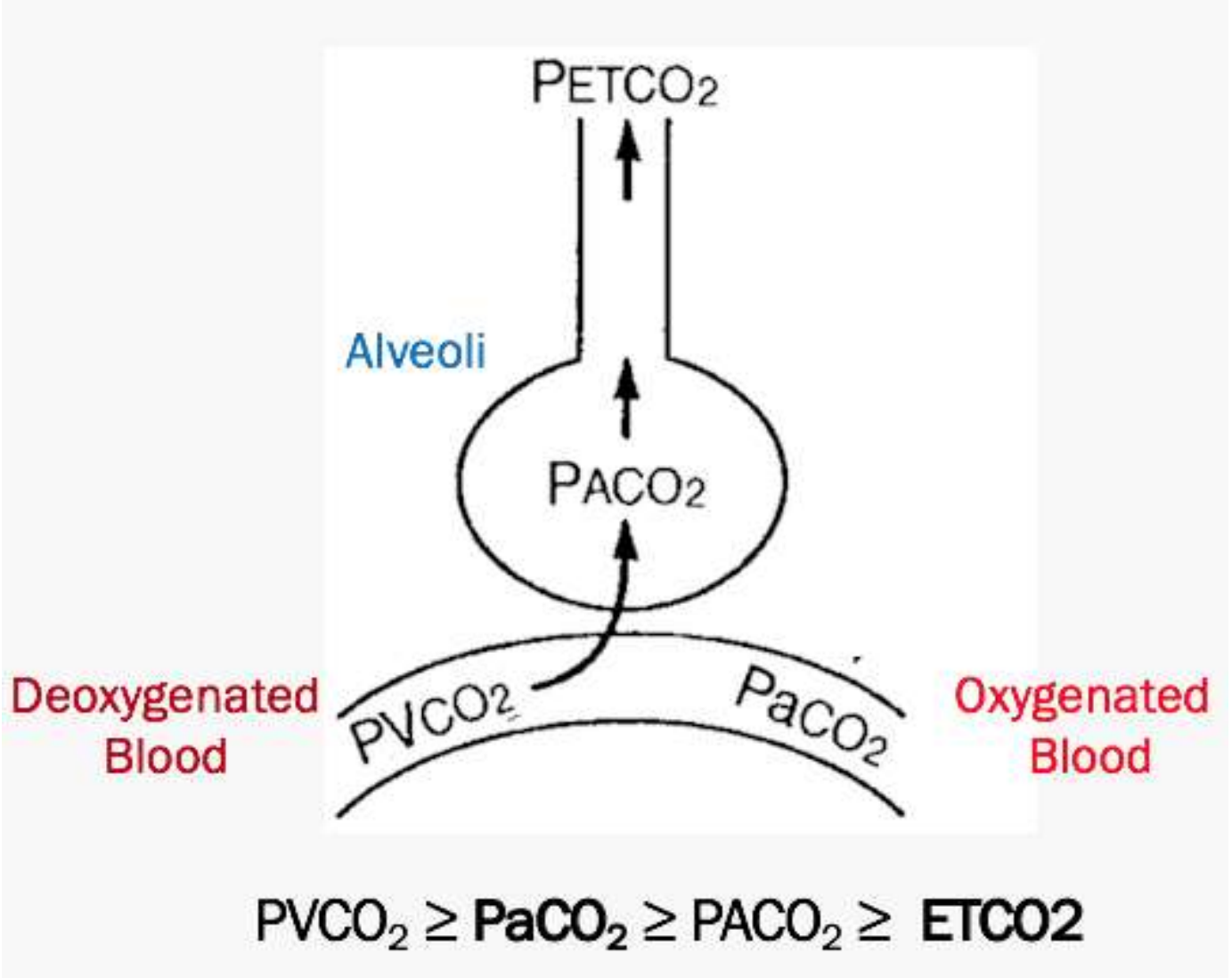
Normal <u>ventilatory state</u>

(gas exchange)



