Pulse oximetry

Cassidy Goering, RVT
Anesthesia Section
Lead Nurse
Veterinary Health Center

Outline

-Physiology

-Importance

-How the probe works

-What is a saturation

-Oxygen Hemoglobin Dissociation

-Plethysmography

-Hypoxemia

-Interference

Probe/ Placement

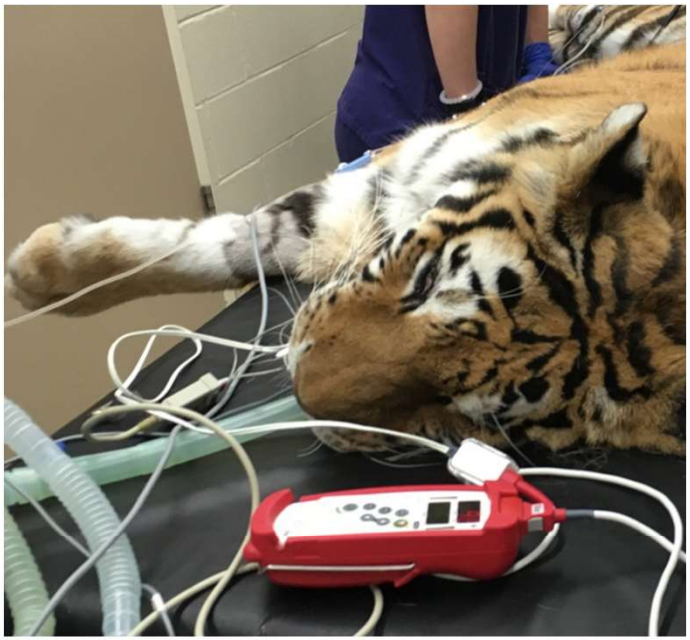
Also measures…

Fundamental Principles of Pulse Oximetry

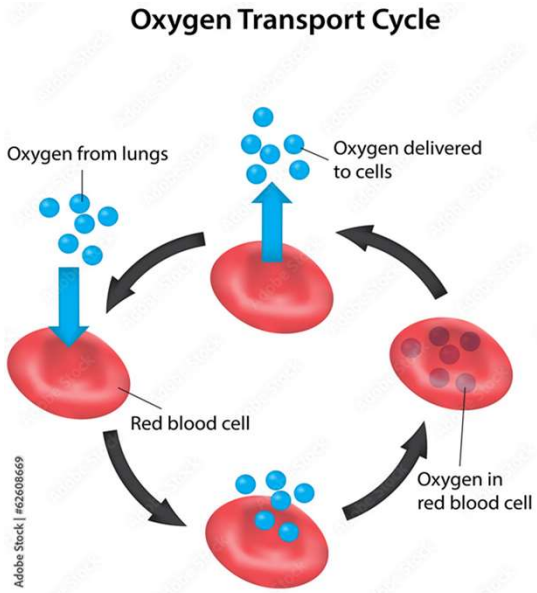
LED light source, photometer, control circuit, display screen

Noninvasive, continuously detecting pulsatile change of percent saturation

***Continuously estimating % hemoglobin saturated with oxygen**



Oxygen transport

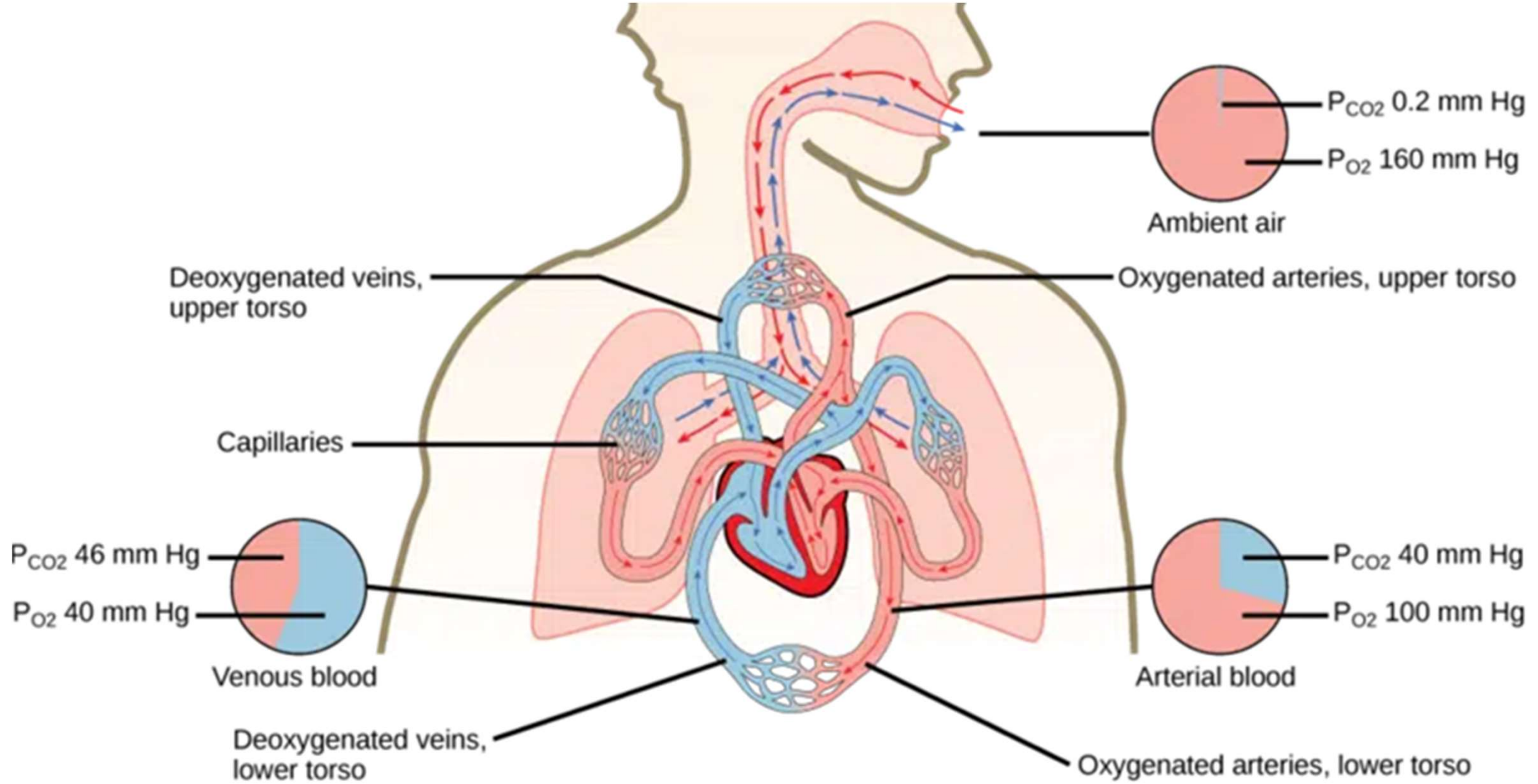


Venous blood (deoxygenated blood) —> Lungs —> Arterial blood (oxygenated blood) —> Tissues (for cellular metabolism) —> Venous blood for returning to the lungs

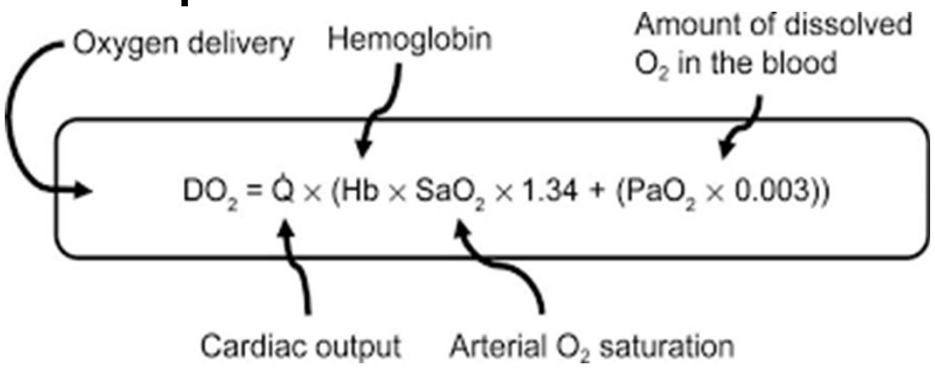
Once oxygen leaves the lungs:

-O2 diffuses into plasma and then binds to the protein *Hemoglobin*

-Hemoglobin located in RBCs


P_{CO2} 0.2 mm Hg
P_{O2} 160 mm Hg
Ambient air
Deoxygenated veins, upper torso
Oxygenated arteries, upper torso
Capillaries
P_{CO2} 46 mm Hg
P_{O2} 40 mm Hg
Venous blood
P_{CO2} 40 mm Hg
P_{O2} 100 mm Hg
Arterial blood
Deoxygenated veins, lower torso
Oxygenated arteries, lower torso

Oxygen Transportation



DO2= CO x CaO2

DO2= delivery of oxygen to tissues

CO= Cardiac output

CO= Stroke volume x heart rate

CaO2= oxygen carrying capacity

CaO2= (Hb x 1.39 x SaO2) + 0.003Hg x PaO2

CaO2 says how much O2 is carried in a patient's blood

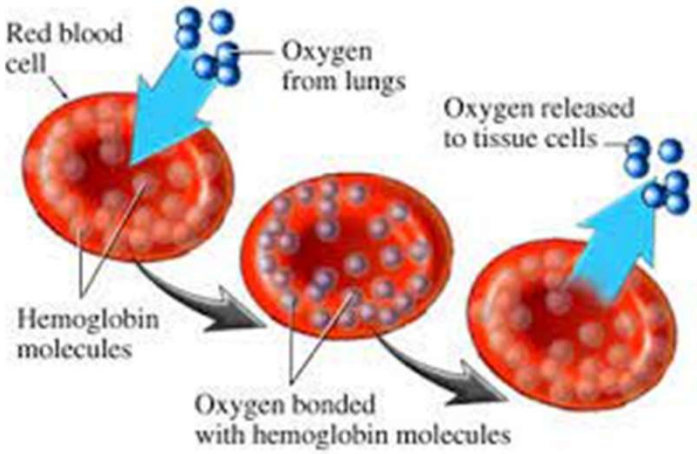
Calculating this….. Not feasible. ….. Use a pulse ox.

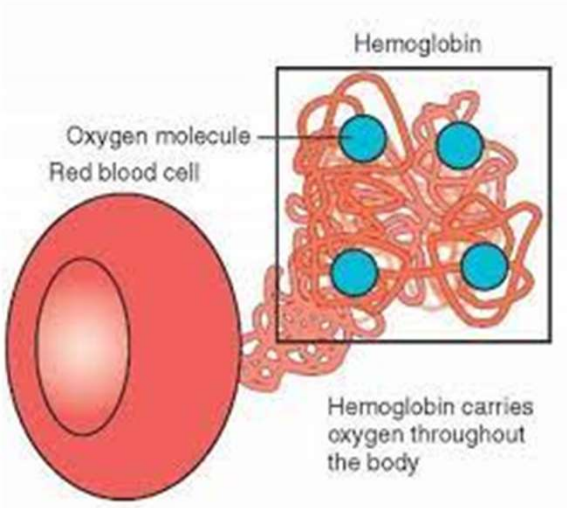
Oxygen Carrying Capacity

-Hemoglobin molecule — 4 oxygen molecules = fully saturated

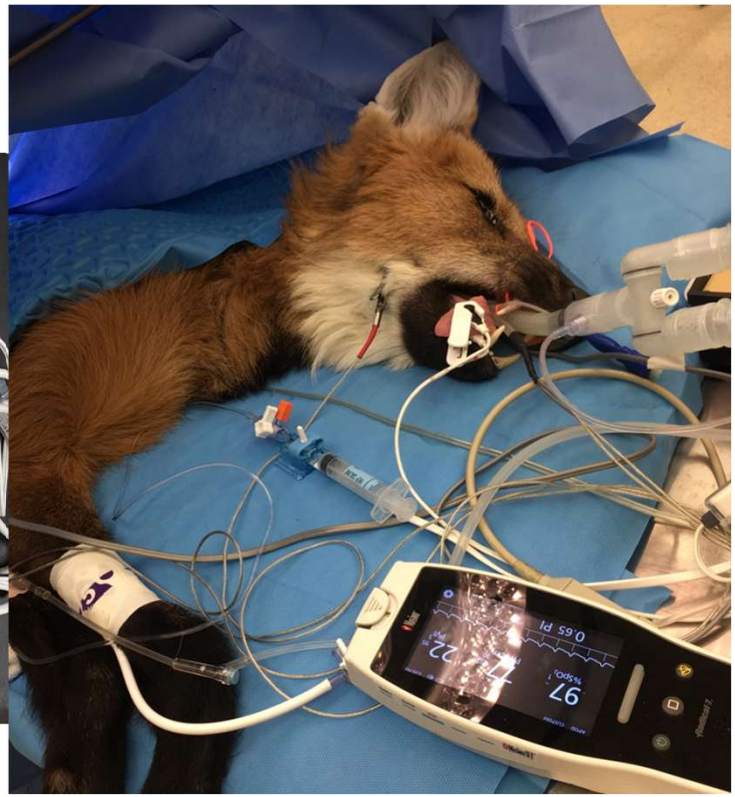
-Each RBC — millions of hemoglobin molecules

—-> each RBC is carrying millions and millions of O2 molecules





Info communicated from the pulse ox



Pulse-ox communicates

- -% Hb saturated w/ O2
- -Peripheral perfusion
- -Pulse rate
- -Pulse rhythm (waveform)

Information regarding respiratory and cardiovascular systems.

Ensure: adequate circulation, oxygenation

Best Thing about a Pulse Ox

Everyone can use!

-Quick reading —-> Quick intervention

Quickest, easiest,

potentially most beneficial intervention

-Oxygen mask

<u>Pulse ox may prompt:</u>

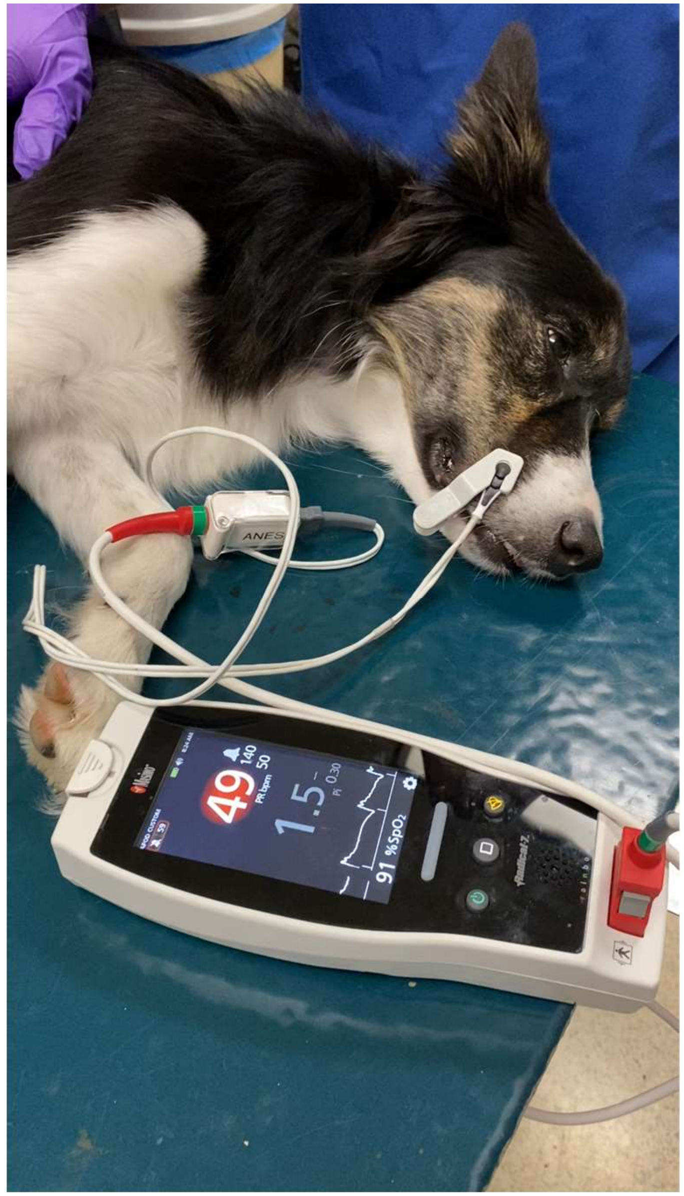
-anesthetic intervention

-oxygen mask/ nasal insufflation/ high flow

-chest tap (disease depending)

-sedation to ease breathing (calm down)

-chest rads (further diagnostics)


ANES
49
PR bpm
140
50
1.5
PI
91 %SpO2

When to use

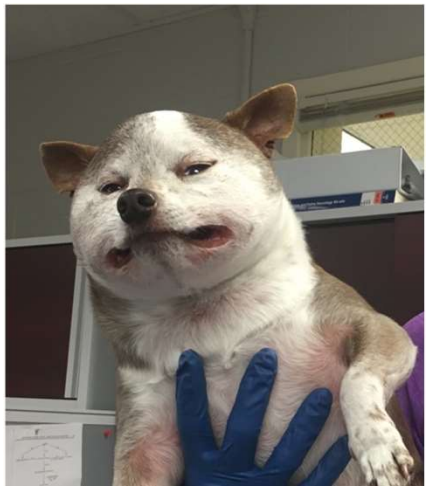
Unsure of patient's O2 status?

