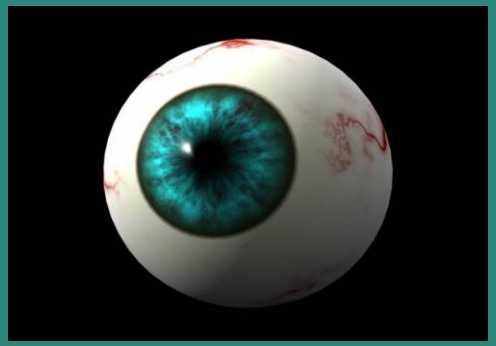
Monitoring the Emergency Patient



ارائه دهنده: دکتر حسن سلیمان پور

استاد و فوق تخصص مراقبتهای ویژه

فلوشیپ احیای قلبی-ریوی

فلوشیپ پزشکی مبتنی بر شواهد

معاون آموزشی و پژوهشی بیمارستان امام رضا (ع) تبریز

Monitoring during ED

Perspective

What is monitoring?

The verb monitor(derived from the Latin *monere*, "to warn") means to check systematically or to keep watch over.

Monitoring during ED

Perspective

- To *monitor* means to measure or observe a physiologic parameter either continuously or intermittently.

Monitoring during ED

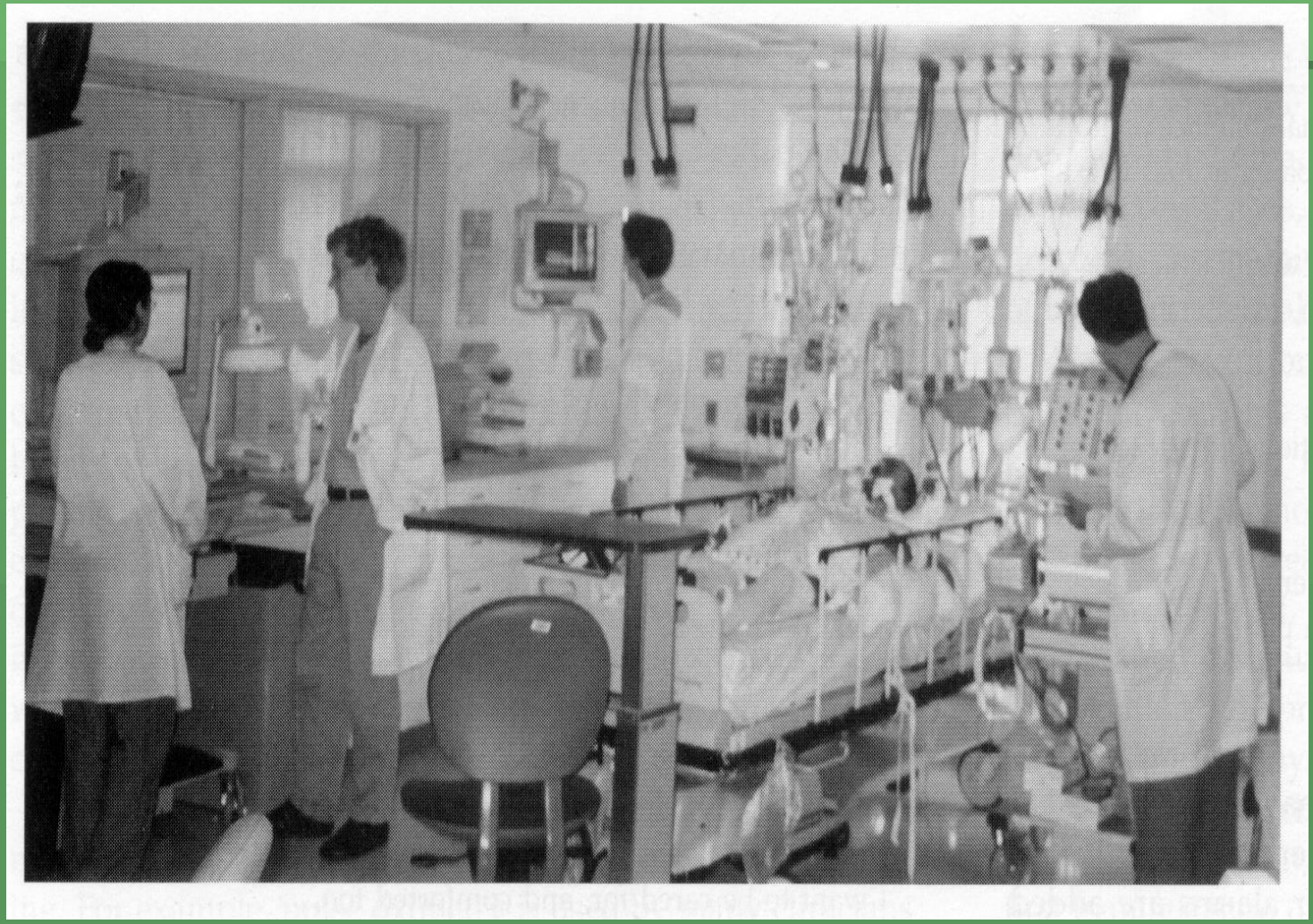
Perspective

- The monitoring device may provide a "snapshot in time" or may detect deterioration, track improvement, or measure the effects of interventions.

Monitoring during ED

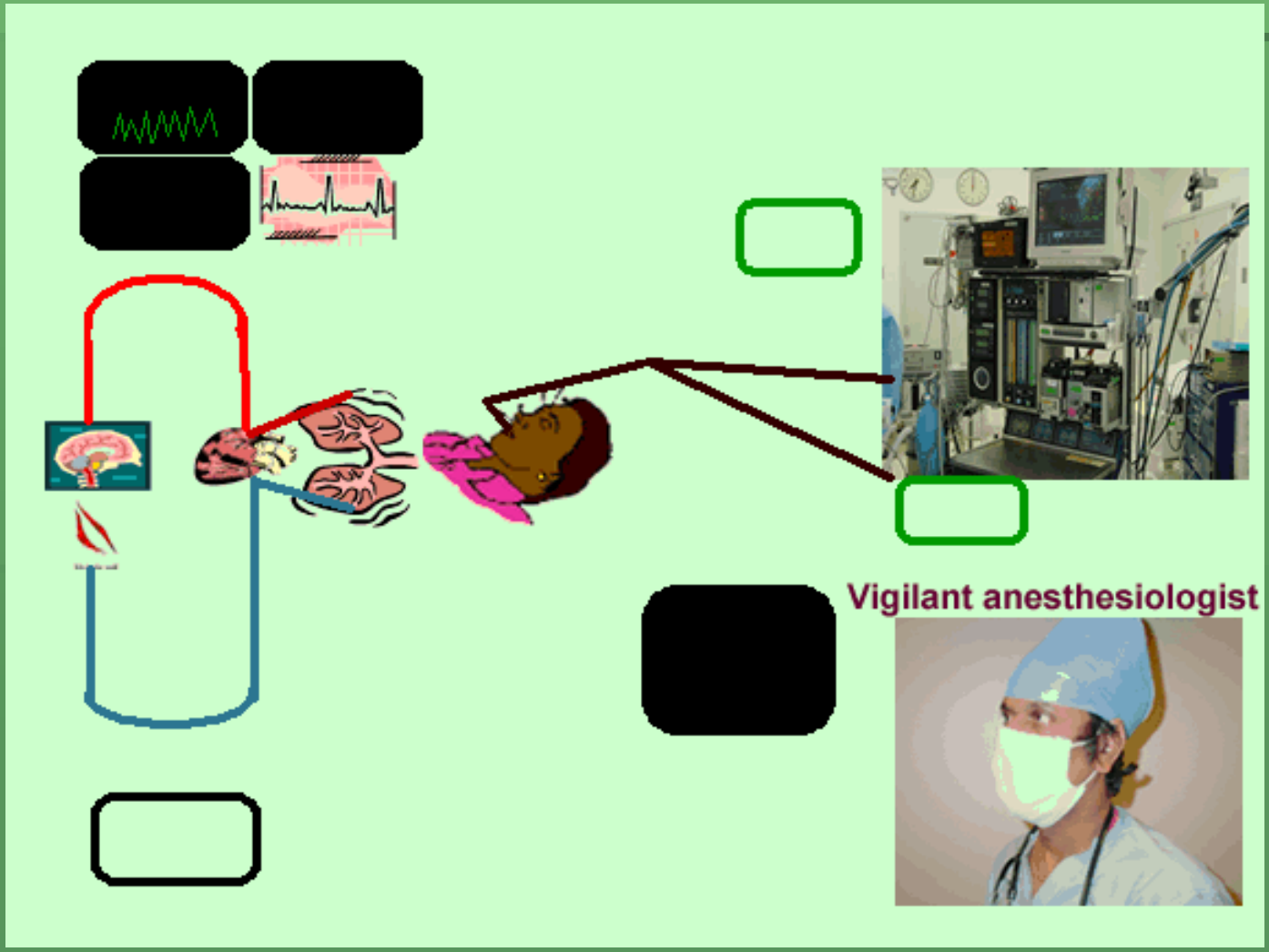
- Monitoring parameters, such as clinical observation, routine vital sign measurement, and electrocardiogram monitoring, are basic requirements in emergency medicine

Who's Watching the Patient?



Pierson, IN: Tobin, Principles and Practice of Critical Care Monitoring

Monitoring during ED



Monitoring during ED

Although some might consider electronic devices the only cardiovascular monitors, the fundamental basis for circulatory monitoring remains in the eyes, hands, and ears of the Emergency Physician.

Monitoring during ED

In many ways, the Emergency Physician 's senses capture more information than even the most sophisticated electronic monitors.

Monitoring during ED

- cornerstones for standard physical examination :
  - **Inspection**(eye)
  - **palpation**(Hand)
  - **Auscultation**(ear)

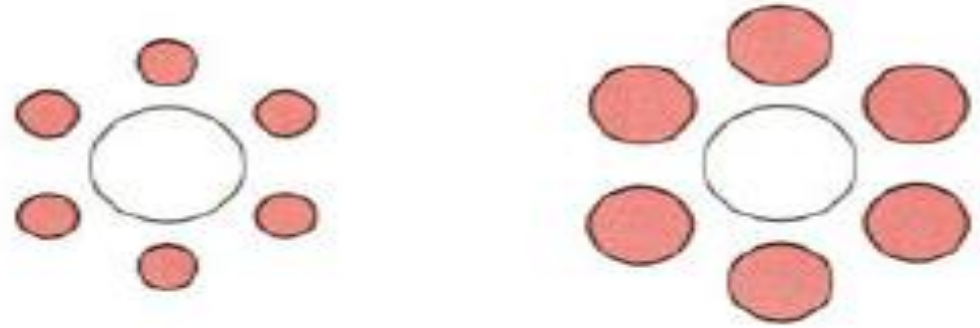
Why monitor during ED?

- Maximize safety
- legal requirement

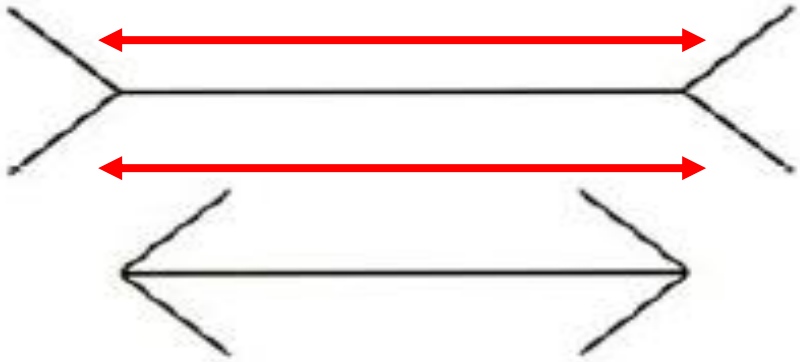
Why do we need monitoring equipment?

- Human error
- Personal satisfaction
- Legal appointment

Human error

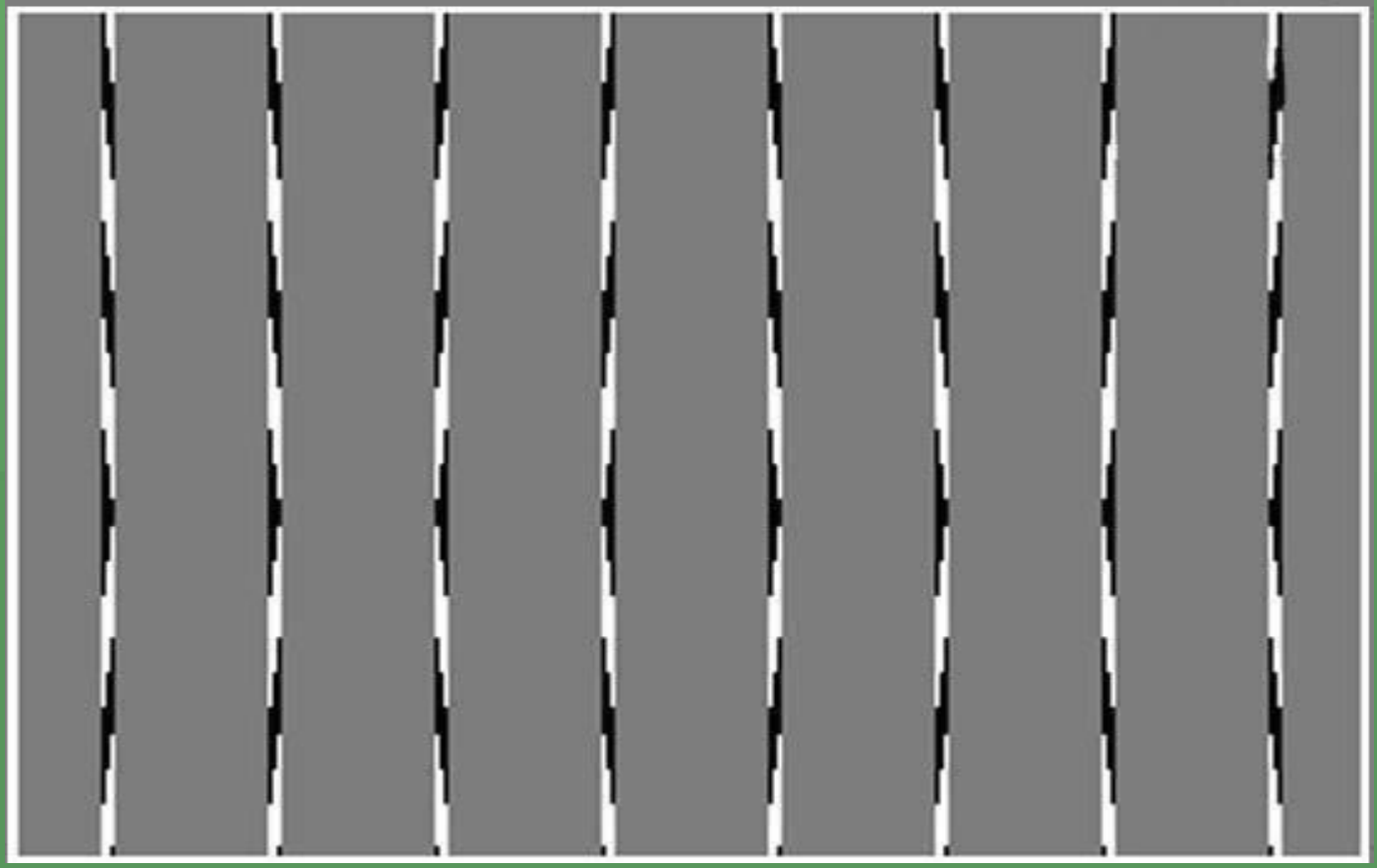


Which circle is larger?