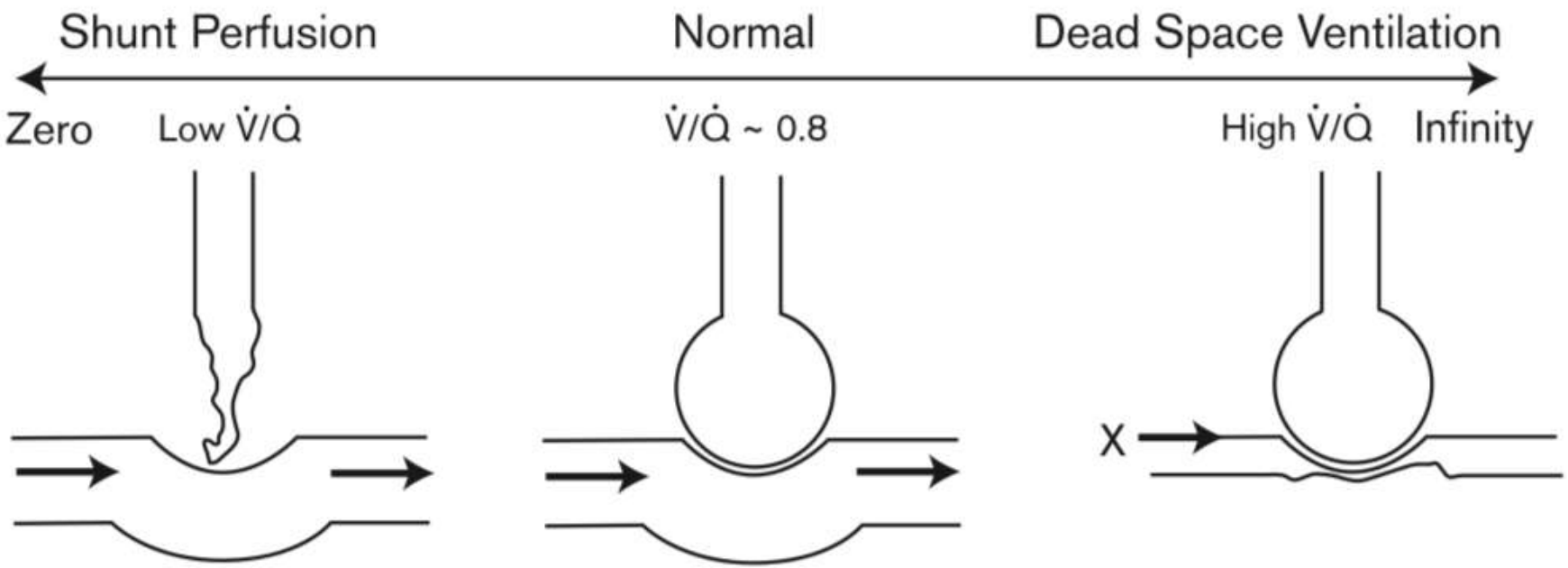
This gradient is invariable positive

$PaCO_2 \geq EtCO_2$



The CO_2 Gradient is determined at the level of the alveoli

Atelectasis
Mucus plug
Pulmonary edema
Pneumonia
Mainstem ETT
ETC…

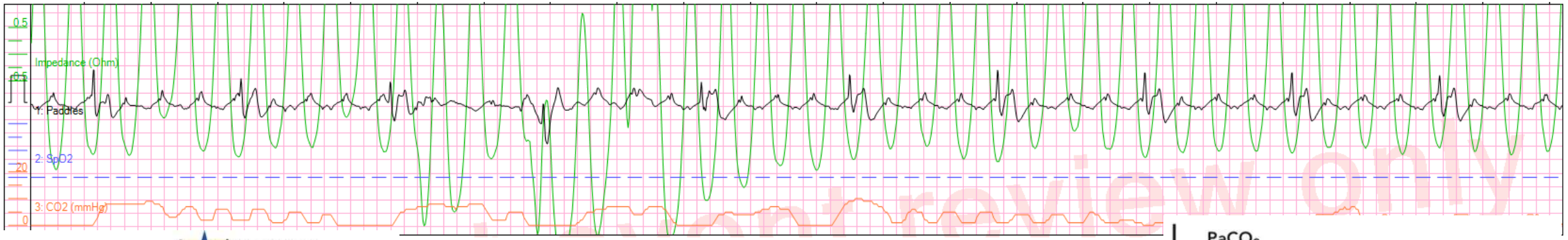


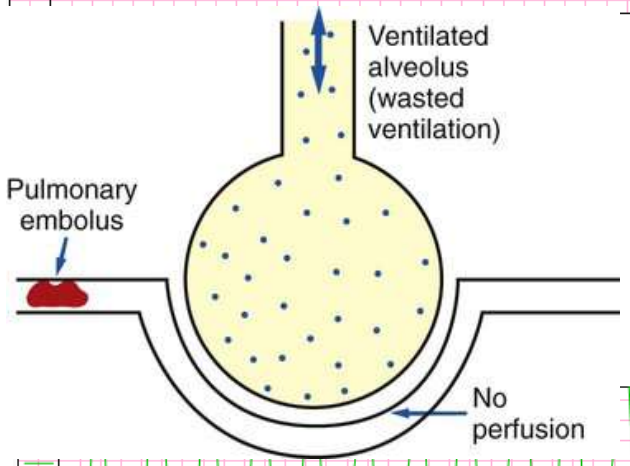
PE
Reduced CO
Shock
Cardiac arrest
ETC…