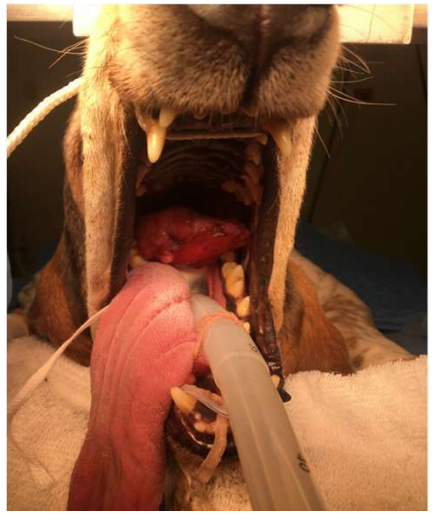
- e.g., hit by car
- e.g., aspiration pneumonia
- increased respiratory effort/noise

Every single sedated patient

Every single anesthetized patient

Every single patient recovering from anesthesia



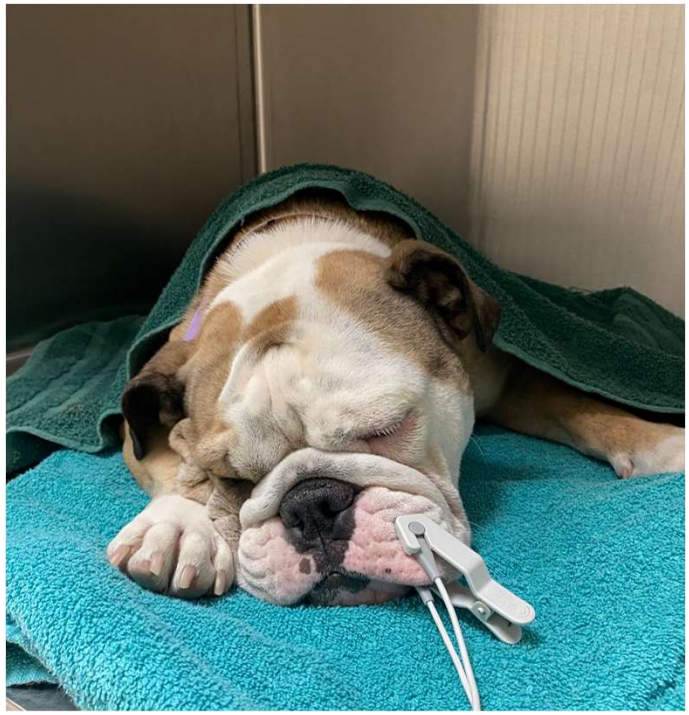


Adverse Respiratory Events

"roughly one-third to one-half of adverse events requiring critical interventions in hospitals are related to altered respiratory function" -MyAmericanNurse.com

Animals + Respiratory Events

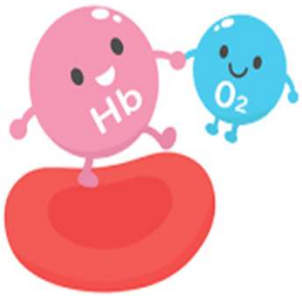
- Alterred respiratory functions in the hospital
  e.g., stressed cat with respiratory disease
  Overweight bulldog on a long jog



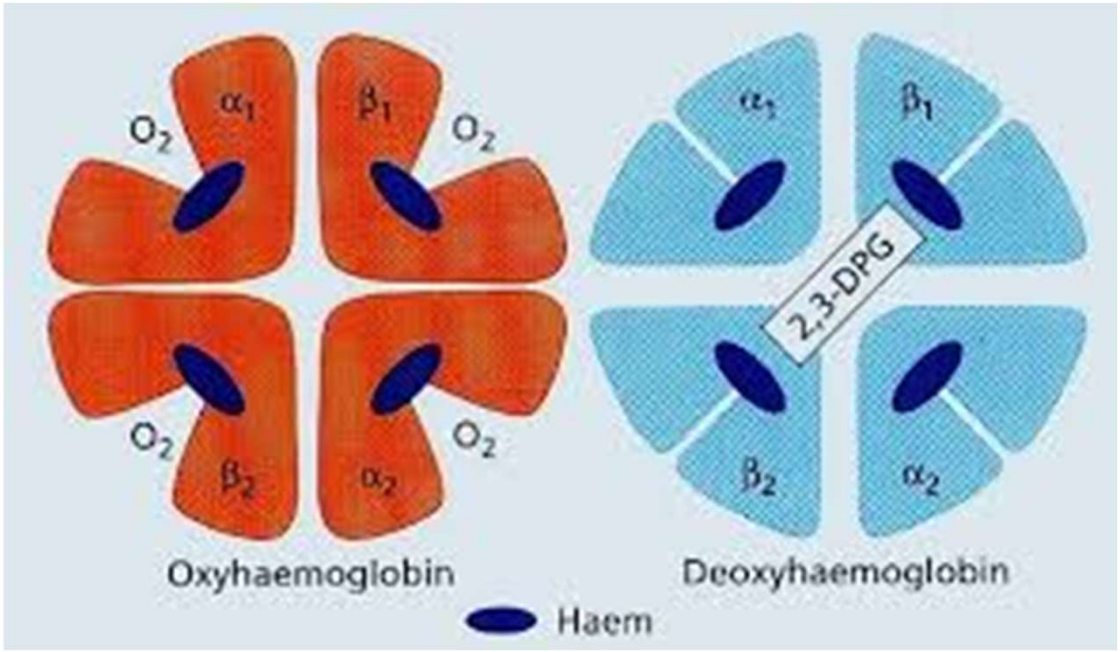
Throw a pulse ox on!

Key Terms

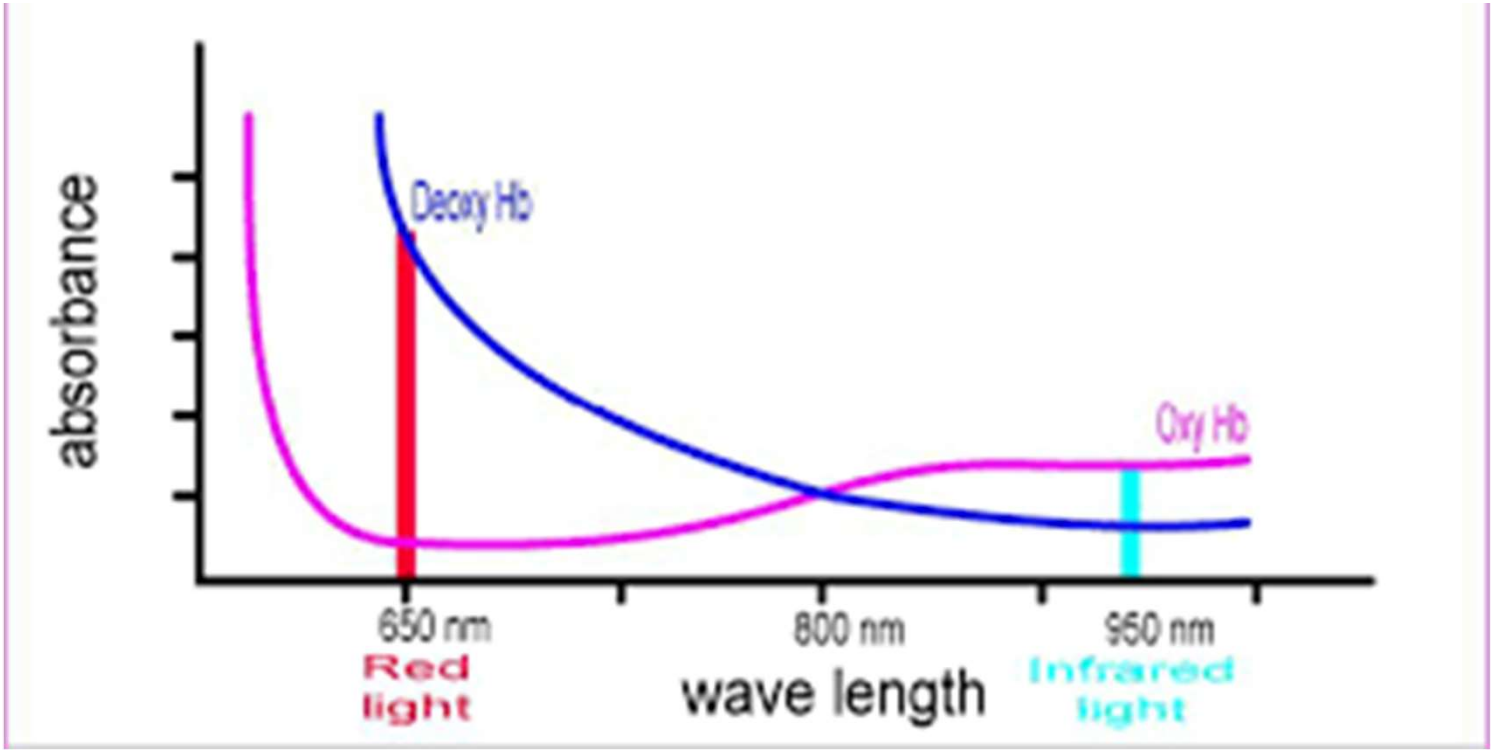
-Hemoglobin molecules saturated with O2: Oxyhemoglobin