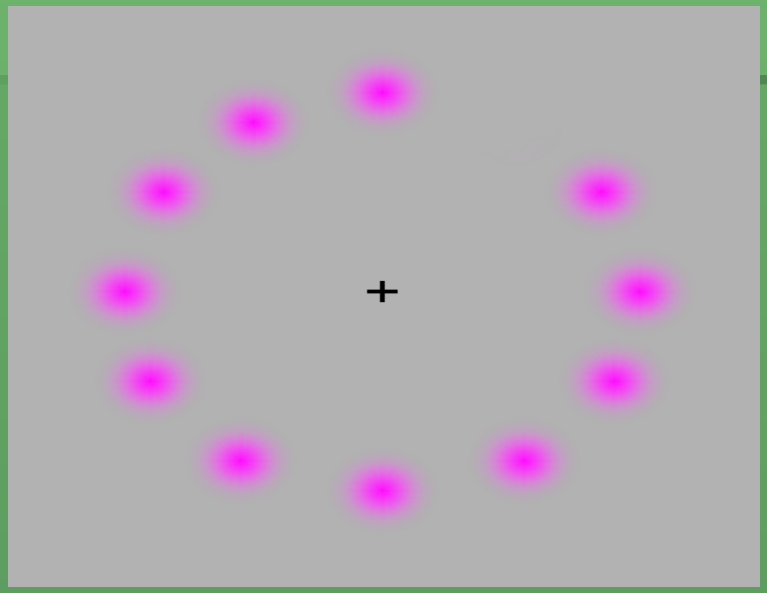


Which line is longer?

این خطوط صاف هستند !
با چشمانی که اینقدر خطای دید دارند
دیگران را قضاوت نکنید ...



Human error



۱- در صورتی که حرکت نقطه متحرک را تعقیب کنید تنها یک رنگ را می بینید، صورتی.
۲- حالا لحظاتی به علامت + که در وسط قرار دارد خیره شوید.. نقطه متحرک را پس از لحظاتی به رنگ سبز خواهید دید.
۳- حالا زمان بیشتری را بر روی علامت + تمرکز کنید، پس از لحظاتی نقاط صورتی آهسته آهسته ناپدید خواهند شد.
عجیب اینجاست که هیچ نقطه سبزی در این عکس در کار نیست و در واقع نقاط صورتی نیز ناپدید نمی شوند.
این دلیل محکمی است که ما همیشه دنیای خارج را آنگونه که هست نمی بینیم.

Monitoring in the Past

Harvey Cushing

father of anesthesia monitoring

Monitoring in the Past
Harvey Cushing

- *Not just a famous neurosurgeon …*
  *but the **father of anesthesia monitoring***
- Invented and popularized the anesthetic chart
- Recorded both BP and HR
- Emphasized the relationship between vital signs and neurosurgical events
  (increased intracranial pressure leads to hypertension and bradycardia)

Monitoring in the Past

- Visual monitoring of respiration and overall clinical appearance
- Finger on the pulse
- Blood pressure (sometimes)

Monitoring in the Past

Monitoring during ED

Pulse Oxymetry

Pulse oximetry

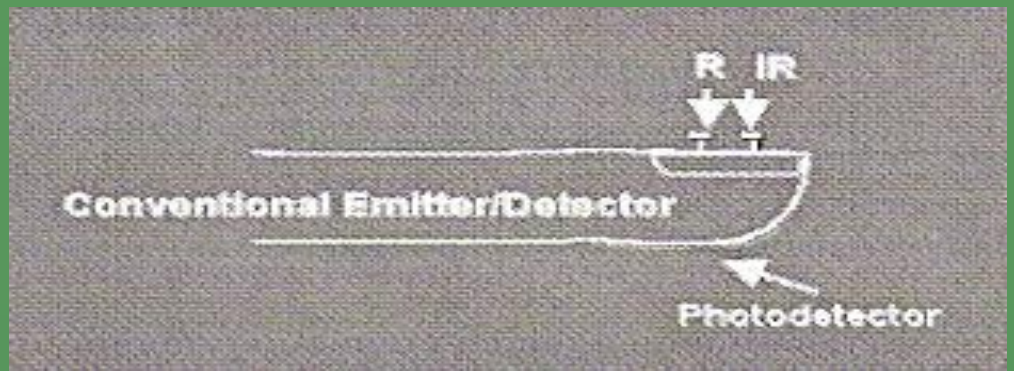
Oxygenation (descending or ascending or stable) (visual or auditorial)
Pulse rate or heart rate (visual or auditorial)
Rhythm (visual or auditorial)

Pulse oximetry

fifth vital sign

PULSE OXIMETRY

- اندازه گیری غیر تهاجمی ومداوم میزان اشباع اکسیژن خون شریانی است.
- اساس کار پالس اکسیمتری اصول اسپکتروفوتومتری است که نشان دهنده جذب نور قرمز (Red Light) توسط هموگلوبین احیا شده
- (de oxigenated) وجذب نور مادون قرمز (infra red light) توسط اکسی هموگلوبین است .
- نور قرمز طول موج حدود 600-750nm وطول موج نور مادون قرمز 950 nm-850 است که توسط یک دیود منتشرکننده نور در پروب پالس اکیسمتری ایجاد میشود وپس از عبور از بافت ها به فتودتکتور در طرف دیگر پروب میرسد .



What is a Pulse Oximeter

- Pulse oximetry is a non-invasive diagnostic test used for detecting the percentage of hemoglobin (Hb) that is saturated with oxygen.
- Known as the "5th Vital sign" assessment tool.

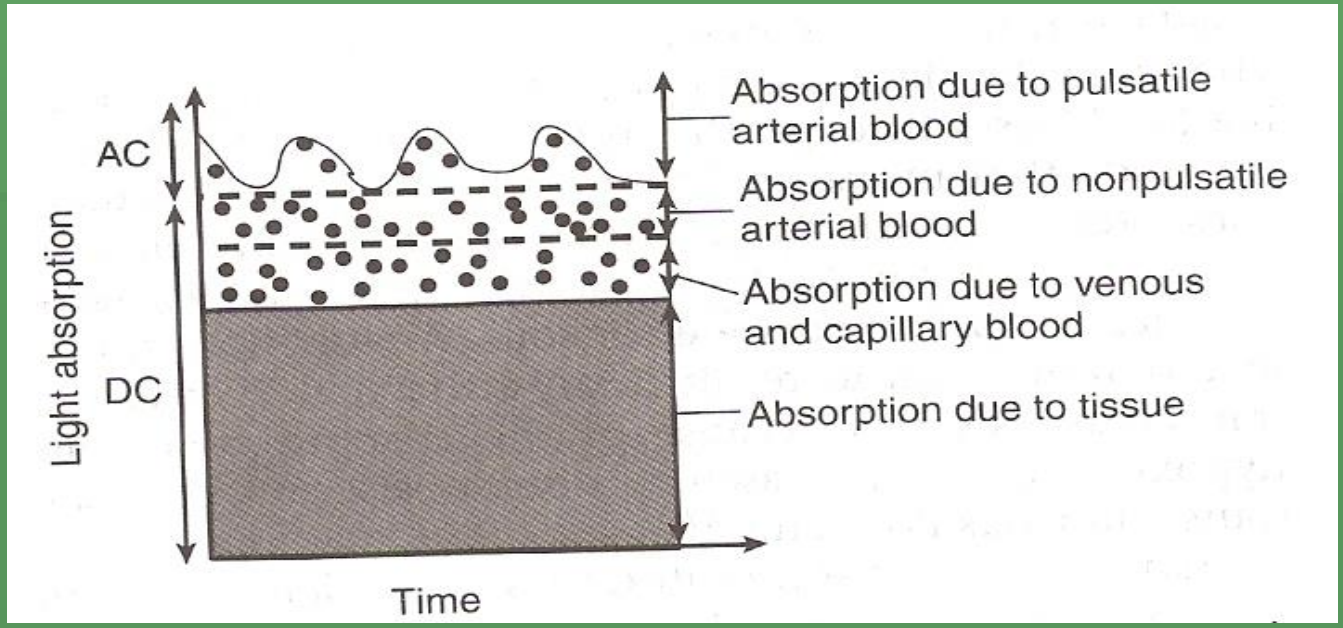
برای افتراق خون شریانی از وریدی نیز از قوانین پلتیسموگرافی استفاده میشود.

1- خون شریانی دارای نبض است

2- نبض در زمان سیستول قلبی ایجاد میشود

3- حجم خون در این زمان افزایش می یابد

spo2= Hbo2/Hb+Hbo2



The Pulse Ox:

A great monitor

- ease of sensor placement
- lack of user calibration
- noninvasive nature
- low cost
- Valuable information

Transcutaneous Oximetry

- در نواحی از پوست که جریان خون افزایش دارد capillary Pao2 تقریباً معادل Pao2 است . بخصوص وقتی ناحیه مورد بررسی گرم باشد .این دستگاه معمولاً یک الکترود کوچک دارد که میتواند به پوست بچسبد .پوست ناحیه در حد 41-40 درجه سانتی گرا د گرم میشود وo2 از داخل پاپیلاری به داخل پوست شیفت میشود .
- Po2 بدست آمده با این روش تقریباً برابر Pao2 است.
- در بالغین به علت ضخیم بودن پوست ونیز در موارد وازوکانستریکشن محیطی اندازه گیری ممکن است دقیق نباشد .
- این روش در نوزادان مفید است .چرا که جریان خون لوکال پوستی بالا است ونمونه گیری خونی متعدد از آنها میتواند سبب آنمی شود .
- ثابت زمانی در این روش بالا است وافت ناگهانی Pao2 با تاخیر نشان داده میشود.در استفاده طولانی از این روش ممکن است سوختگی پوستی ایجاد شود .

قانون Beer- Lambert

- جذب نسبی یا انعکاس نور توسط مونیتورهای مختلفی می شود اندازه گیری نمود و از این طریق غلظت ماده در معرض نور را تخمین زد (مثلاً دی اکسید کربن در گازهای تنفسی و هموگلوبین پلاسما).

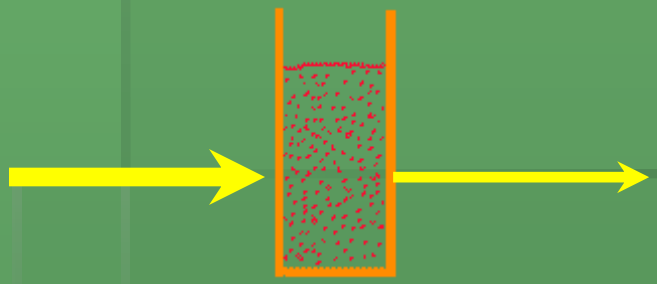
- میدان جذب در اسپکتروفوتومتری بر اساس قانون B.L. است که می گوید اگر شدت معینی از نور از محفظه ای با ابعاد معین عبور کند، غلظت مواد محلول موجود در مسیر نور را می توان معین کرد بشرطیکه شدت نور وارد شونده و عبور کننده را اندازه بگیریم.

Beer-Lambert Law

$$I_{(\text{trans})} = I_{(\text{in})} e^{-DC\acute{\alpha}}$$

Or

$$A = \acute{\alpha}_1 D_1 C_1 + \acute{\alpha}_2 D_2 C_2 + \acute{\alpha}_3 D_3 C_3 + \ldots \acute{\alpha}_n D_n C_n$$



I(trans) = Intensity of transmitted light

I(in) = Intensity of incident light

e = base of natural log (2.718)

D = distance

C = concentration of solute

$\acute{\alpha}$ = extinction coefficient

A = Absobtion

Monitoring during ED

- در اورژانس به علت اینکه موارد اندازه گیری ما (دی اکسید کربن یا هموگلوبین) بیشتر طیف های قرمز و مادون قرمز را جذب می کند بیشتر از این طیف ها استفاده می شود.

- جای خوشبختی است که نور قرمز و مادون قرمز میتواند به بافتها نفوذ کند.