Ventilation-Perfusion Spectrum

And
as your are collecting his history he arrests in front of you…

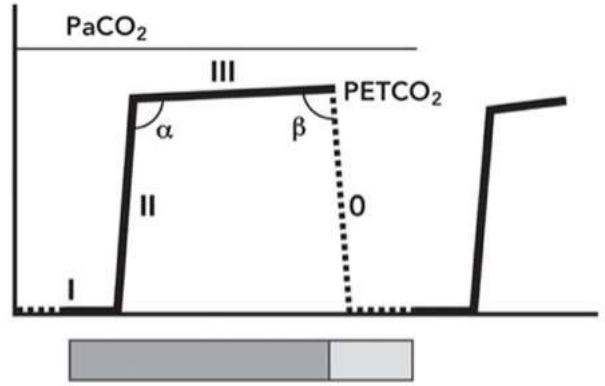
Post Intubation Initial $EtCO_2$ 10

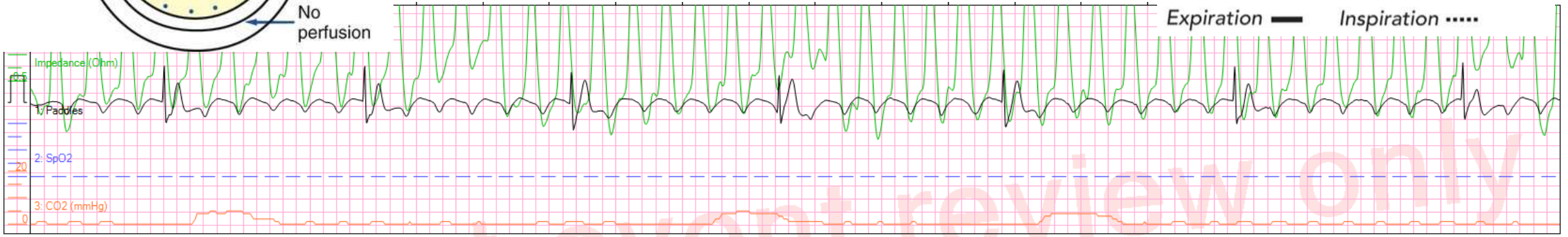




Transported to emergency department with ongoing CPR

After 50 minutes of resuscitation
$EtCO_2$ 5-10
However, ABG pH 6.9 and $PaCO_2$ 135