-Hemoglobin molecules NOT carrying any O2: Deoxyhemoglobin



Infrared & Red



Absorption

-DeoxyHb: absorbs red light ….. less red in color

DeoxyHb absorbs more light at 660nm RED LIGHT

-OxyHb: absorbs infrared light … brighter red in color

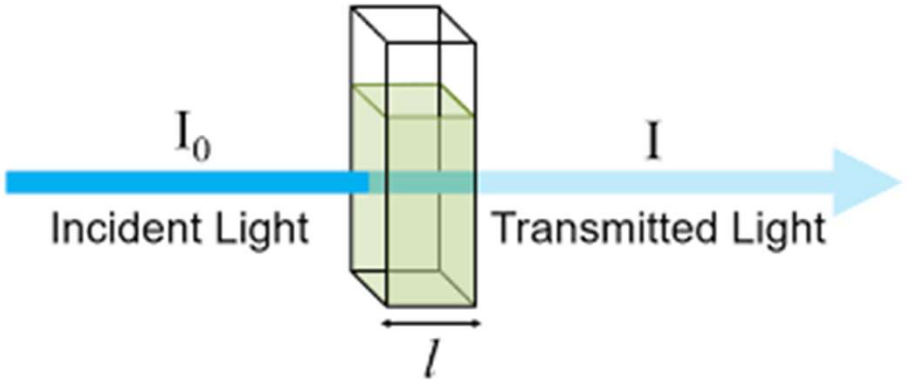
OxyHb absorbs more light at 940nm INFRARED LIGHT

Beer-Lambert's Law

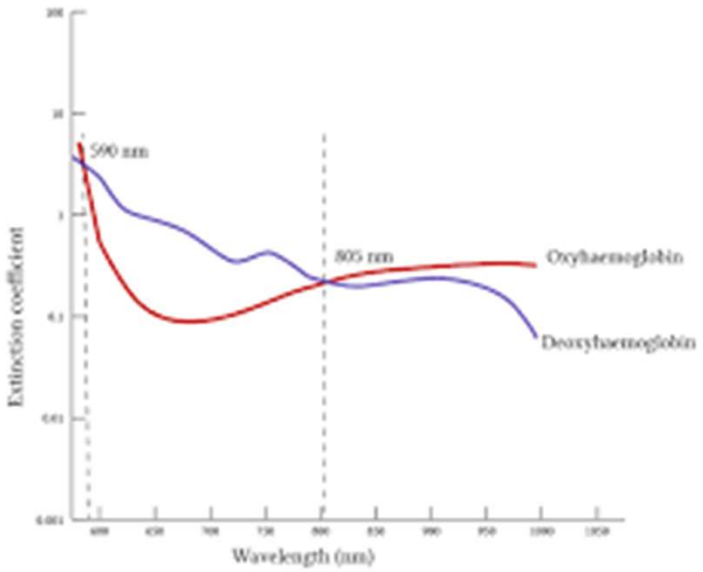
Beer Law- t*he concentration of a given solute in a solvent is determined by the amount of light that is absorbed by the solute at a specific wavelength*

Lambert's law- *equal parts in the same absorbing medium absorb equal fractions of the light that enters them*

Together: The measured absorbance of a single compound is directly proportional to the concentration of the compound and the length of the light path through the sample



Beer-Lambert's Law explained



More simply put…

Beer- Lambert's law is a composition of both concepts, correlating absorbance to both the concentration and the optical path through the substance.

Is a math equation of the concentration of a substance in a solution and the changes of light that go through it.

Basically - the pulse ox gives a reading based on the absorbance of infrared light and red light.

Values

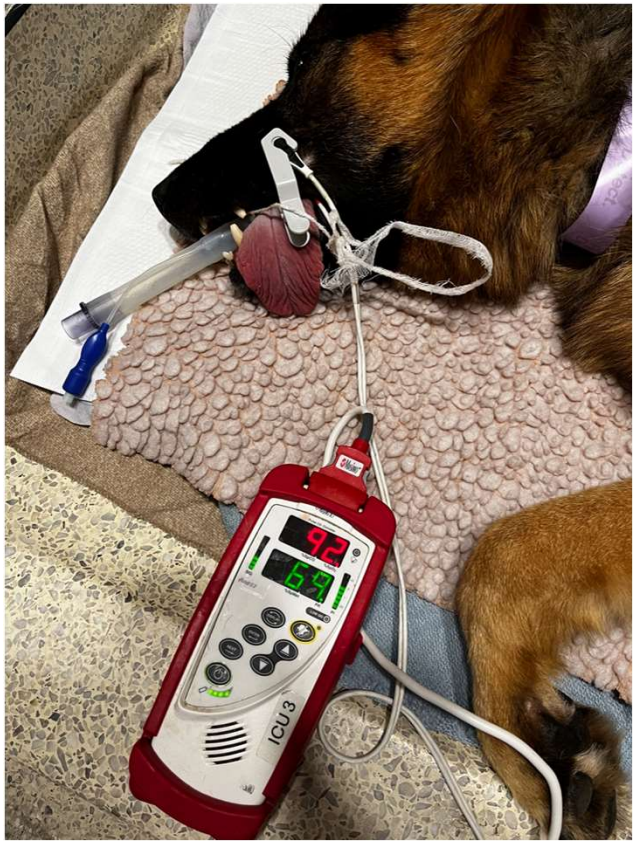
Healthy patient

Room air- 95%

Anesthetized- > 95%

Hypoxemia

anything < 90%



What do these numbers mean

Example- SpO2: 97%

97% of RBCs read by the probe had hemoglobin molecules that were fully saturated with O2 ……3% were not