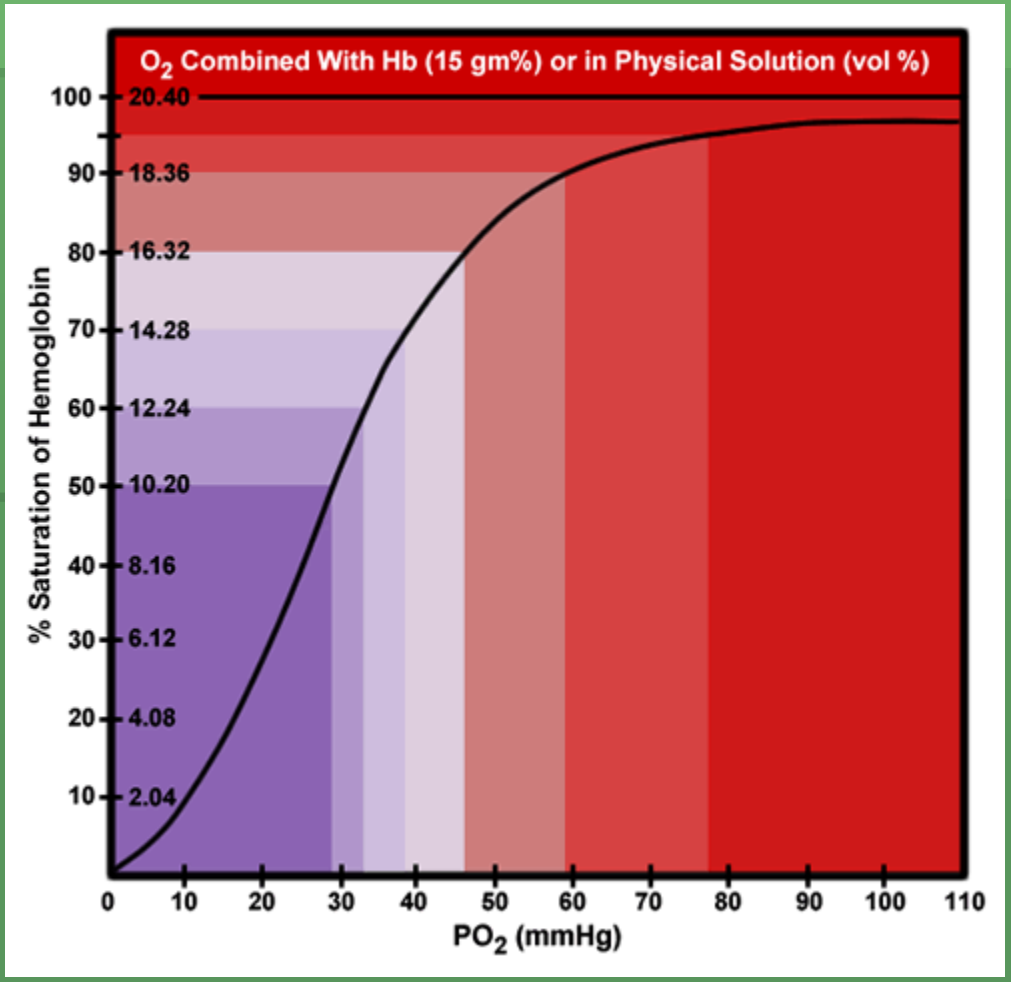
Monitoring during ED

- نور مادون قرمز توسط مولکولهای ریز جذب می شوند منتها مولکولهایی که غیر متقارن و باند شده باشند، مثل مولکولهای نیتروژن، اکسیژن و هلیوم توسط مادون قرمز قابل اندازه گیری نیستند.
- محدودیت دیگر مادون قرمز آنست که توسط شیشه جذب می شود بنابراین محفظه های اندازه گیری این وسایل می بایست از جنس یاقوت درست شود که به نور قرمز و مادون قرمز نفوذپذیر باشد

Accuracy of Pulse Oximetry

Arterial oxygen content (equation) =

(Hgb x 1.36 x SaO2) + (0.0031 x PaO2)



Presented by: Kevin Dooley & William Etukudo

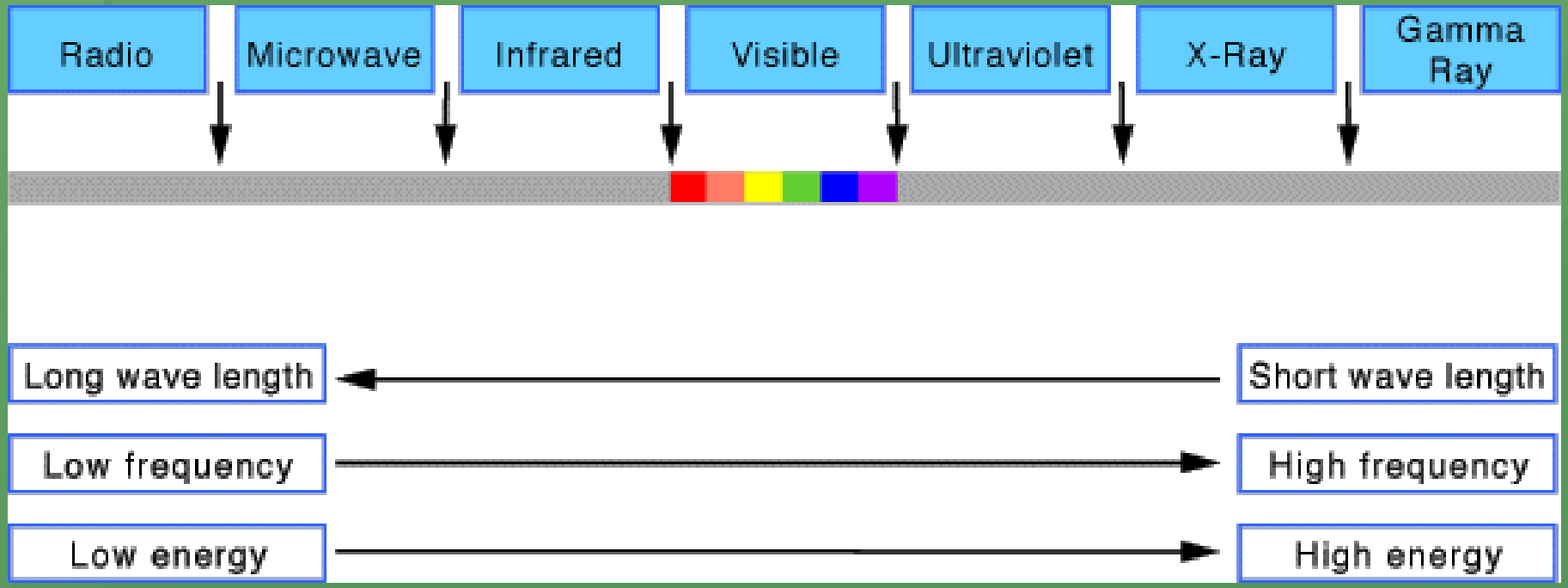
Pulse Oximetry

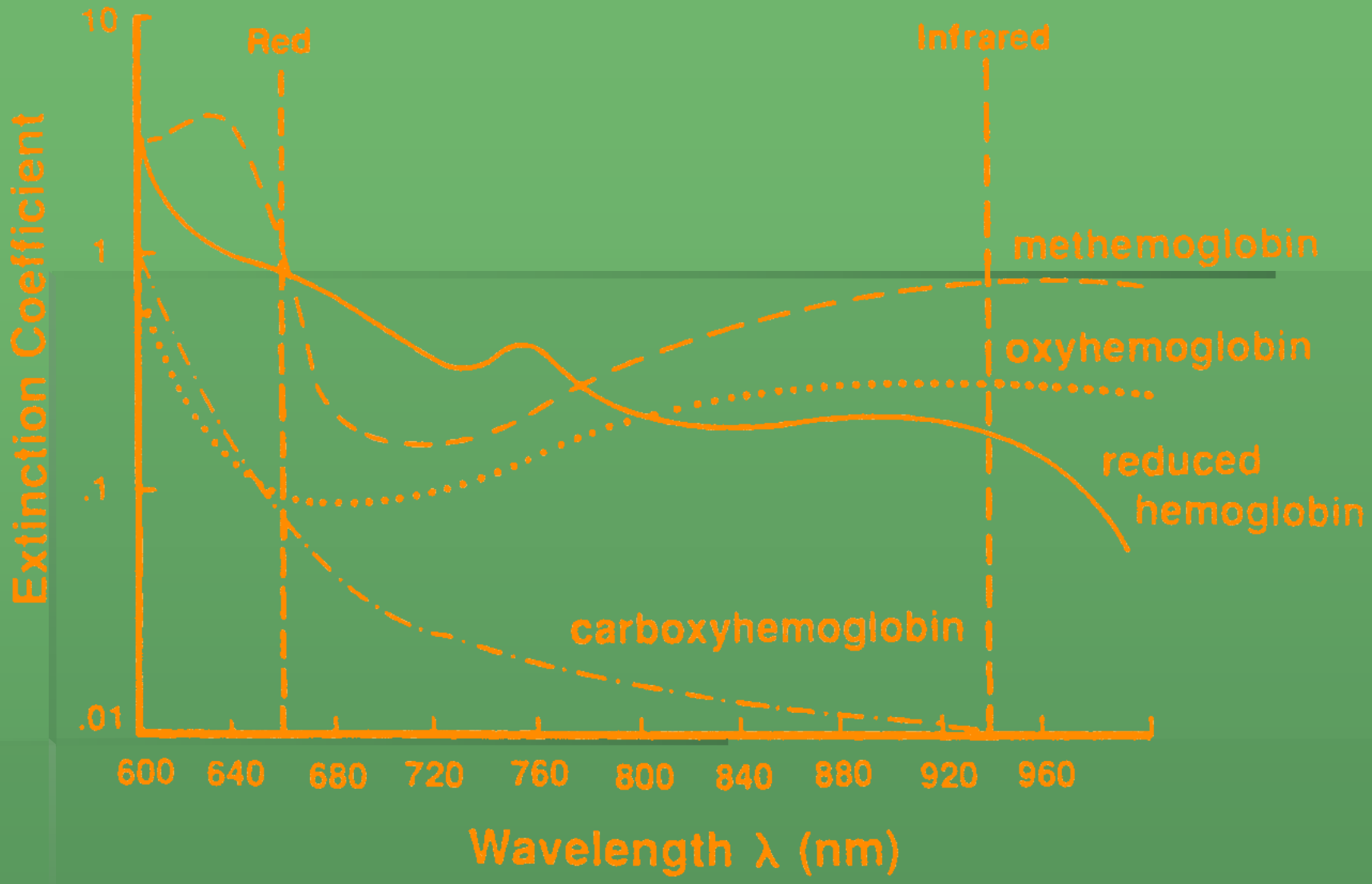
- Rosen :

  At the wavelength of red light (660 nm), reduced hemoglobin absorbs about 10 times as much light as oxyhemoglobin, whereas at the infrared (IR) wavelength (940 nm), the extinction coefficient of oxyhemoglobin is near that of reduced hemoglobin.

How Pulse Oximetry Works?

- Oxyhemoglobin absorbs infra red light 940nm
- Deoxyhemoglobin absorbs visible red light 660nm

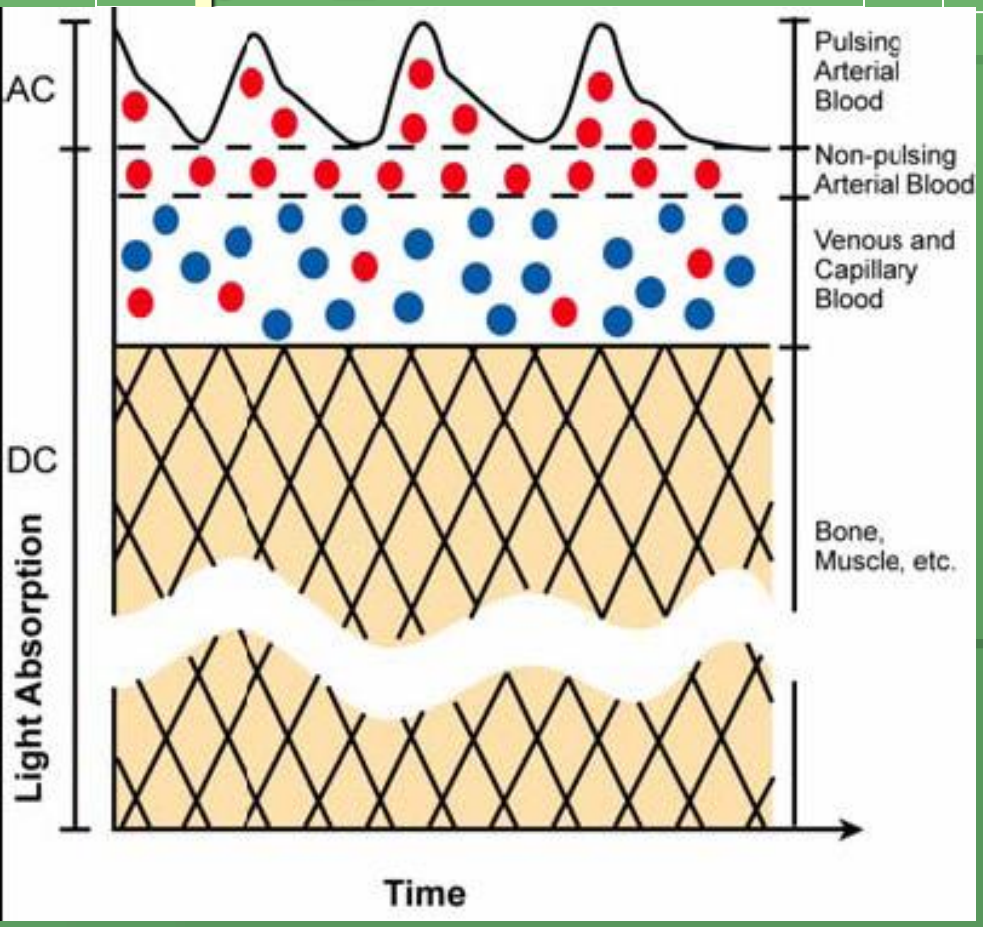




Prologe JA: Pulse Oxymitry: Technical aspects of machine design.
Int Anesth Clinics 25(3):137, 1987