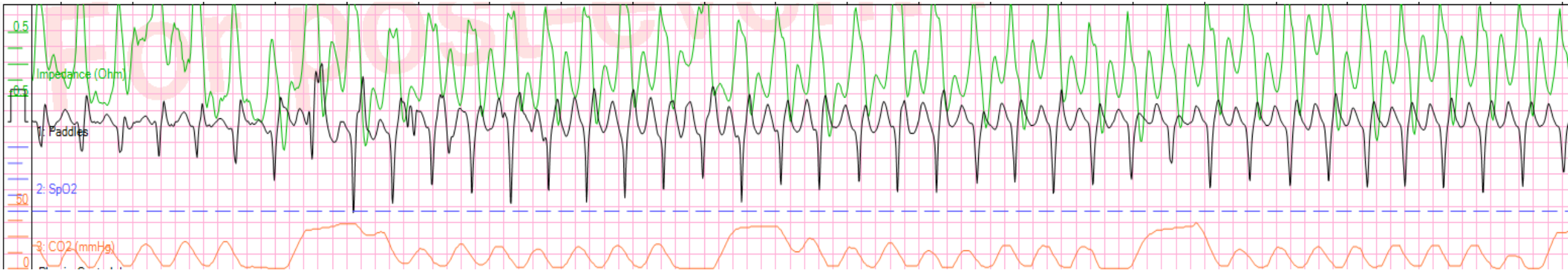


patient review only

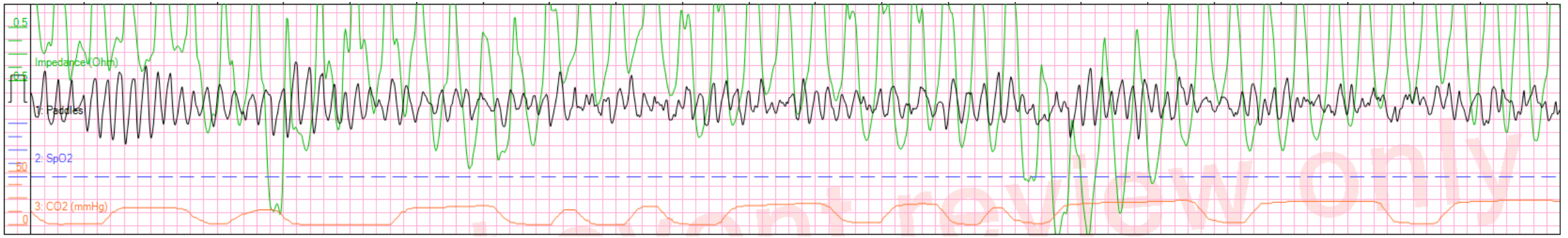
CARDIAC ARREST



- ✓ Verification of ETT
- ✓ Visualization of ventilations
- ✓ Quality of chest compressions
- ✓ **ROSC**
- ✓ **Prognostication**