Remember- gives you a percent of oxygen saturation in the peripheral hemoglobin

But also- clue you into partial pressure of arterial oxygen

PaO2 vs. SpO2

The PaO_2 is O2 dissolved in plasma

Healthy patient, room air

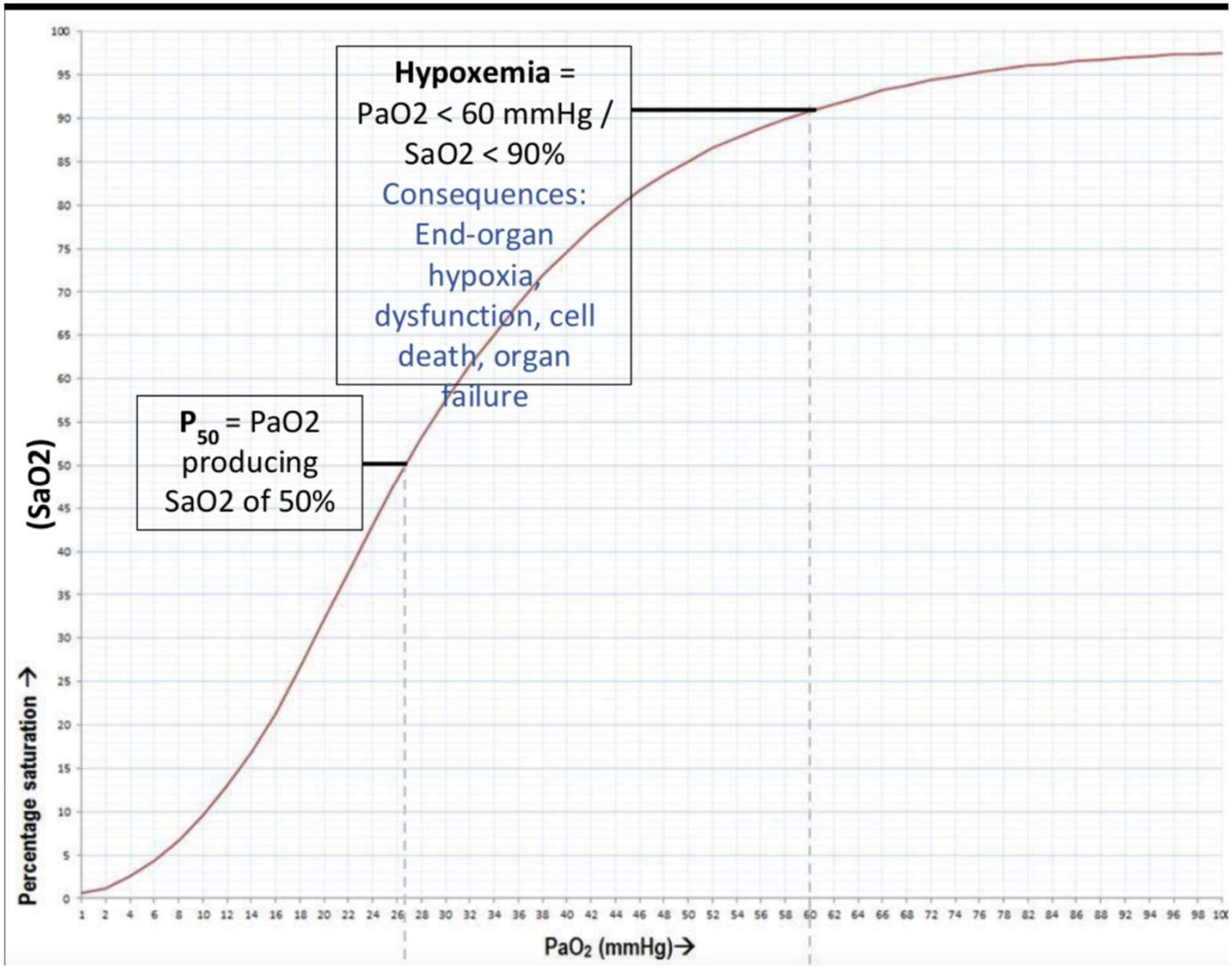
PaO_2: 80-100mmHg ……. SpO_2: 95%

Healthy patient, 100% O2

PaO2: 400-500mmHg…. SpO2: 95-99%

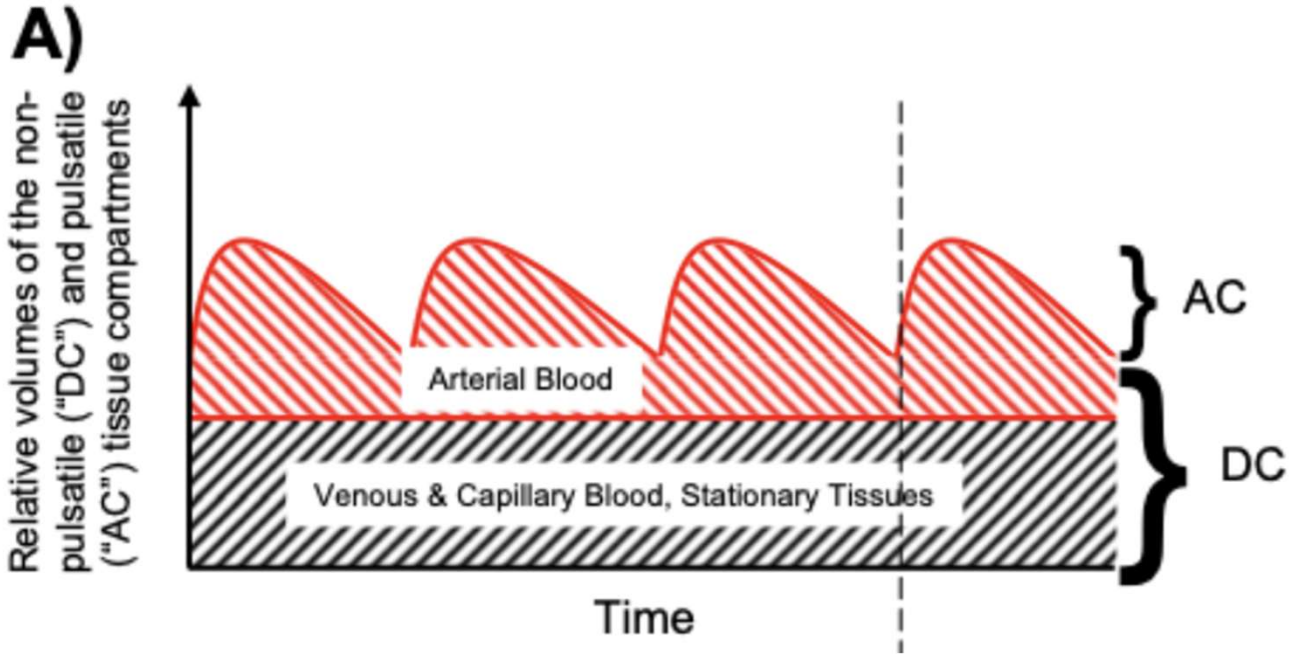
ACID/BASE			
pH	↓	7.20	
PCO2	↑	61	mmHg
PO2	↑	378	mmHg
BE		-6.6	mmol/L
tCO2		24.1	mmol/L
HCO3		22.2	mmol/L

Relationship: Demonstrated by Oxygen Hemoglobin Dissociation Curve



Partial Pressure of Oxygen

Plethysmography



A/C vs. D/C

Photoplethysmography represents A/C

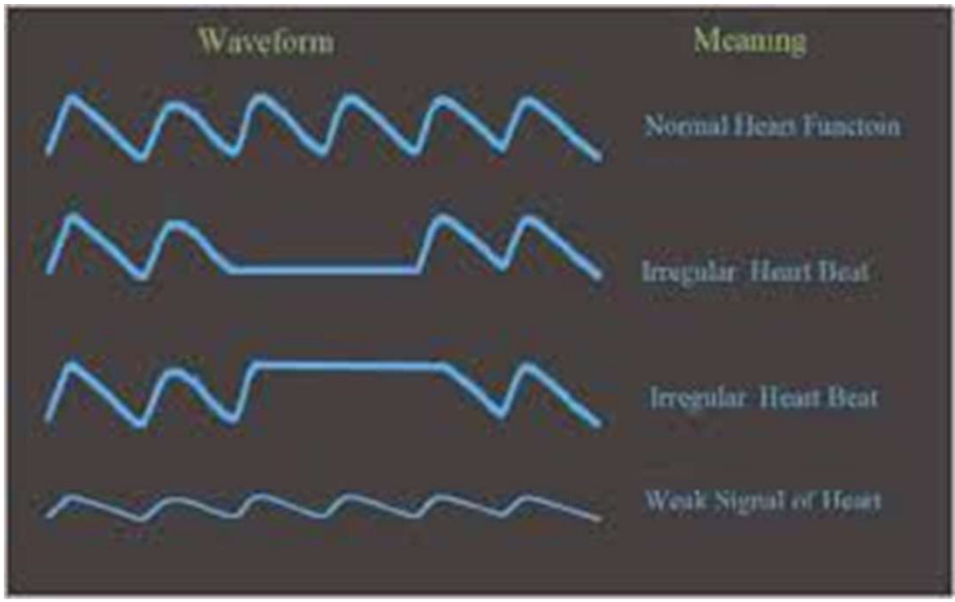
Arterial blood flow signal has PULSATILE flow

vs. venous has NO pulsatile flow

Ratio of absorbance= (AC 660/ DC 660) / (AC 940/ DC 940)

Numerators over consonants. ….. Alternating flow over direct flow

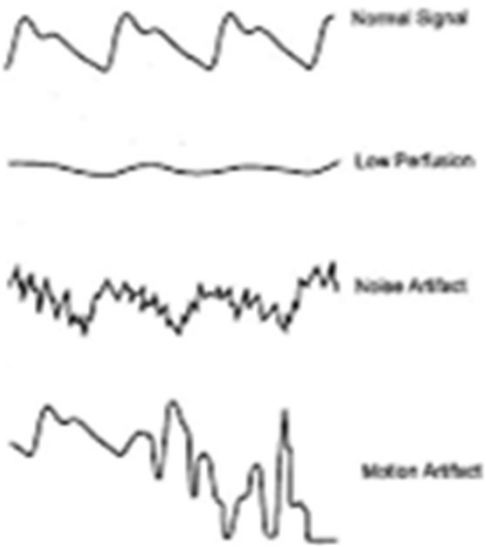
DO YOU HAVE A PULSATILE SIGNAL?!