Calculating S_pO_2

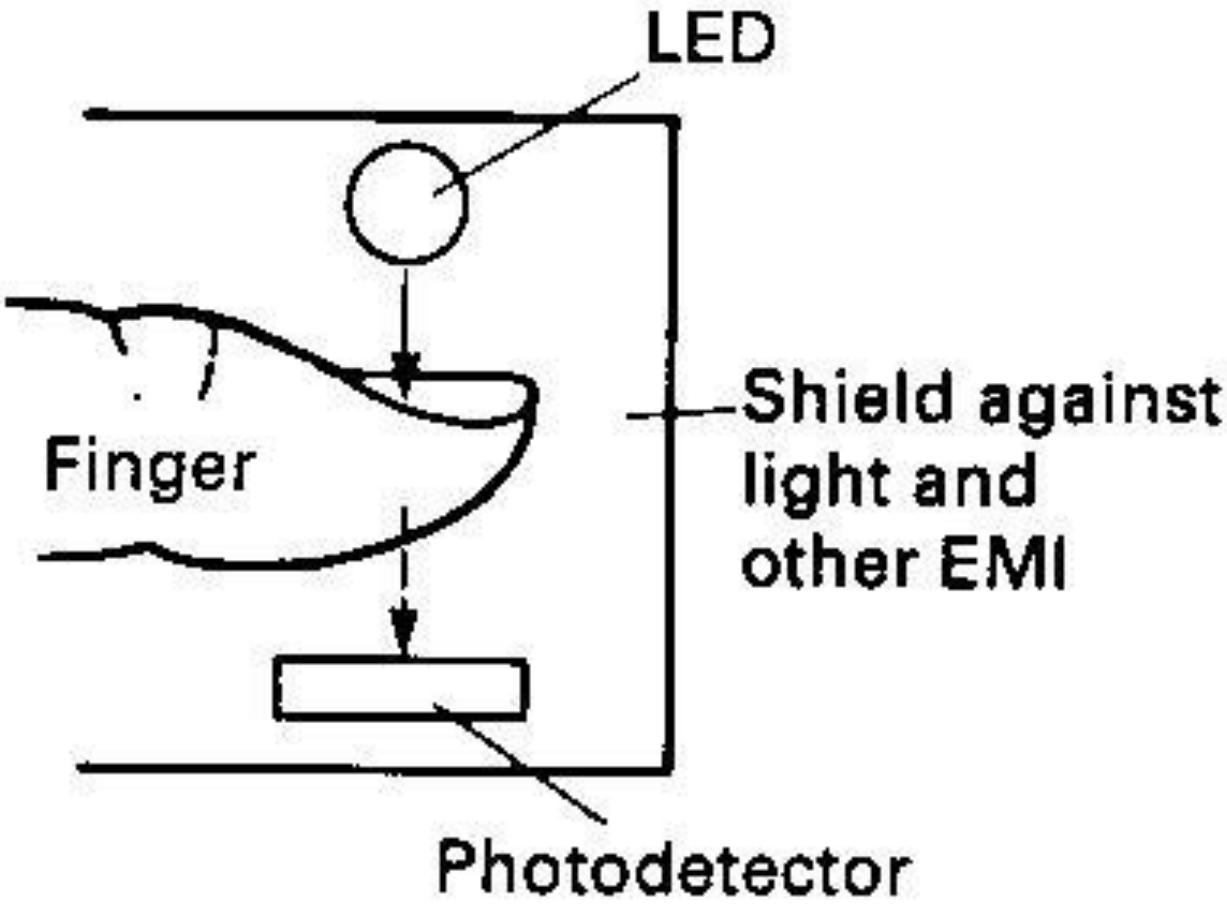
$$R = \frac{AC_{660} / DC_{660}}{AC_{990} / DC_{990}}$$



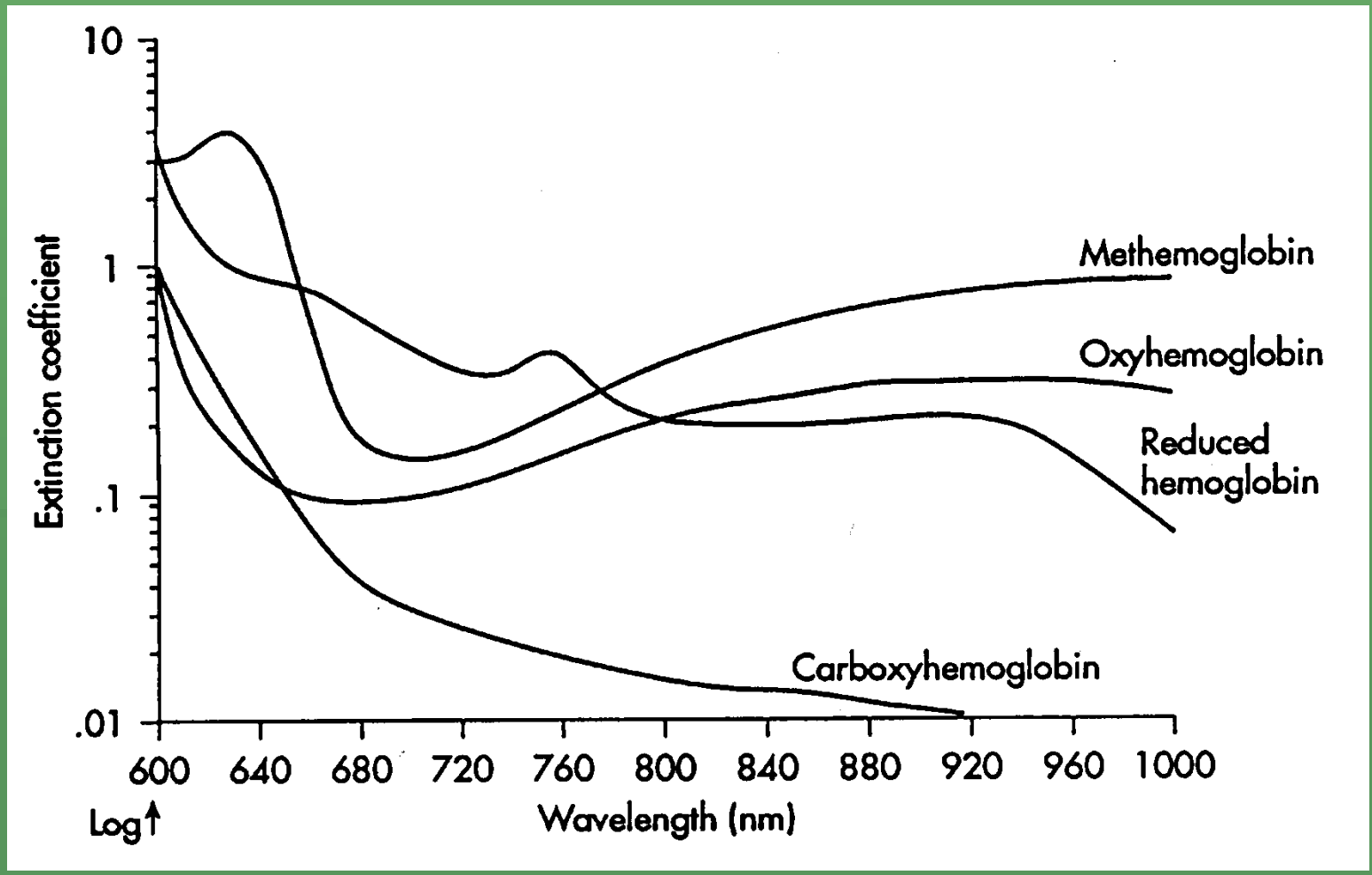
- 2 LED diodes, 1 photodetector
- Each LED lights hundreds of times per second
- Differences in detected intensity of transmitted light at each wavelength are measured to determine the AC and DC components
- All variables in Beer's Law are constant except for distance

Pulse Oximetry

Principle of operation



ABSORPTION SPECTRA



SOURCES OF ERROR

- Sensitive to motion
- Standard deviation is certified to 4% down to 70% saturation
- Sats below 85% increase the importance of error in the reading
- Calibration is performed by company on normal patients breathing various gas mixtures, so calibration is certain only down to 80%

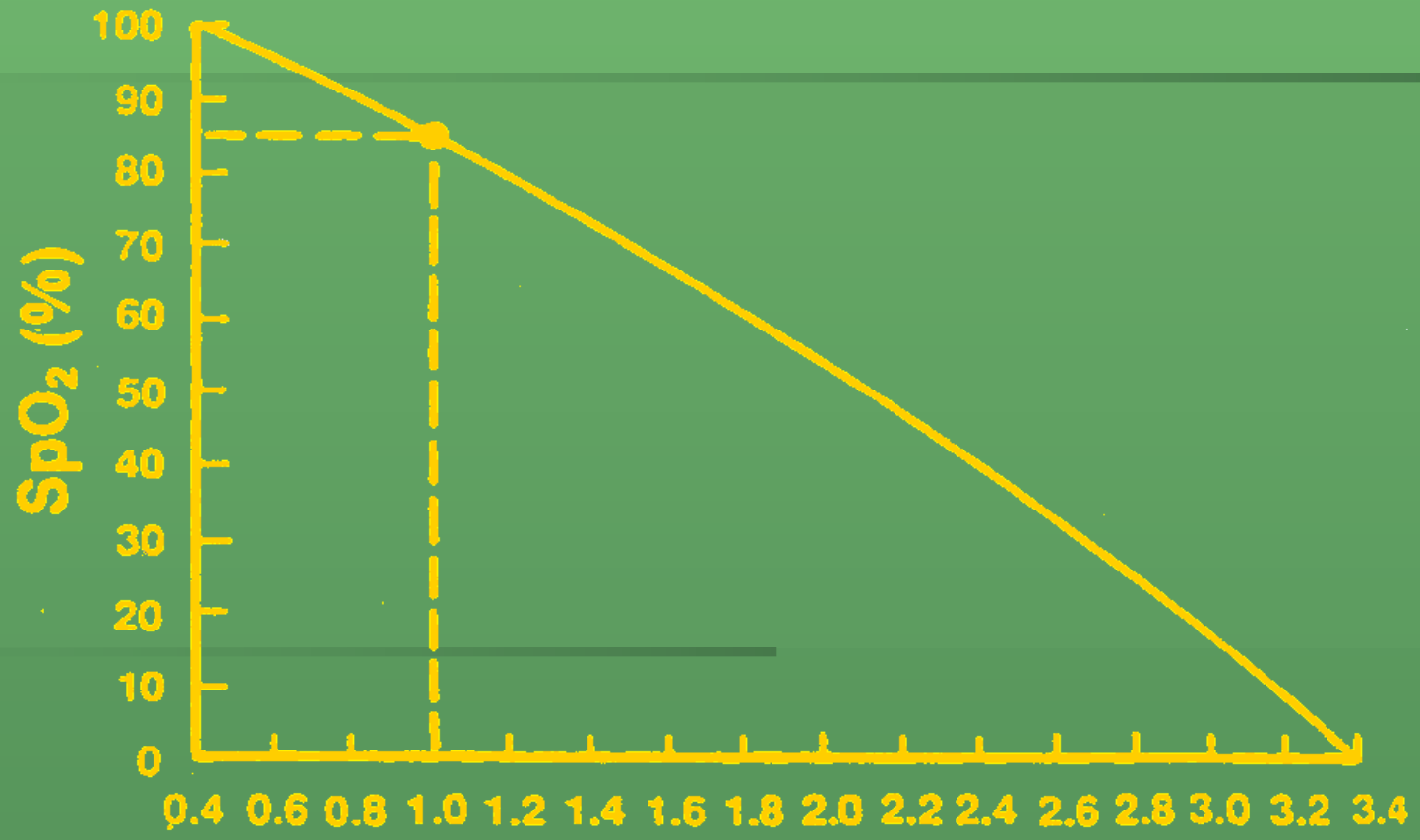
SOURCES OF ERROR

- Skin Pigmentation
  - Darker color may make the reading more variable due to optical shunting.
  - Dark nail polish has same effect: blue, black, and green polishes underestimate saturations, while red and purple have no effect
  - Hyperbilirubinemia has no effect
- Low perfusion state
- Ambient Light
- Delay in reading of about 12 seconds

SOURCES OF ERROR

- Methylene blue and indigo carmine underestimate the saturation
- Dysfunctional hemoglobin
  - Carboxyhgb leads to overestimation of sats because it absorbs at 660nm with an absorption coefficient nearly identical to oxyhgb
  - Methgb can mask the true saturation by absorbing too much light at both 660nm and 940nm. Saturations are overestimated, but drop no further than 85%, which occurs when methgb reaches 35%.

Calibration Curve



$$R = \frac{AC_{660}/DC_{660}}{AC_{940}/DC_{940}}$$

SOURCES OF ERROR

- Affect of anemia is debated
- Oxygen-Hemoglobin Dissociation Curve
  - Shifts in the curve can affect the reading
  - Oximetry reading of 95% could correspond to a P_aO_2 of 60mmHg (91% saturation) or 160mmHg (99% saturation)

Accuracy of Pulse Oximetry

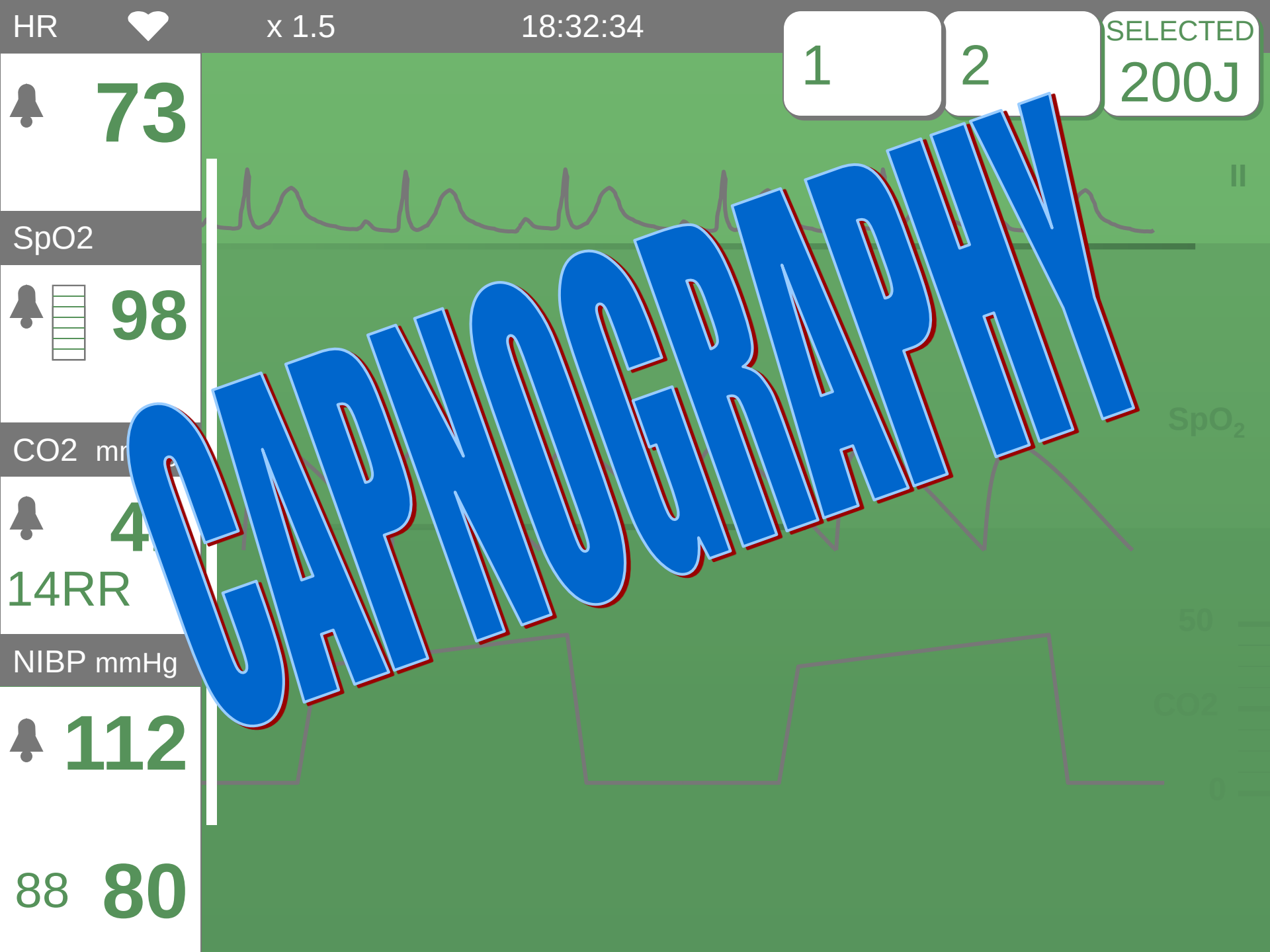
SpO2 overestimated SaO2. It has been found that SpO2 value of 96% is reliable to ensure SaO2 > or = 90%.