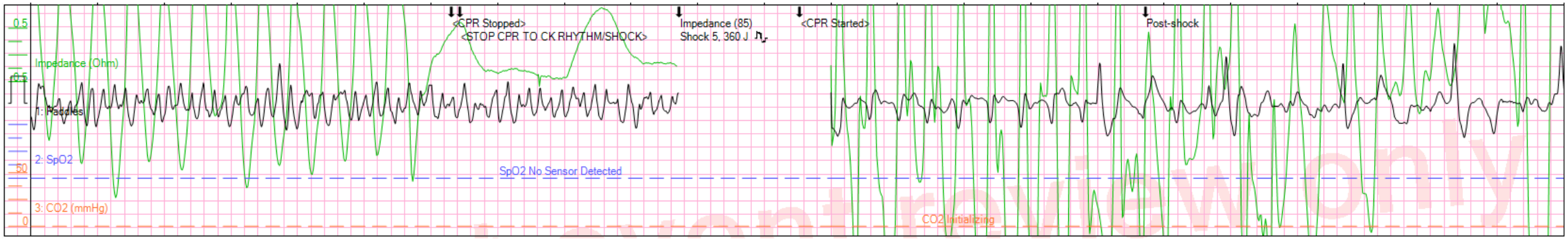
Ventricular Fibrillation



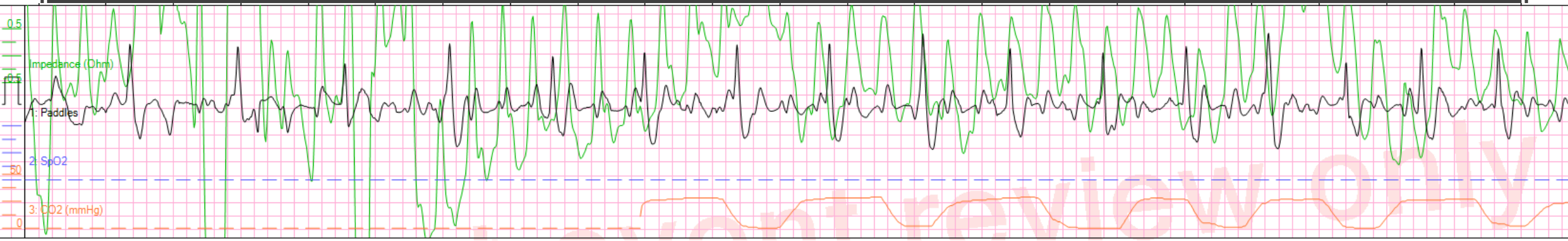
End tidal ~ 20-25

What do you do with this?

Bring the lightning!



ROSC



End tidal ~ 50 ($EtCO_2$ 25 prior to defibrillation)

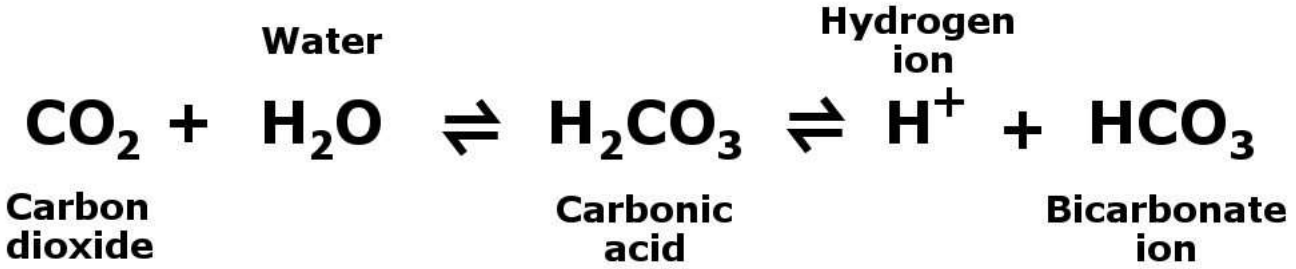


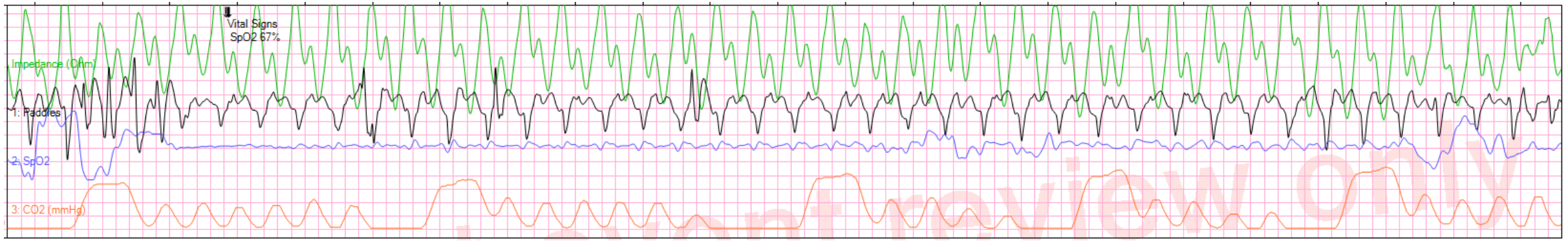
$EtCO_2$ rise > 10 mmHg specific but not sensitive for ROSC

LOOK FOR TRENDS

Bicarb administration

Don’t be fooled…





exam preview only

$EtCO_2$ 50

$EtCO_2$ 30

$EtCO_2$ 20

$EtCO_2$ 10



Termination of resuscitation

$EtCO_2 \leq 10$ mmHg after 20 mins 100% mortality



”ACLS is for dentist”