Strong waveform!

-mimicking arterial blood pressure tracing

-accurate pulse rate



**Top of waveform: systole*

heart contracting

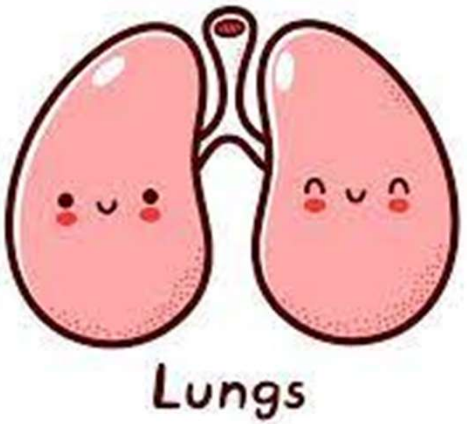
**Downward wave: diastole*

heart is relaxed and filling


HOME
09 30
Oct 19, 23
EtCO2
mmHg
60
30
0
6.3 mm/sec
40
RR
25
SpO2
%
100
91
PR bpm
86
25 mm/sec


HOME
09:30
Oct 19, 23
EtCO2
mmHg
60
30
0
6.3 mm/sec
41
RR
15
SpO2
%
100
98
PR bpm
73
25 mm/sec

Ventilation



-What: mechanical process

-How: respiratory muscles

-Why #1: respiratory center in the brain- MEDULLA!

-Why #2: acid base influence (blood pH)

-partial pressure of O2 and CO2

Hypoventilation

Reduced tidal volume +/-
reduced respiratory rate

Anesthesia's Effects on Ventilation

- Muscle relaxation
- Reduced functional capacity of the lungs
    - -Positioning
    - -Atelectasis
- Respiratory depressants
    - -Most anesthetics and analgesics reduce sensitivity to CO_2

    e.g., opioids, ketamine, propofol/ alfaxalone, volatile anesthetics


APOD
CUSTOM
93
99
89
%SpO2
114
180
80
PR bpm
1:58 PM
99
PVI
0.74
0.30
PI
Sodium Chloride
Sodium Chloride

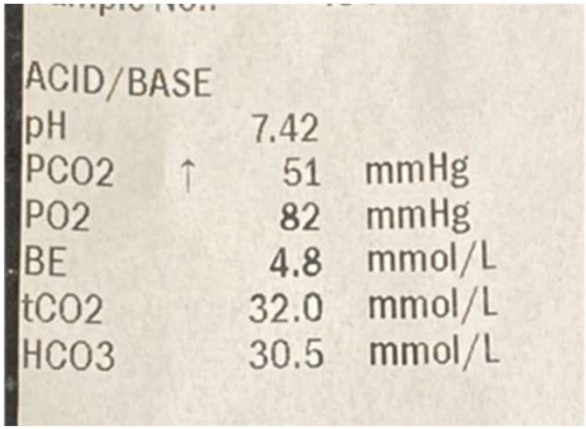
….Leading to Hypoxemia

Flashback Normal: 100% oxygen = PaO2: 400- 500mmHg = 100% oxygen SpO2: 96- 100%

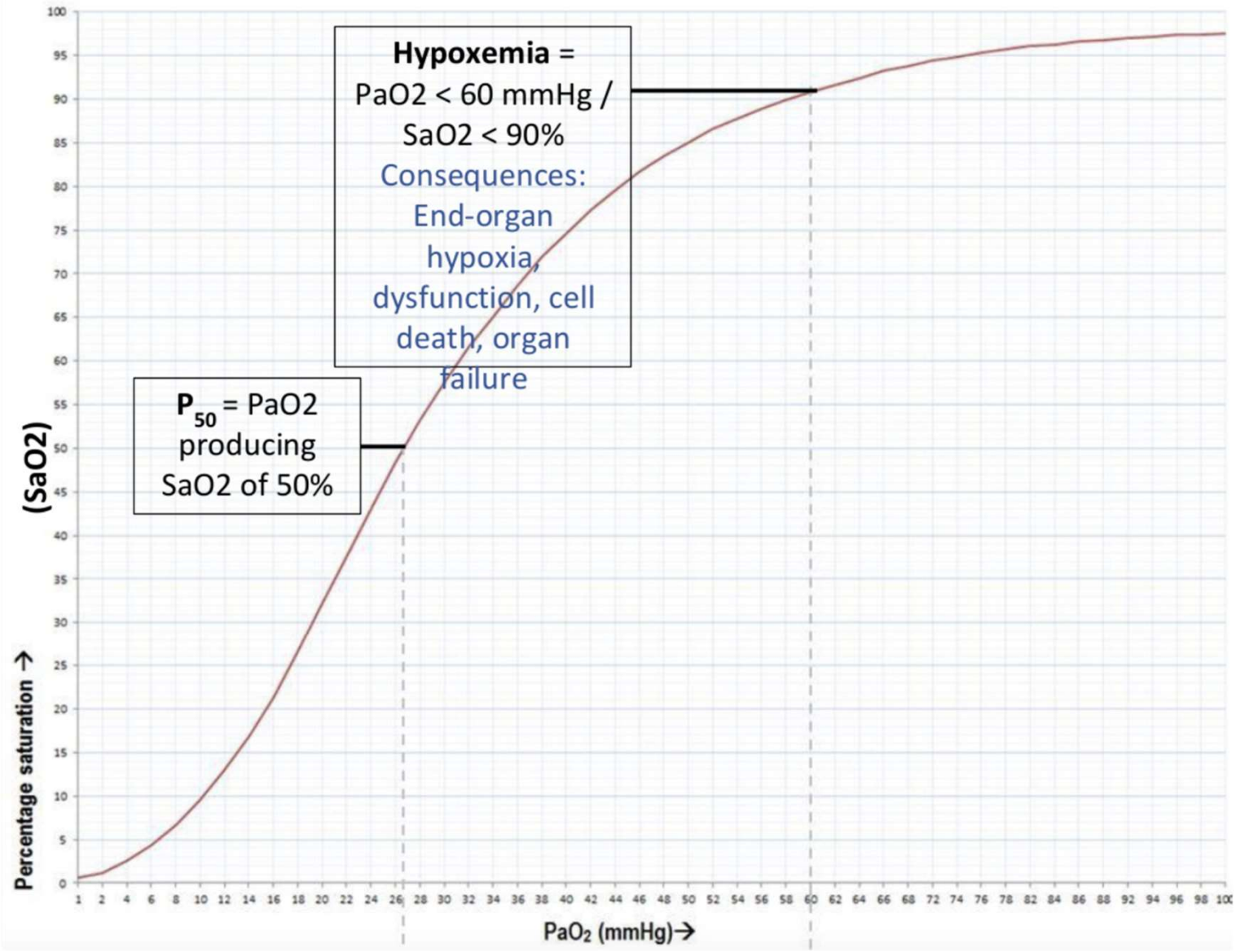
PaO2: <60mmHg or SpO2: <90%

Small decline of SpO2 equals a huge change of PaO2

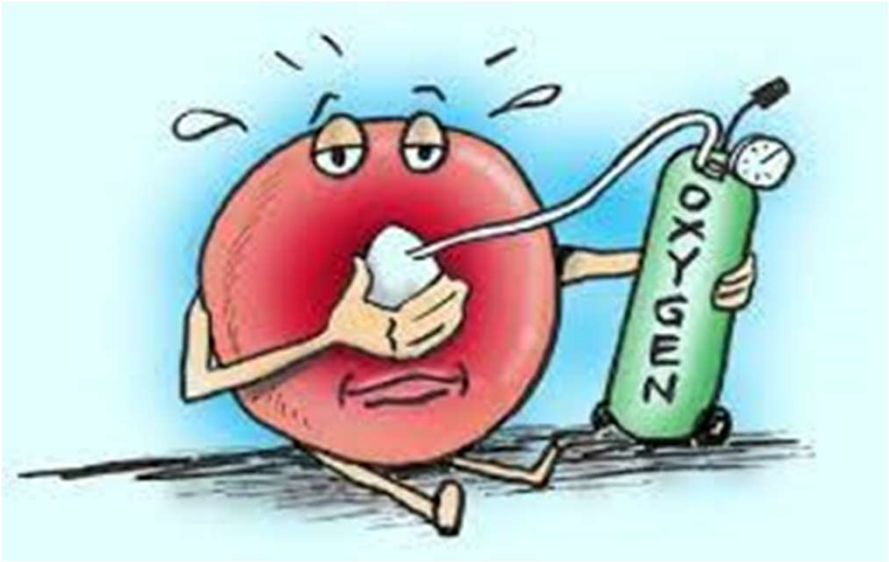
<u>Red flashing lights!</u>



ACID/BASE			
pH		7.42	
PCO2	↑	51	mmHg
PO2		82	mmHg
BE		4.8	mmol/L
tCO2		32.0	mmol/L
HCO3		30.5	mmol/L