- **Pulse oximetry is accurate above 90% oxyhaemoglobin saturation(2-3%), but much less so below 70%, and inaccurate below 50%.**
- **Factors adversely affecting:**
  - **transducer movement**
  - **peripheral vasoconstriction**
  - **nonpulsating vascular bed**
  - **Hypotension**
  - **Anemia** 5 g/dl
  - **Dyshemoglobinemias (COHb, MetHb 85%, HbF, HbSS)**
  - **changes in systemic vascular resistance**
  - **Hypothermia**
  - **presence of intravascular dyes**
  - **nail polish (**Blue, black, green)
  - **Methylene blue 65%**
  - **Edema**
  - Skin pigmentation: Dark skin
  - Ambient Light (Florescent lights)

Pulse Oximetry

- In general, signals are weaker from ears than from fingers except in hypotension or peripheral vasoconstriction, but ear responses are faster.
- Nasal bridge probes have been reported to read falsely high.
- In children particularly, it is essential to be certain the signals are adequate; a valid pulse reading can be of some reassurance

Capnography


HR
x 1.5
18:32:34
1
2
SELECTED
200J
73
SpO2
98
CO2 mr
4
14RR
NIBP mmHg
112
88
80
II
SpO2
50
CO2
0
CAPNOGRAPHY

CAPNOGRAPHY

- Term capnography comes from the greek work *KAPNOS*, meaning smoke.
- Anesthesia contex: inspired and expired gases sampled at the Y connector, mask or nasal cannula.
- Gives insight into alterations in ventilation, cardiac output, distribution of pulmonary blood flow and metabolic activity.

What is capnography?

- کاپنو گرافی ثبت عملی مقدار co2 دمی و باز دمی است
- منحنی کاپنوگرام نمایش گرافیکی فشار نسبی co2 در سراسر تنفس است

Why Capnography?

اطلاعاتی در باره میزان تولید co2

پرفیوژن ریه

ونتیلاسیون الوئولی

الگوهای تنفسی

دفع co2 از سیرکوئیت بی هوشی و ونتیلاتور

نشان داده شده که کاپنو کافی در کشف به موقع حوادث مضر تنفسی خیلی موثر است

به کار گیری توام کاپنو گرافی و پالس اکسیمتری 93٪ از حوادث مضر حین بیهوشی جلوگیری می کند (مطالعهASA)

Physiology

- هوای دمی حاوی مقادیر قابل اغماض دی اکسید کربن است
- دی اکسید کربن از کاپیلر های ریوی به داخل الوئولها انتشار می یابد
- هنگام باز دم ابتدا' هوای راههای هوائی فوقانی وبعد تحتانی وبعد از ان الوئولها خارج می شوند
- کاپنو گرام نمایش حرکت دی اکسید کربن به بیرون در سراسر باز دم است
- در تمامی بیماران سالم ونرمال میزان دی اکسید کربن تولیدی برابر است
- تغییر در منحنی نرمال می تواند ناشی تغییرات حالات فیزیولوژی باشد و یا یک حالت پاتولوژی ویا ناشی از بد کاری تجهیزات

Physiology ادامه

- هر فاکتوری که تولید وانتشار و دفع دی اکسید کربن تاثیر بگذارد در کاپنوگرام تاثیر خواهد گذلشت
- یک متخصص طب اورژانس باید قادر به تشخیص منحنی های غیر طبیعی ناشی از بد کاری تجهیزات و شرایط فیزیولوژیک وپاتو لوژیک باشد

ASA Standards of Care - Capnography

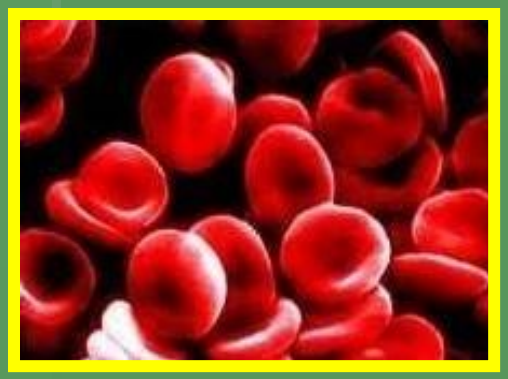
هر بیمار ی که بیهوشی عمومی دریافت می کند کاپنوگرافی جزو مونیتورهای پایه واساسی است .

حداقل استفاده تائید انتوباسیون صحیح و جاگذاری صحیح لارینژال ماسک است

ASA& AHA

کاپنوگرافی را در بیهوشی اجباری می داند مگر با فیلد عمل تداخل کند و یا امانت نباشد

What is Capnography?



- "SMOKE"
- CO_2 produced by the metabolism of glucose
- transported to the pulmonary capillaries
- diffuses into alveoli and eliminated via exhalation

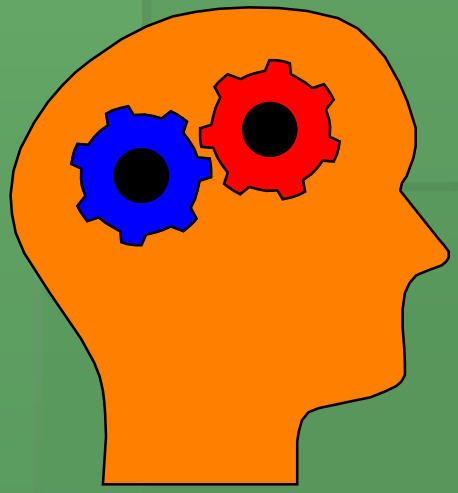
Levels of Capnography Depend On

- Amount of CO_2 being produced (metabolism)
- Whether the CO_2 is being carried to the lungs (circulation)
- Whether the alveoli are being ventilated

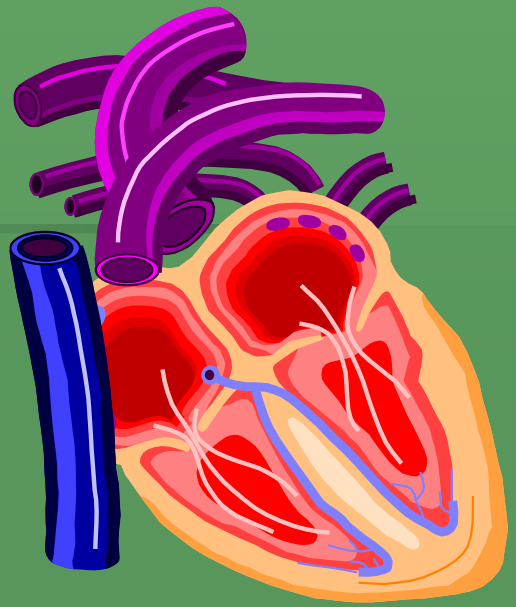
EtCO2

Inspiration (Phase 0)

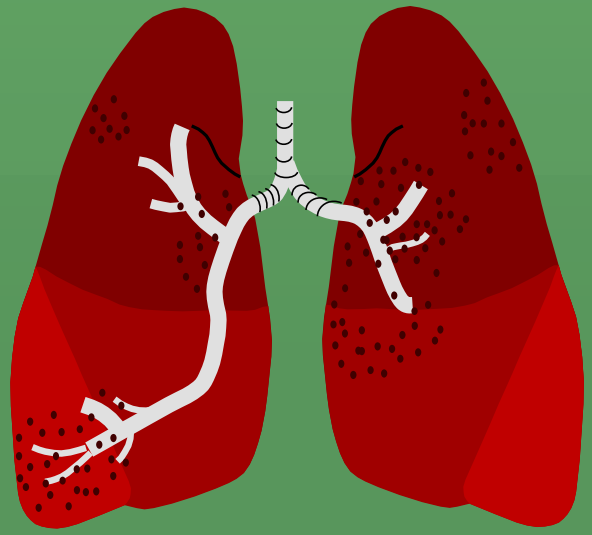
METABOLISM



PERFUSION



VENTILATION



Why Measure $ETCO_2$?

- Three reasons: ABC
  - A = Airway
    - Verify ET tube placement
    - Ensure ongoing ET tube placement
    - Assess changes in airway
  - B = Breathing
    - Assess ventilation (movement of air)
    - Monitor respiration (exchange of gases)
    - Assess treatment
  - C = Circulation
    - Pulmonary blood flow
    - Check CPR efforts
    - Identify ROSC

Pulse Oximetry and Capnography

- You cannot measure ventilation with a pulse oximeter and you cannot measure oxygenation with capnography

PULSE OXIMETRY IS THE VITAL SIGN FOR

Oxygenation

CAPNOGRAPHY IS THE VITAL SIGN FOR

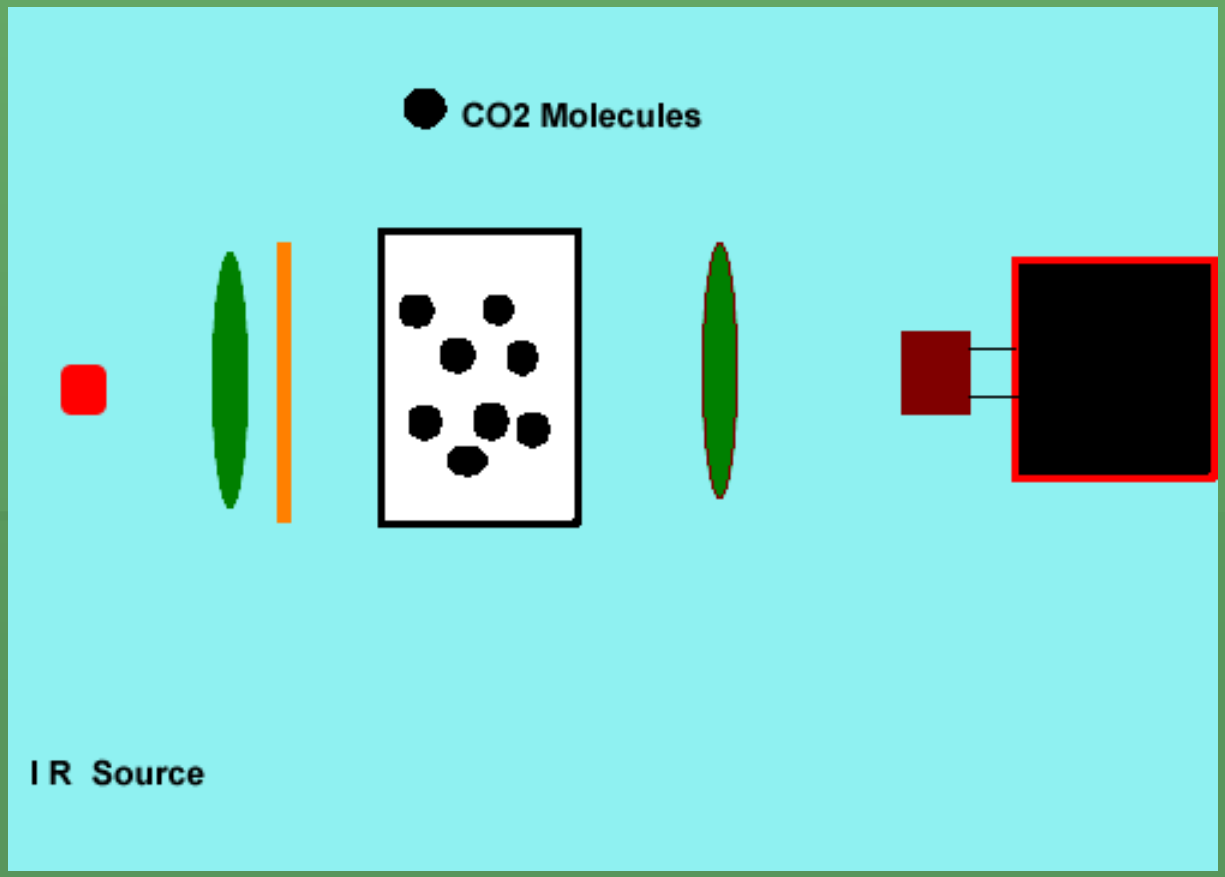
Perfusion

How Capnography Works

Physics of capnography

Infra Red Spectrography

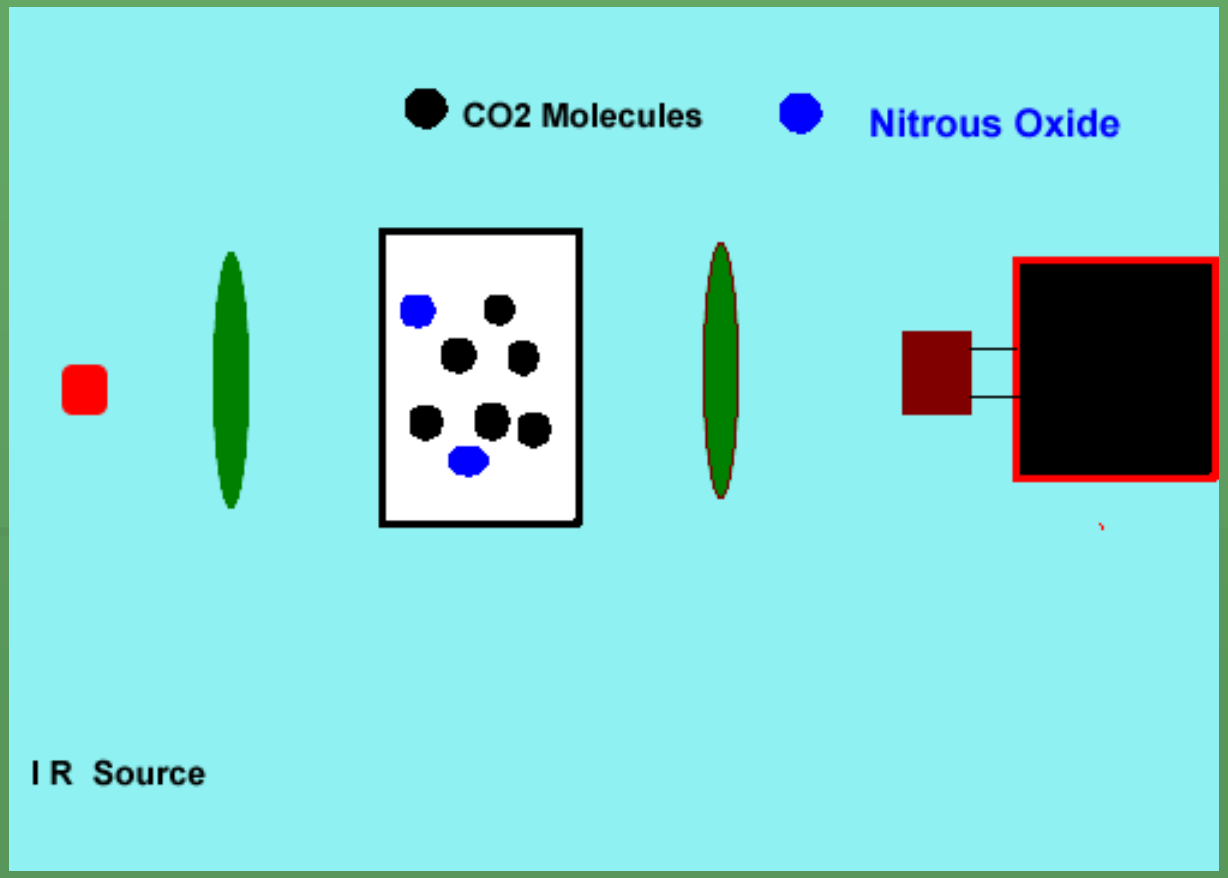
دی اکسید کربن نور مادون قرمز را جذب می کند