Last case: A fender bender…
Polytrauma + TBI = bad day

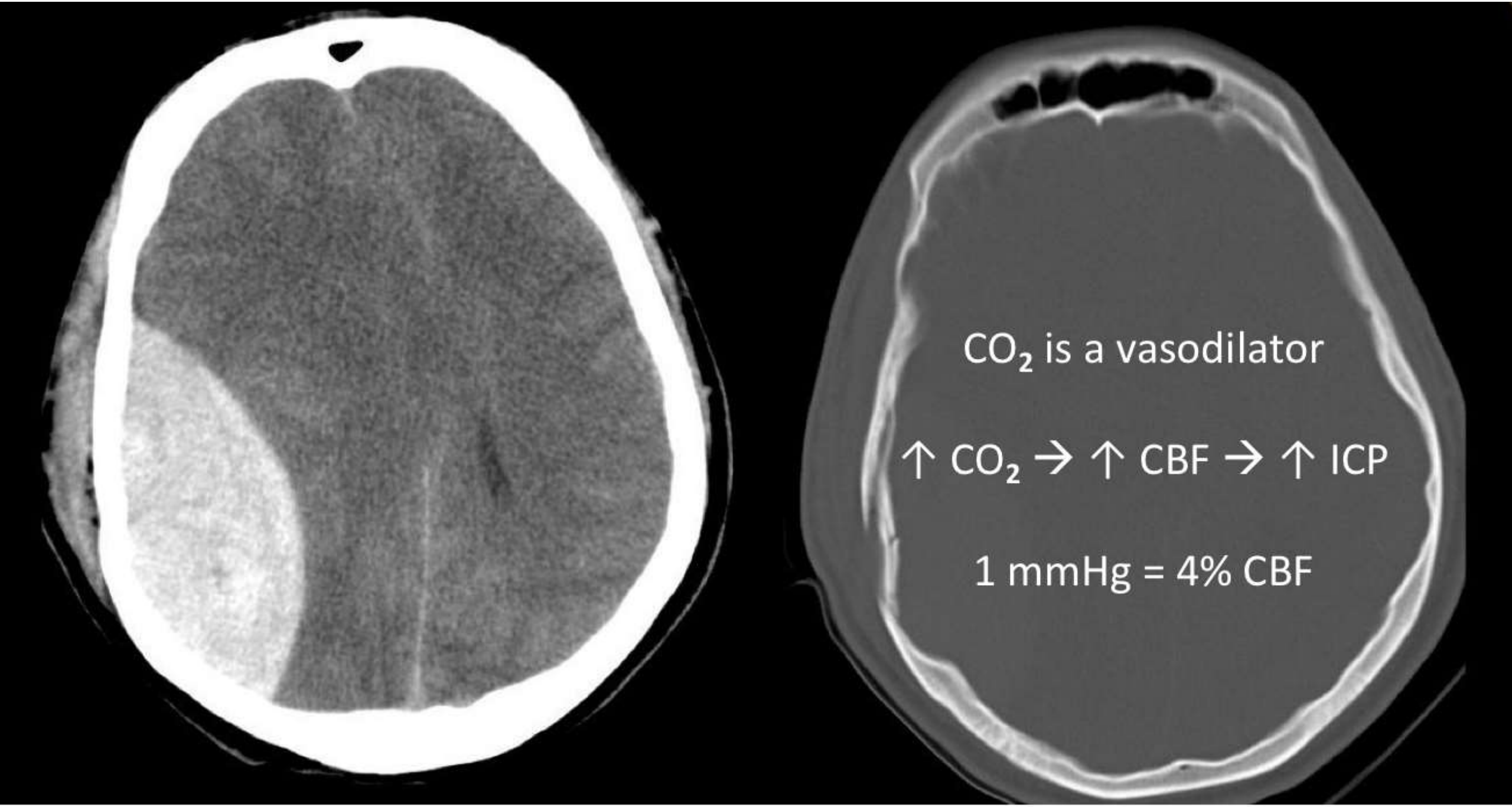
22 yo male MVC. Unresponsive, initial GCS 3 sluggish pupils. Large hematoma right temple with bruising to chest and abdomen and a right closed femur deformity.