Hypoxemia =
PaO2 < 60 mmHg /
SaO2 < 90%
Consequences:
End-organ
hypoxia,
dysfunction, cell
death, organ
failure
P50 = PaO2
producing
SaO2 of 50%
Percentage saturation → (SaO2)
PaO2 (mmHg)→

Hypoxemia



Times of concern: heavy sedation, anesthetic induction, recovery

Consequences of hypoxemia: organ dysfunction, cell death, organ failure

Anesthesia specific reasons: an insufficient fresh gas flow supply, a breathing system that is not correctly assembled, an exhausted oxygen supply, the use of nitrous oxide or a kinked/long endotracheal tube.

Other reasons for hypoxemia: V/Q mismatch (pneumonia/ edema), atelectasis

To be clear!

Patient:

Hypoventilating

On 100% O2

….Normal SpO2 and dangerously high CO2

Normal SpO2 DOES NOT equal normal CO2

Anesthesia's Intervention

- Decrease inhalant
- Reversals
- Positive pressure ventilation
  - No mechanical ventilator? That's okay!
- Pre-oxygenate
- Oxygenate in recovery
- Positioning

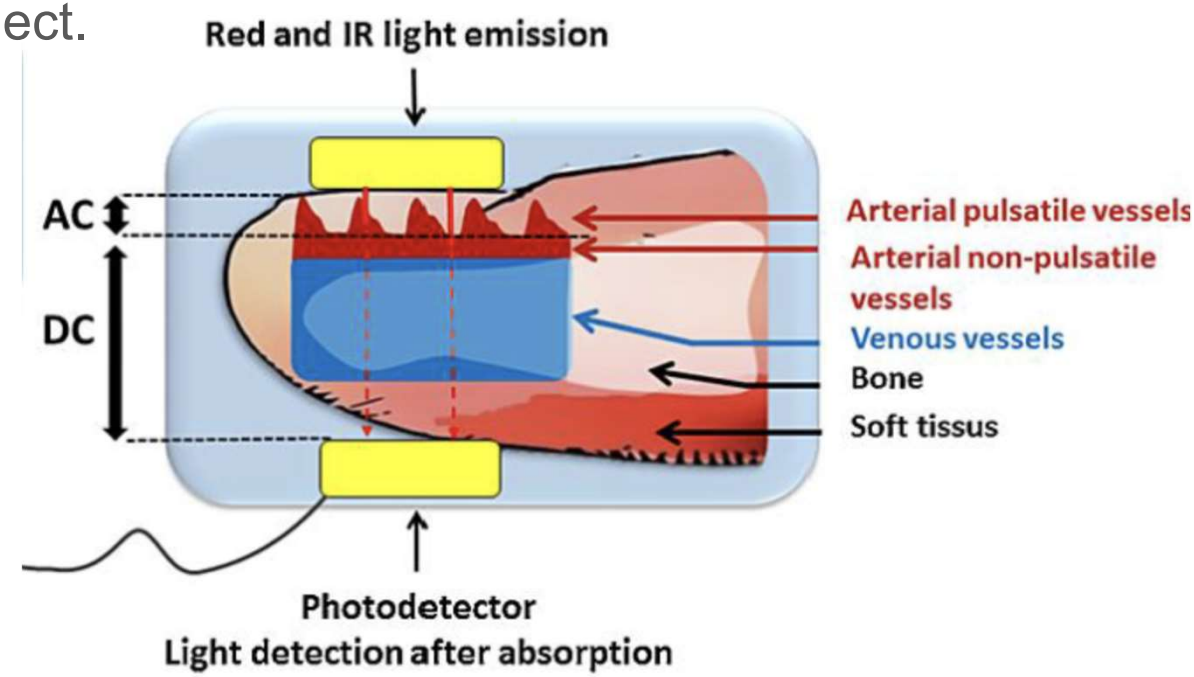
Pulse Oximeters Have a Hard Job

it is rarely used to its full extend or even fully understood by those using the tiny machine.

Pulse ox vs. blood gas analyzer

Blood gas analyzer: arterial (or venous) blood sample

Pulse Ox: paw pad, ear, belly skin, ect.



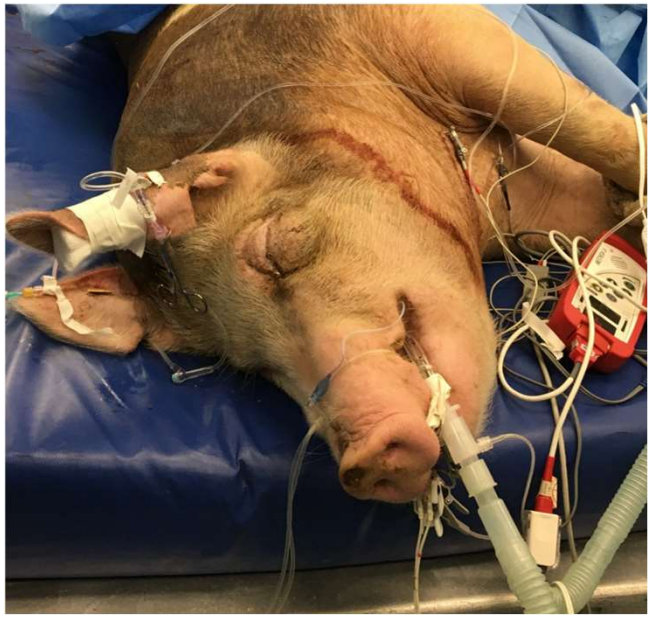
The Tiny Computer's Limits

- Patient movement
- Pigmented skin/ too much hair
- Peripheral vasoconstriction
  - Alpha-2 agonists, hypothermia
- Hypotension/ poor perfusion
- Surgical light interference
- Significant anemia
- Carboxyhemoglobin (carbon monoxide poisoning)

Vasoconstricion

Decreased perfusion/ anemia

Very thick/ pigmented skin



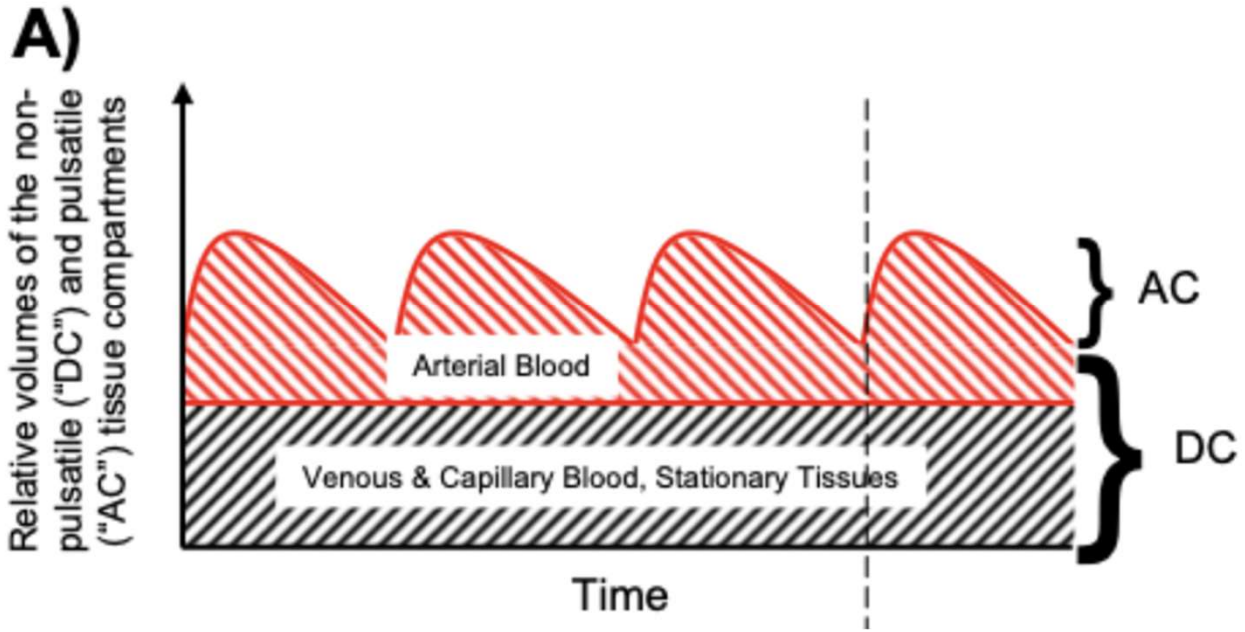

HOME
Date is invalid. Set date and time
60
30
0
6.3 mm/sec
25 mm/sec
EtCO2
0
ARR
SpO2
93
PR bpm
133
MENU
STHESIA 4