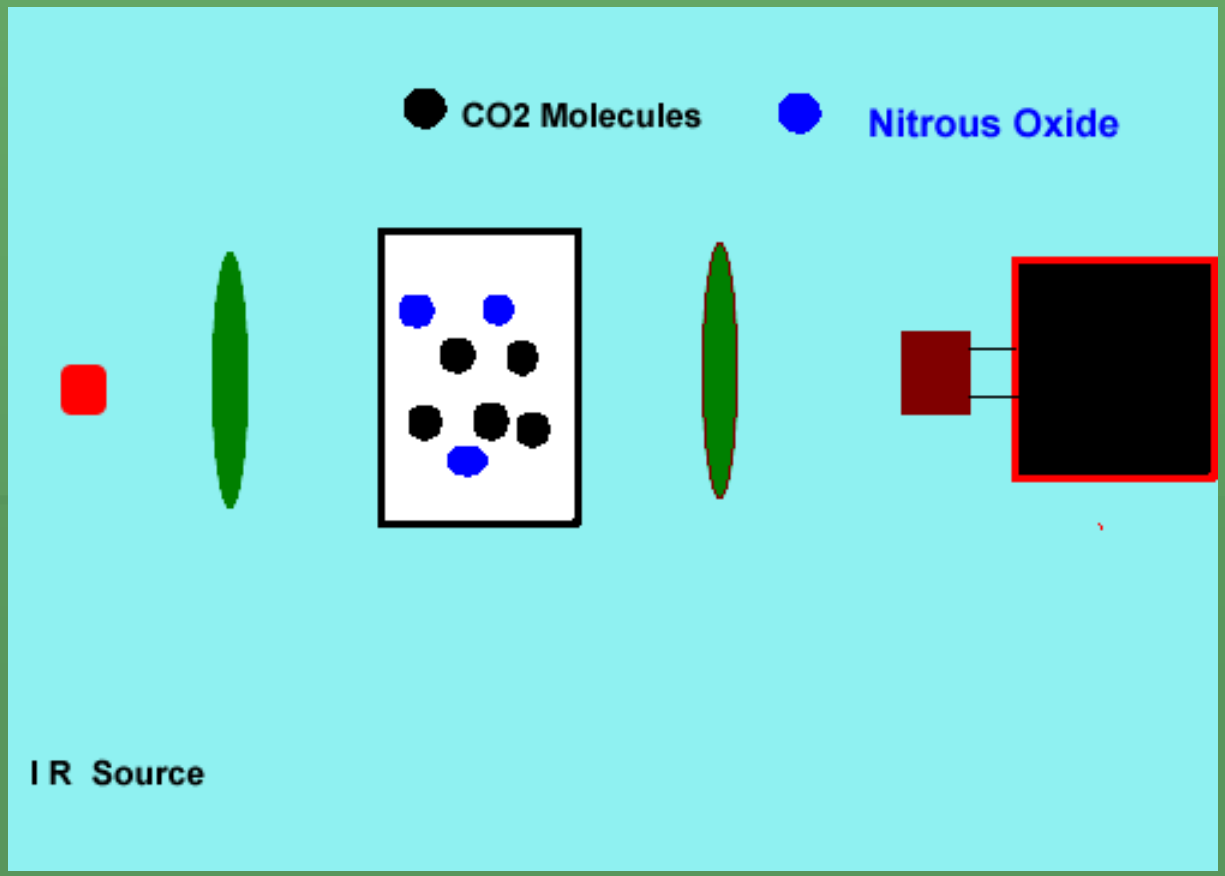
فاکتورهای موثر در اسپکترو گرافی مادون قرمز

- Atmospheric Pressure
- Nitrous Oxide
- Oxygen
- Water Vapor
- Inhalational Agents
- Response Time

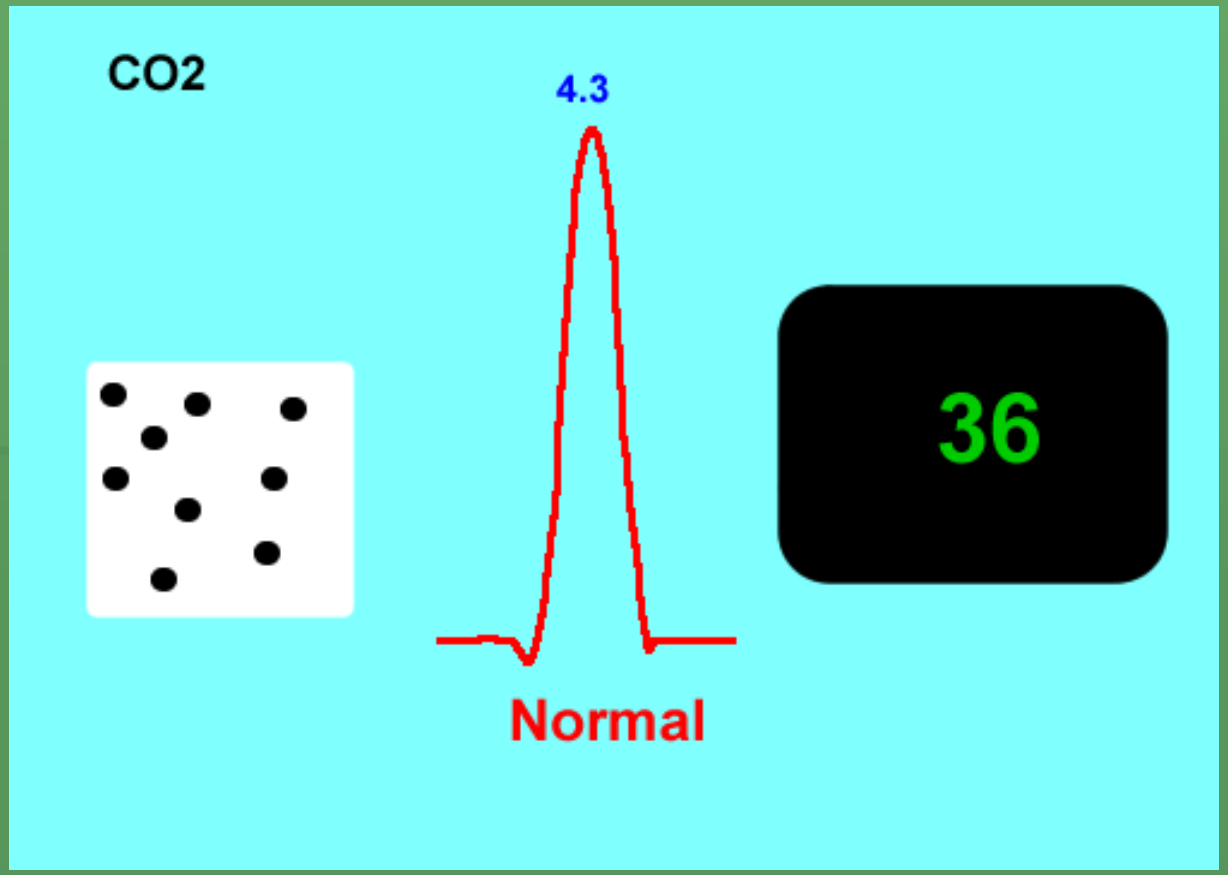
نیتروس اکساید چگونه با اندازه گیری دی اکسید کربن تداخل می کند؟



جذب نور مادون قرمز درطول موج 4.3 µ m حداقل است

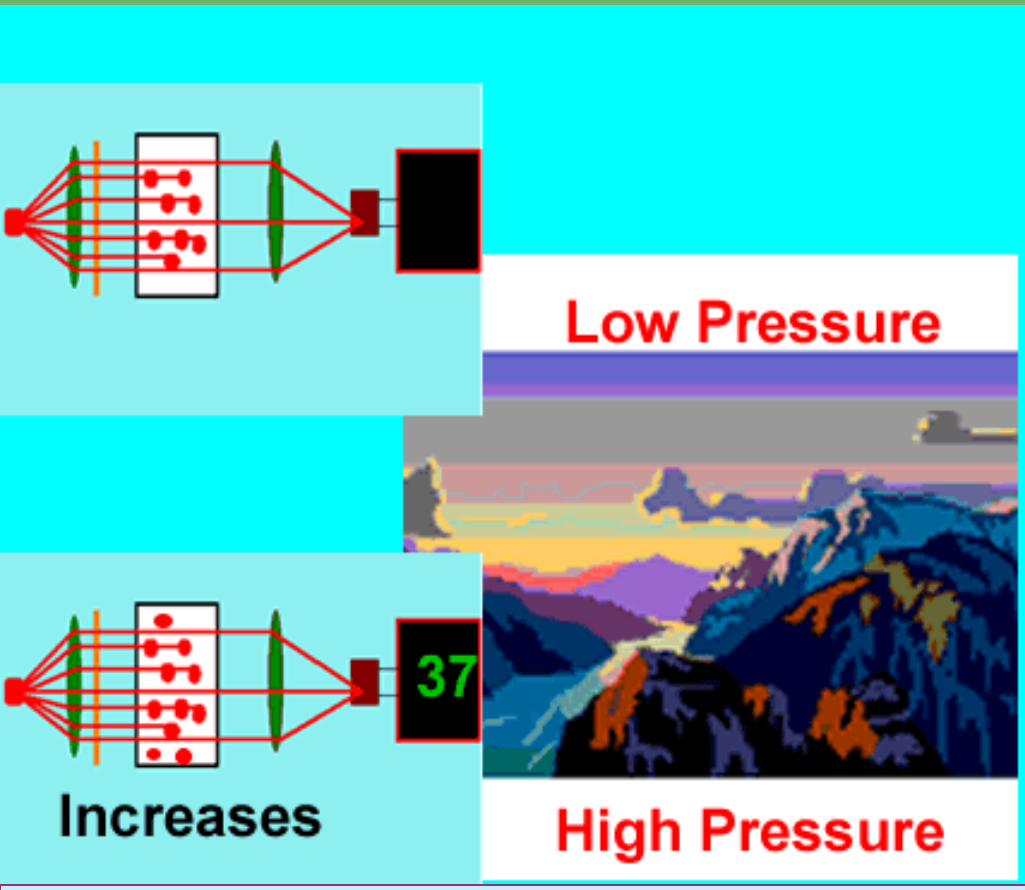


اثر BROADENING collision N2O در ميزان دي اكسيد كربن



Factors affecting IR Spectrography

Effect of Atmospheric Pressure



How does atmospheric pressure affect CO_2?

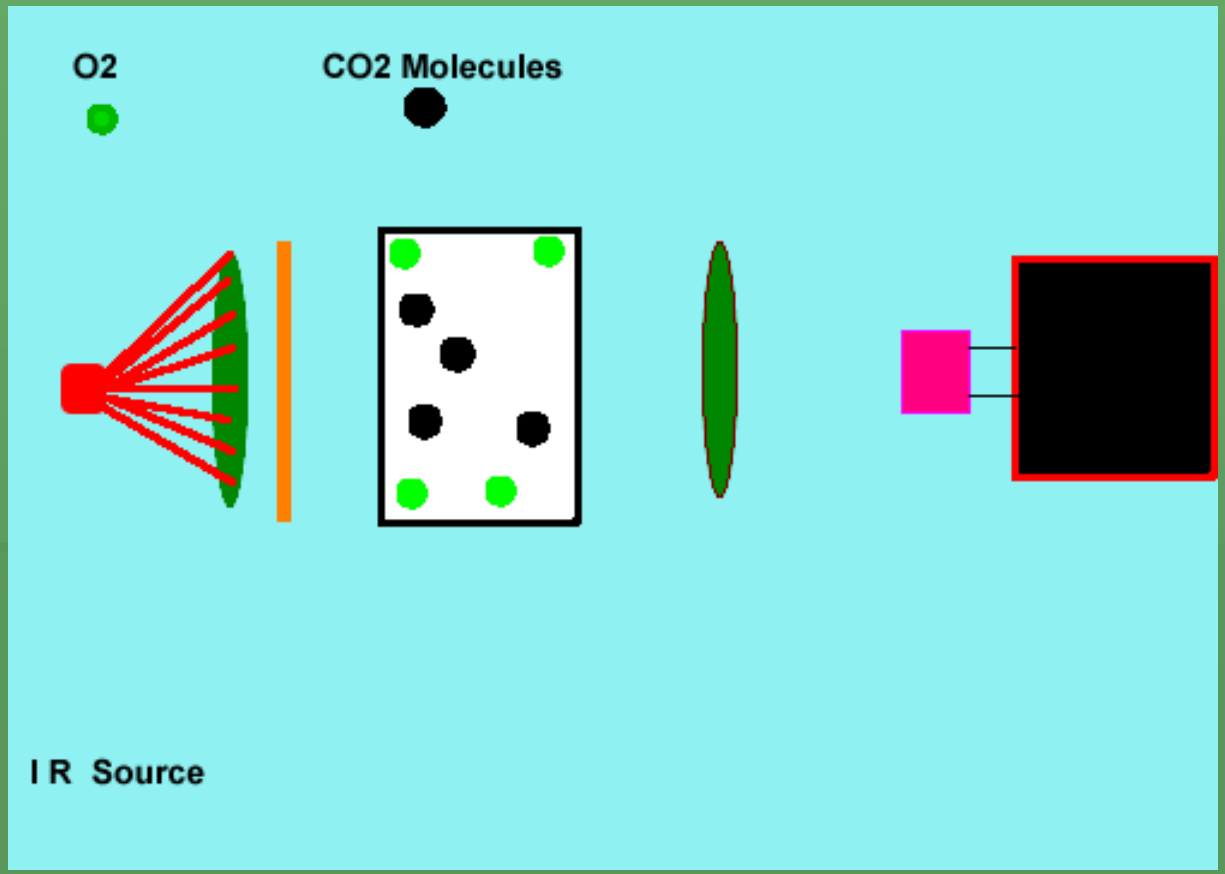
Increases in atmospheric pressure result in an increase in the $PETCO_2$ values by increasing number of IR absorbing moleculesand increasing intermolecular forces