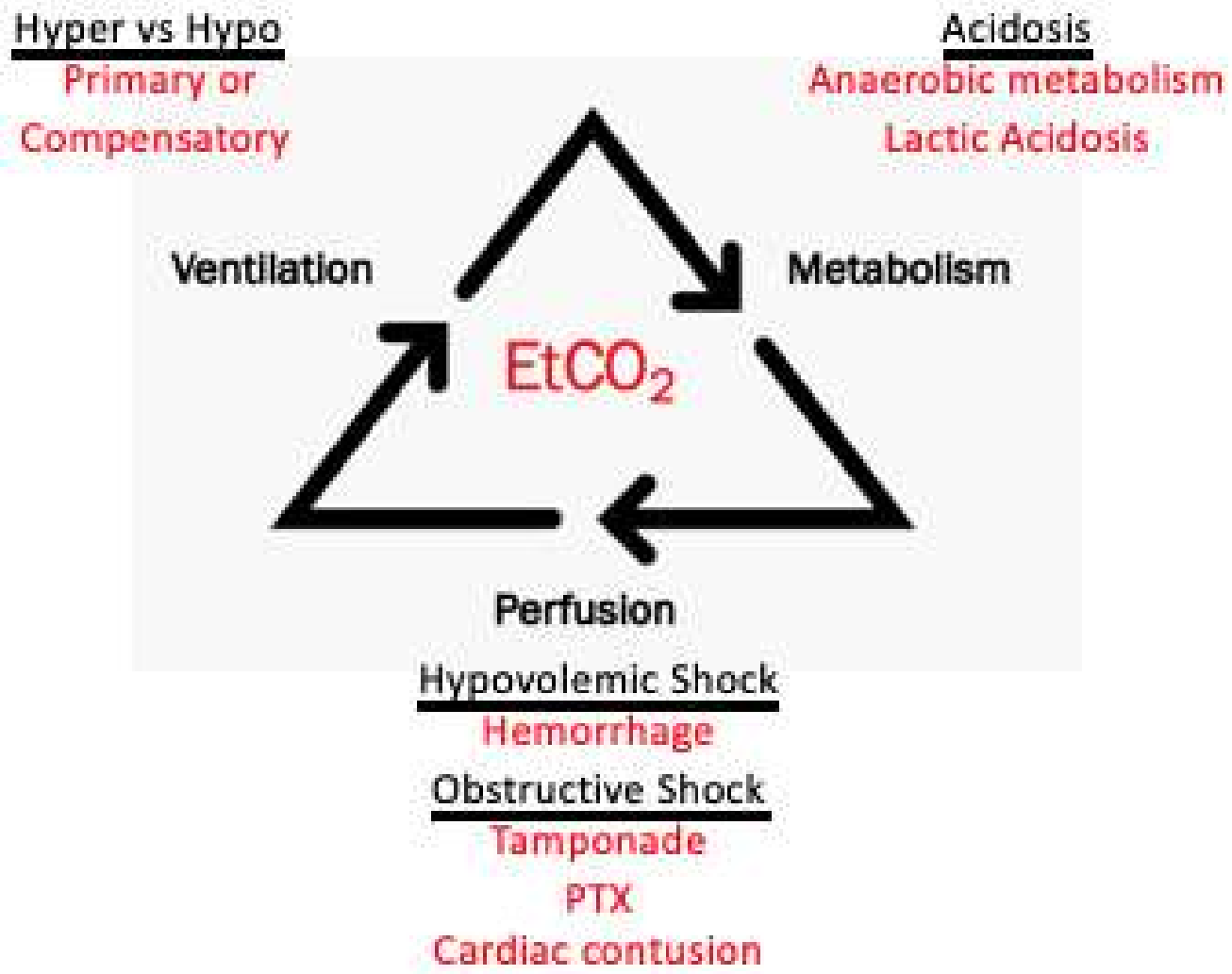
Intubate with ketamine and rocuronium

- HR 125
- BP 90/60
- O_2 95% BVM w/ RR 18 at 100 FiO_2

How are you going to ventilate your patient if?