Ruling out Interference A Ratio of Ratios

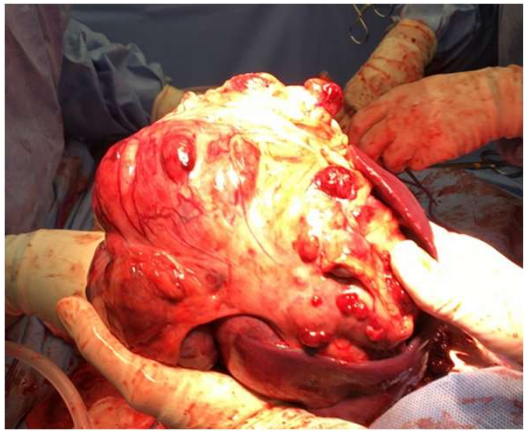
Remember: Pulsing flow over the non-pulsing flow

Given measurement= Artery expanding then collapsing

-Optical Distance = absorption increasing exponentially during the systolic flow



Ruling out Room Light

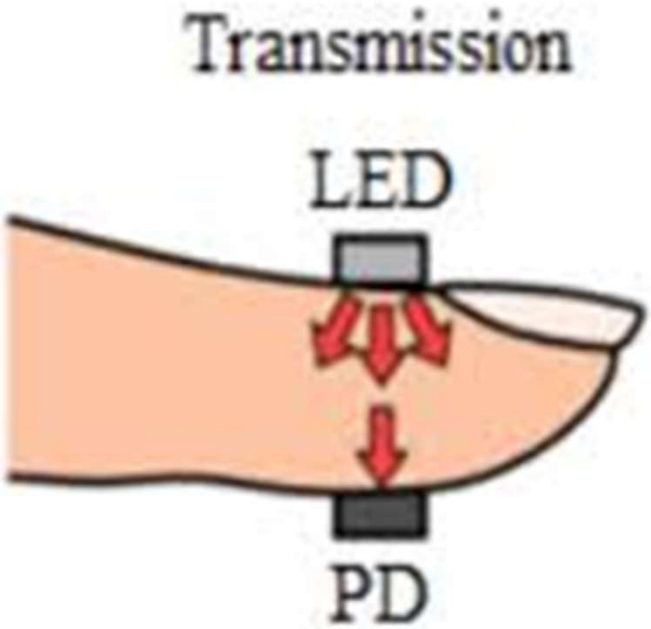


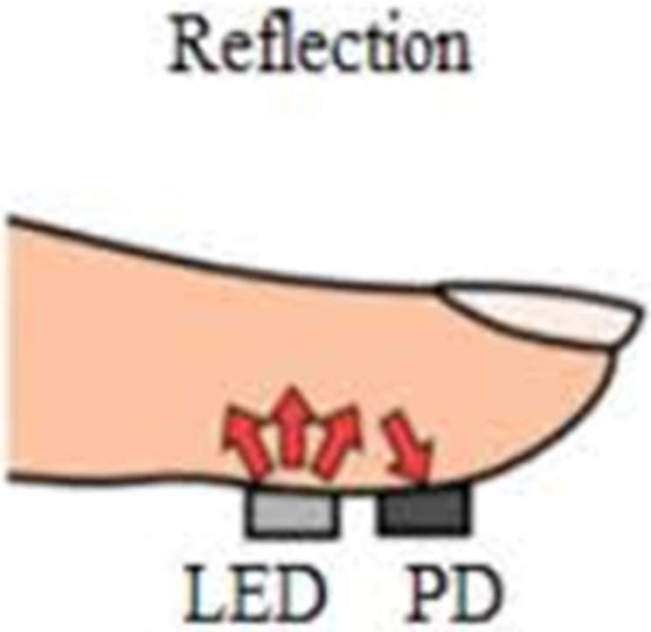
LEDs turned on - ambient light measured when LEDs blink off = measurement without ambient light interference

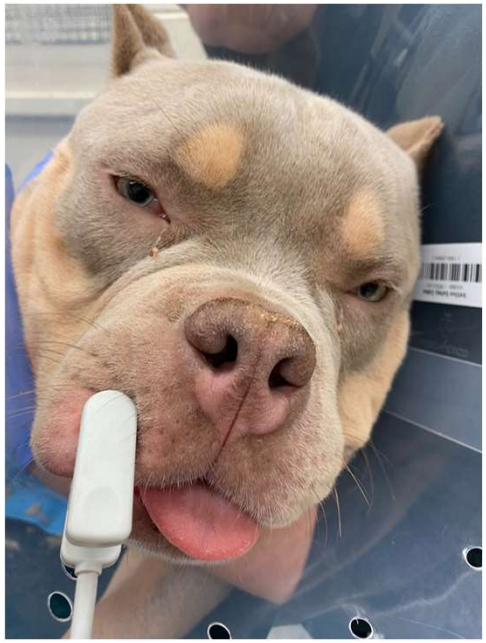
- Room light interference is only about 0.1%
- Surgical light interference could impact SpO2 reading.

*Cover area with 4x4 if probe has to be directly under the light.

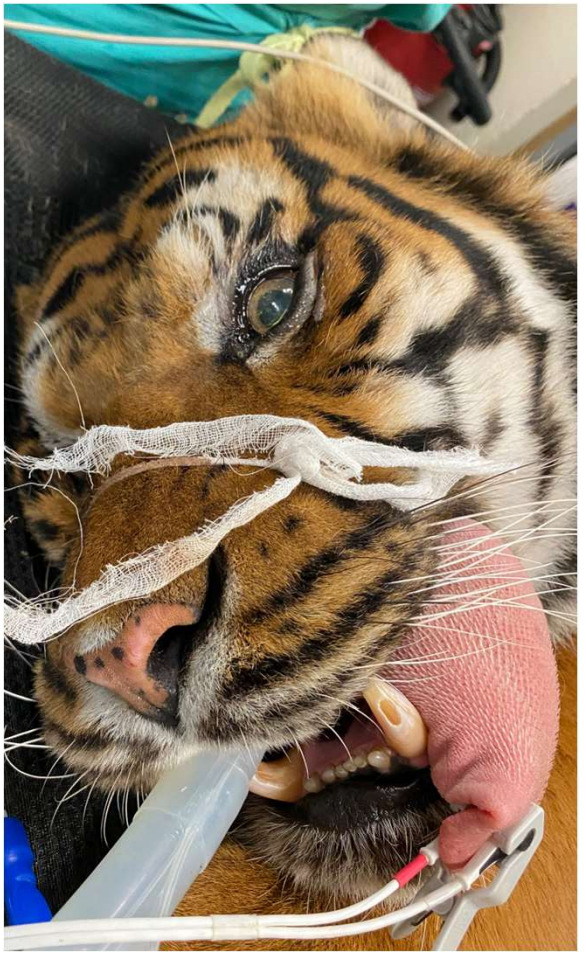
Different Probes








RECOVERY 1



Also measures….

PI

Perfusion Index

Signal strength and quality which relates to tissue perfusion

Alerts you to: poor perfusion

PVI

Plethysmograph variability index

Variability within the pulse ox waveform during inspiration and expiration (mechanical ventilator)

Alerts you to: inadequate circulating volume

Overview

-Clues you in to so many things!

-Important to use in many different situations! …..Recovery!!

-Light—> Receiver

-Accurate?

-Pulse rate +/- Pulse waveform

Thank you!