The effect of Atmospheric pressure can be minimised by:-

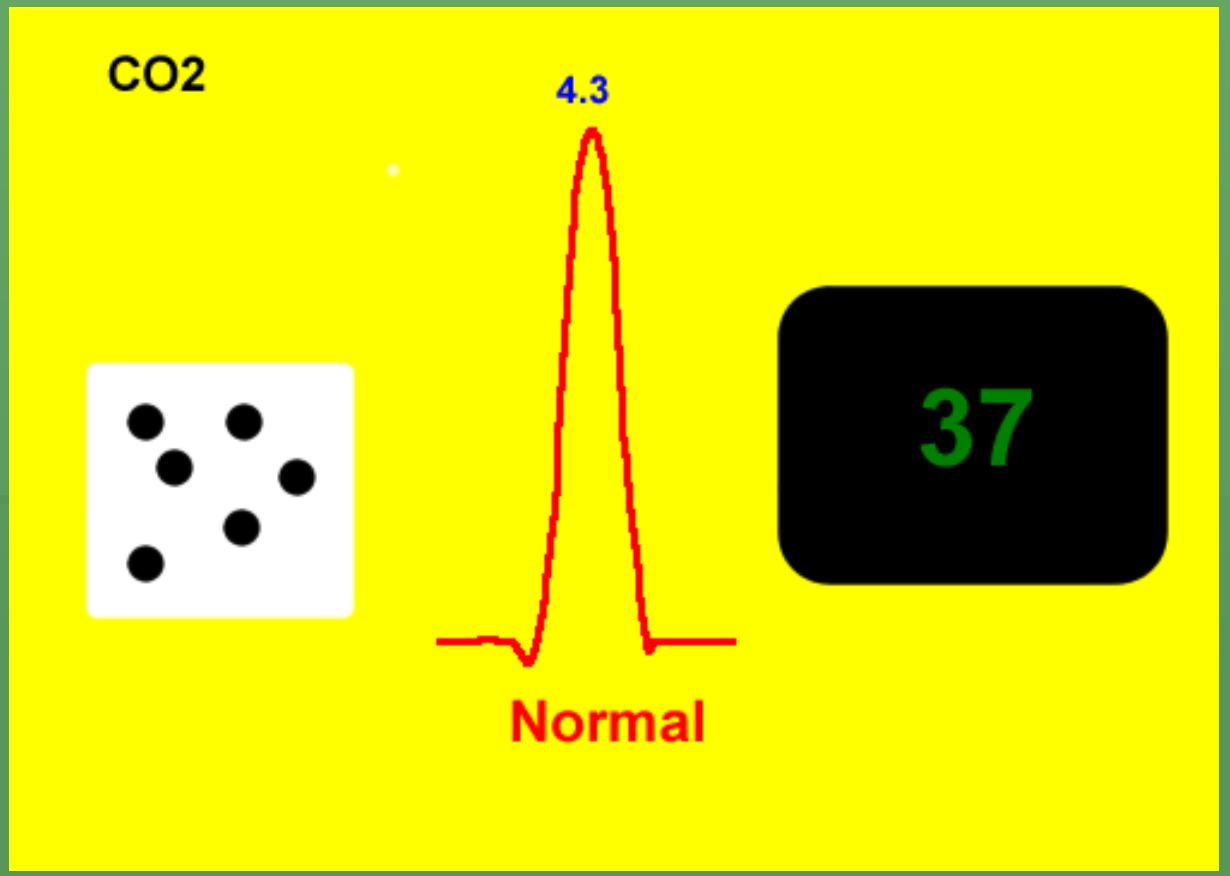
Measuring CO_2 as partial pressures

Calibrating with a known concentration of CO_2 as partial pressure at the site of measurement

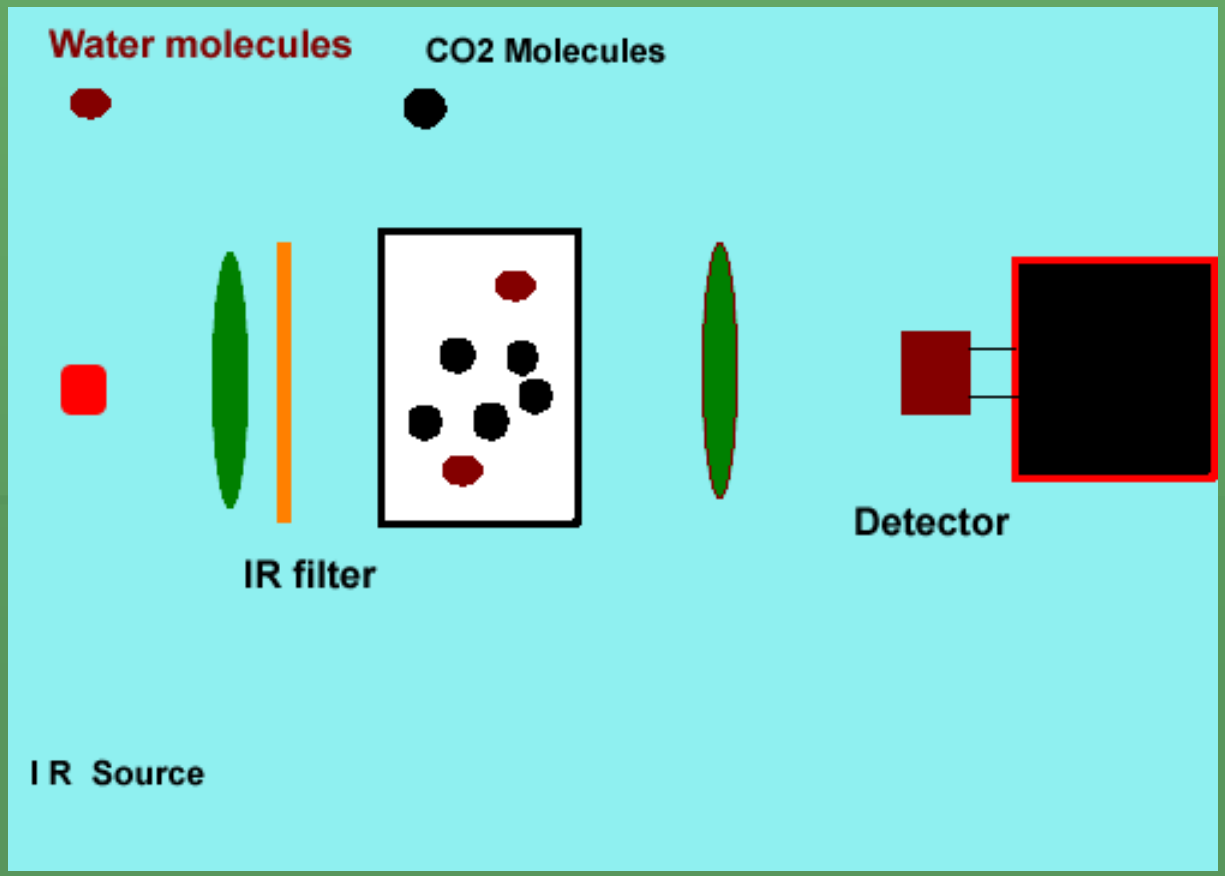
اکسیژن نور مادون قرمز را جذب نمی کند



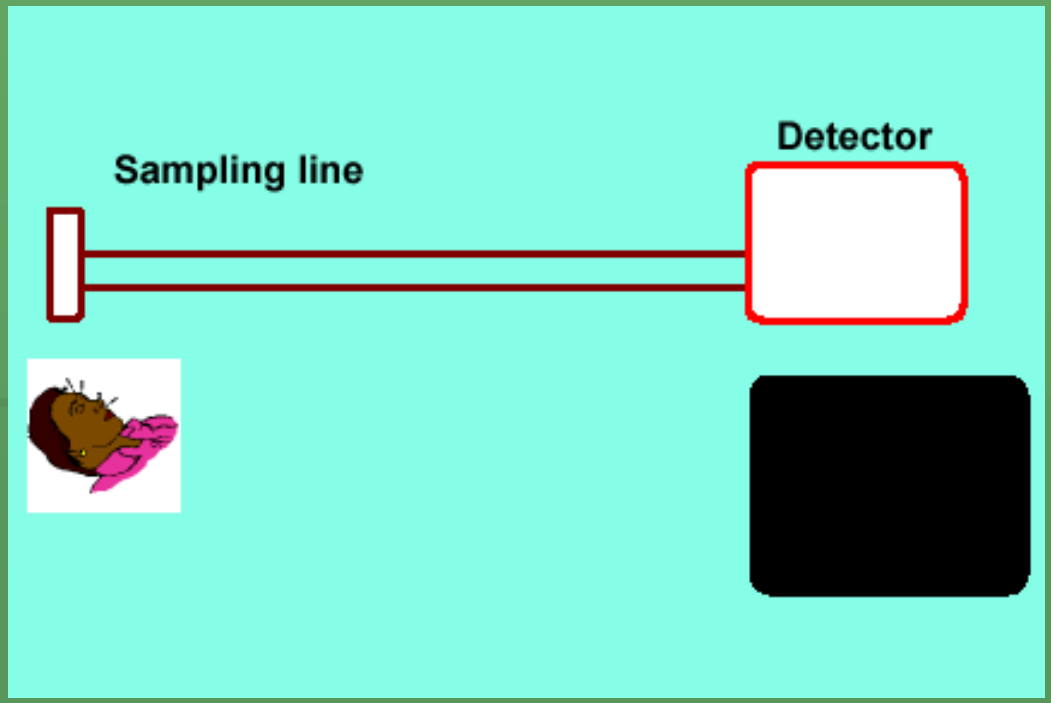
Collision broadening affect of Oxygen



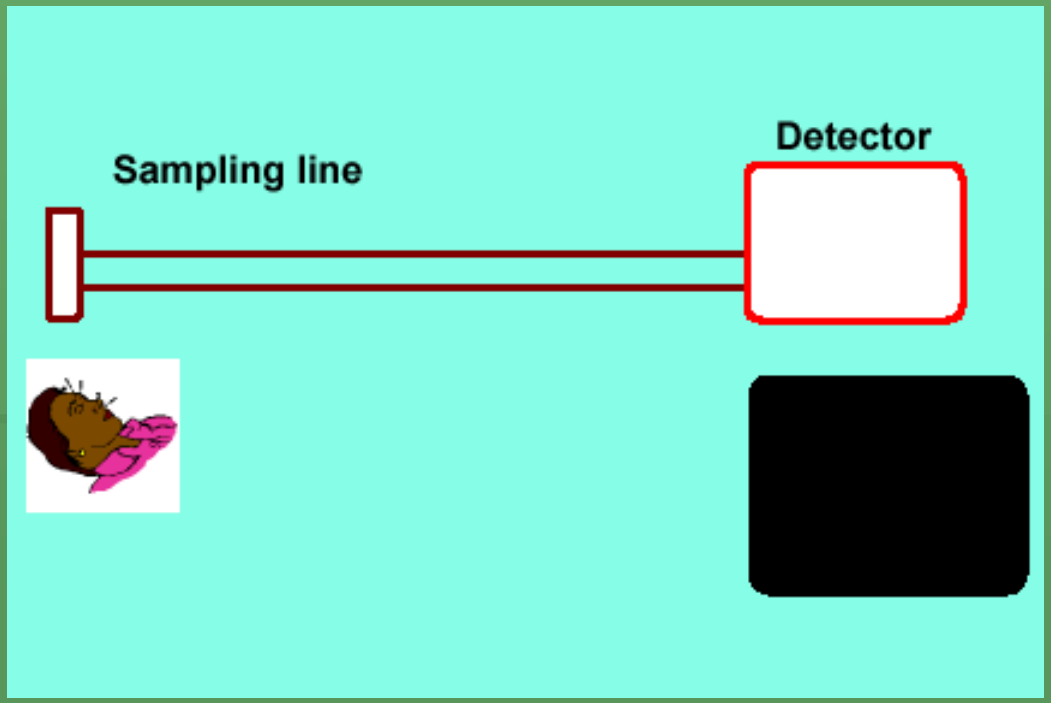
بخار آب مي تواند تغليظ شود و نور مادون قرمز را هدايت بكند



بخار اب متراکم می شود و فشار نسبی دی اکسید کربن را بالا می برد

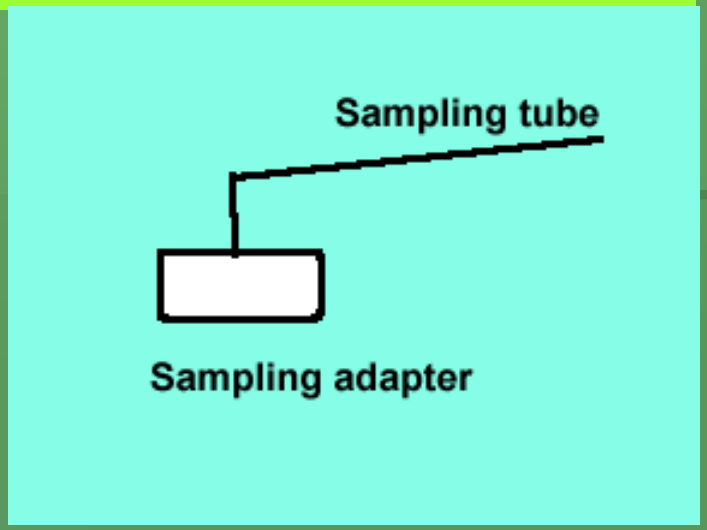


بخار اب متراکم شده می تواند باعث بلوک کاتتر نمونه برداری شود

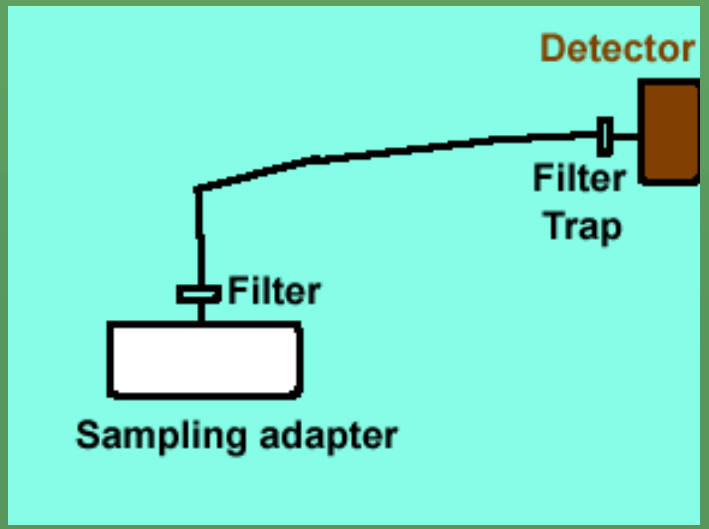


روشهائی برای کاهش الودگی لاین نمونه برداری از مایعات وترشحات بیمار[1]