1. $EtCO_2$ 70
2. $EtCO_2$ 20


CO_2 is a vasodilator
↑ CO_2 → ↑ CBF → ↑ ICP
1 mmHg = 4% CBF



Trauma

$PaCO_2$-$EtCO_2$ gradient

$EtCO_2$ accurately reflects $PaCO_2$ when

Normal <u>perfusion</u> state

(delivery)

AND

Normal <u>ventilatory state</u>

(gas exchange)

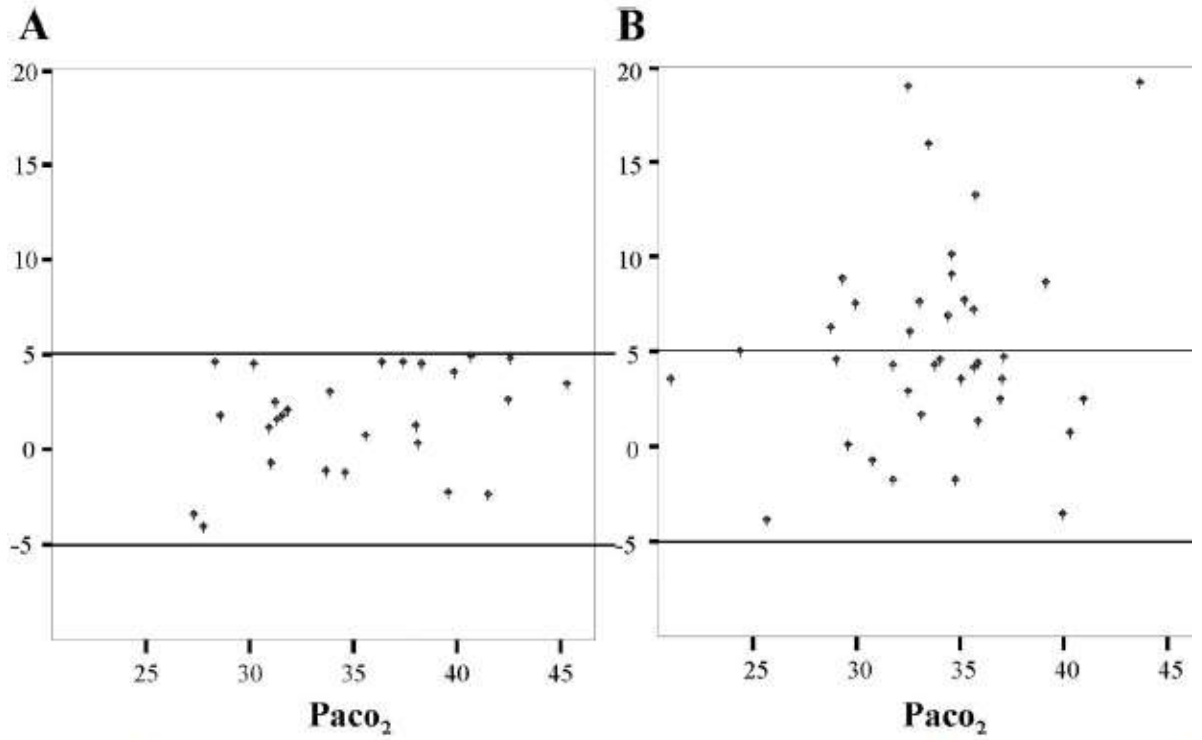


Figure 2. The concordance between $Paco_2$ and $Petco_2$ by Bland-Altman method. (who had no severe chest trauma, no hypotension, and no metabolic acidosis. (*B*) C had severe chest trauma, hypotension, or metabolic acidosis. (*C*) All nontraumatic normal $P(a-et)co_2$.



Polytrauma with TBI

How are you going to ventilate your patient if?

1. $EtCO_2$ 70
2. $EtCO_2$ 20

If $EtCO_2$ is **high** → target eucapnia

If $EtCO_2$ is **low** → "Let it go"



Summary

- Waveform capnography reflects
  - Ventilation
  - Perfusion
  - Metabolism
- Waveform capnography is the 6th vital sign
  - Use it to guide ventilations
  - Recognize common waveforms
  - Guide therapeutics
  - Diagnostic utility
- Understand the $PaCO_2$-$EtCO_2$ gradient and how to apply to your patient

www.escholarship.org/uc/item/5qz744fv