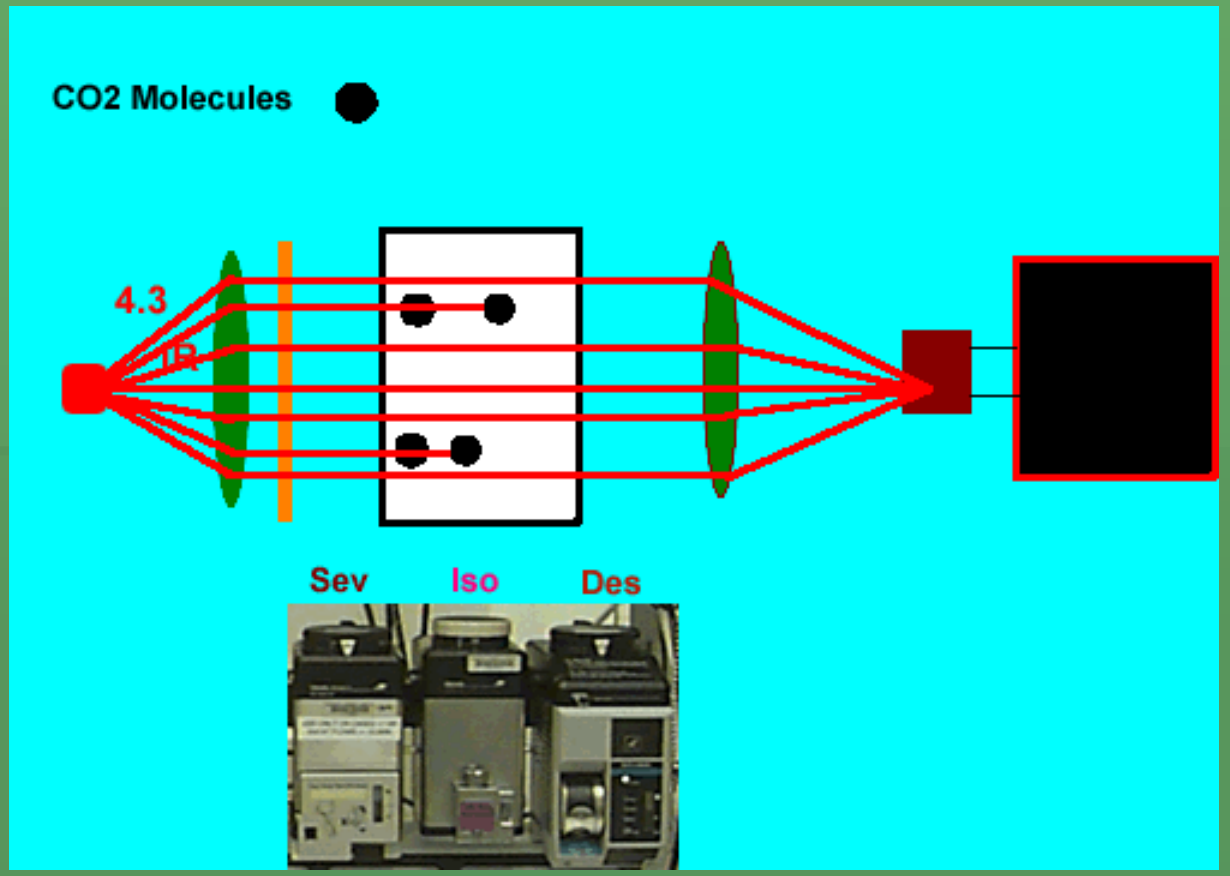
Position the sampling vertically upwards[1]



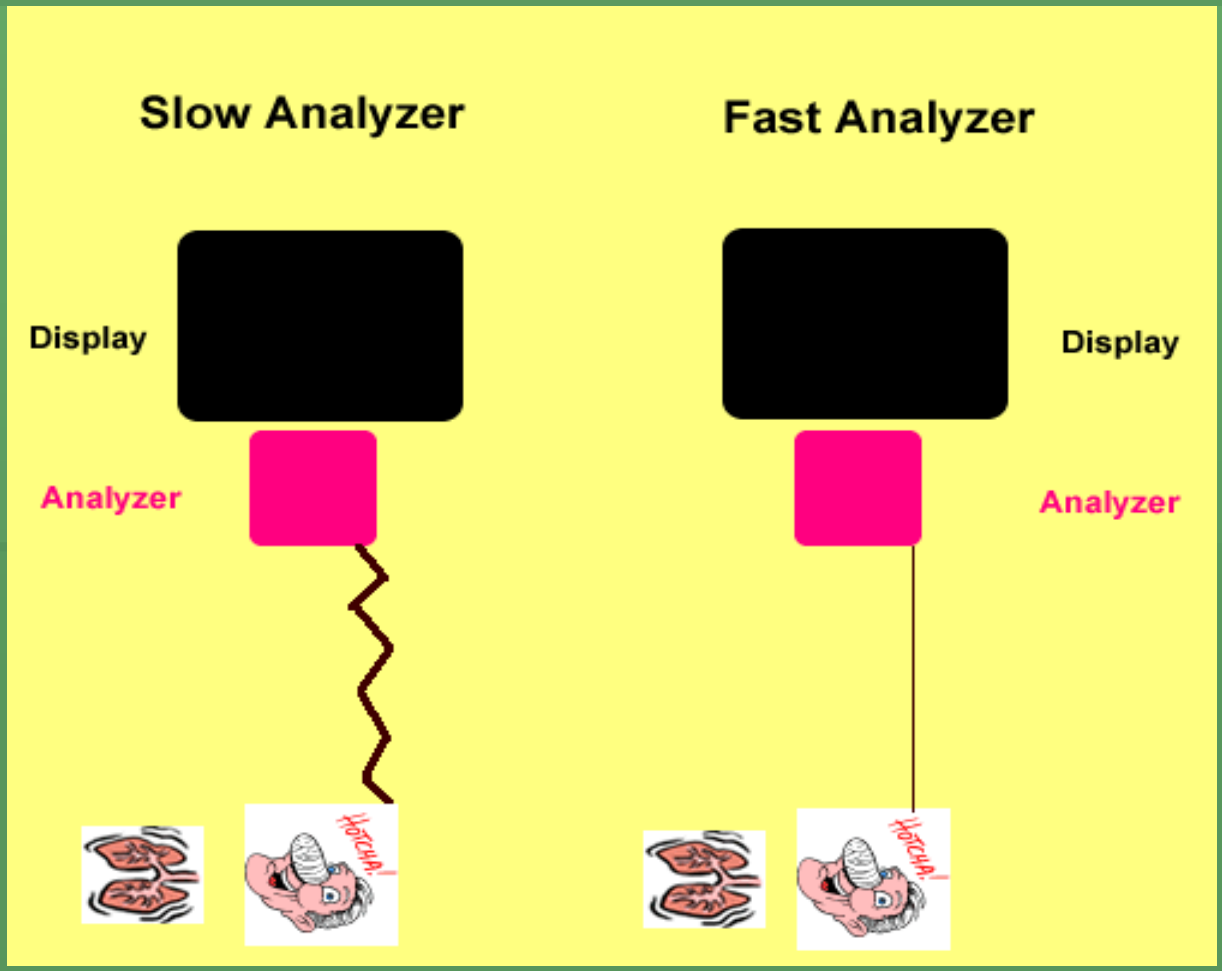
Use water filters at both ends of sampling tube[5]



هوشبرهای استنشاقی در میزان دی اکسید کربن تاثیری ندارند

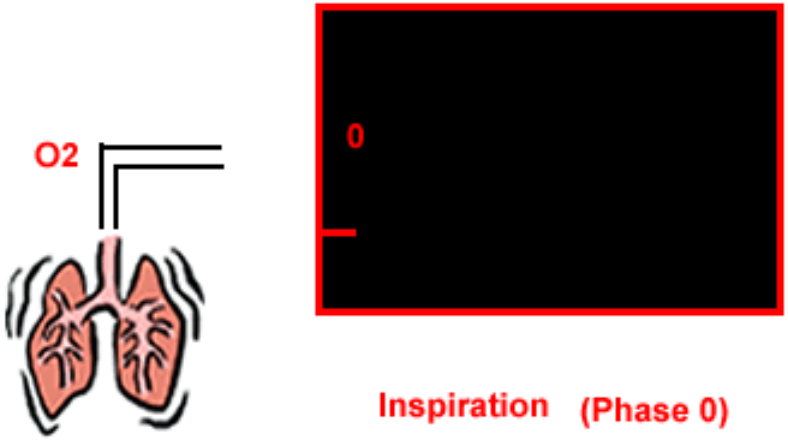


زمان پاسخگوئی أنالیزر باعث کج وید شکلی منحنی دی اسید کربن می شود



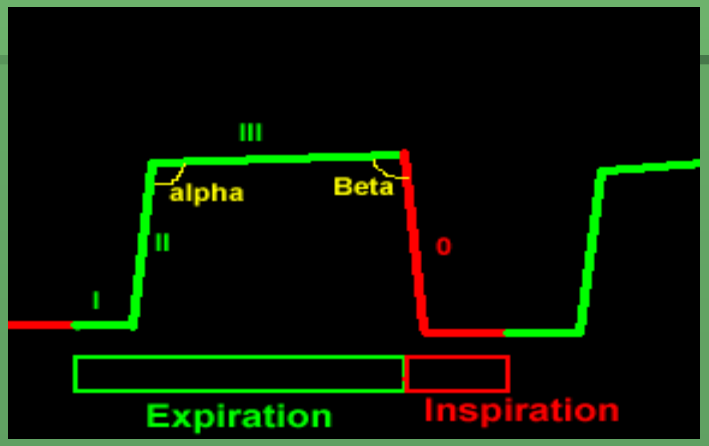
روش شیمیائی اندازه گیری دی اکسید کربن

Basic Physiology



Terminology

Current Terminology



Inspiratory segment

Phase 0: Inspiration **Beta Angle** –

Angle between phase III and descending limb of inspiratory segment

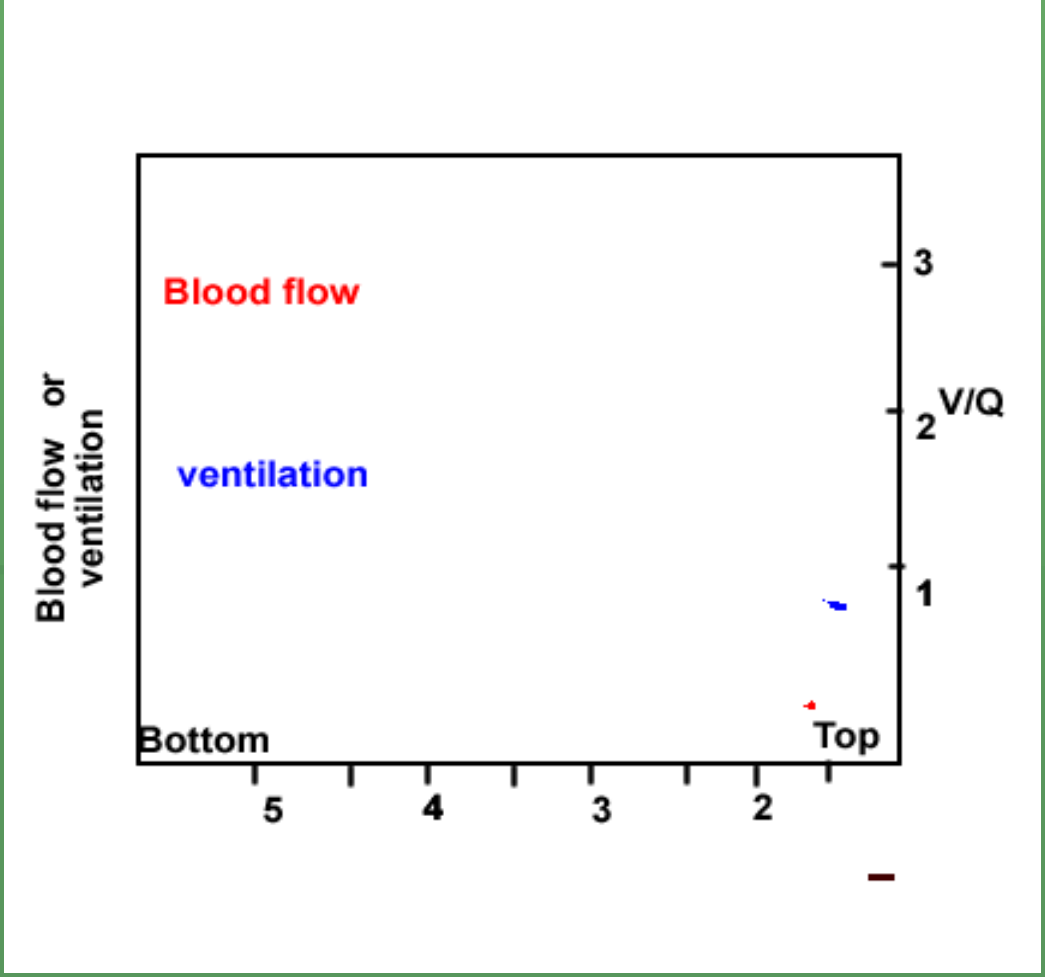
Expiratory segment

Phase I - Anatomical dead space
Phase II - Mixture of anatomical and alveolar dead space

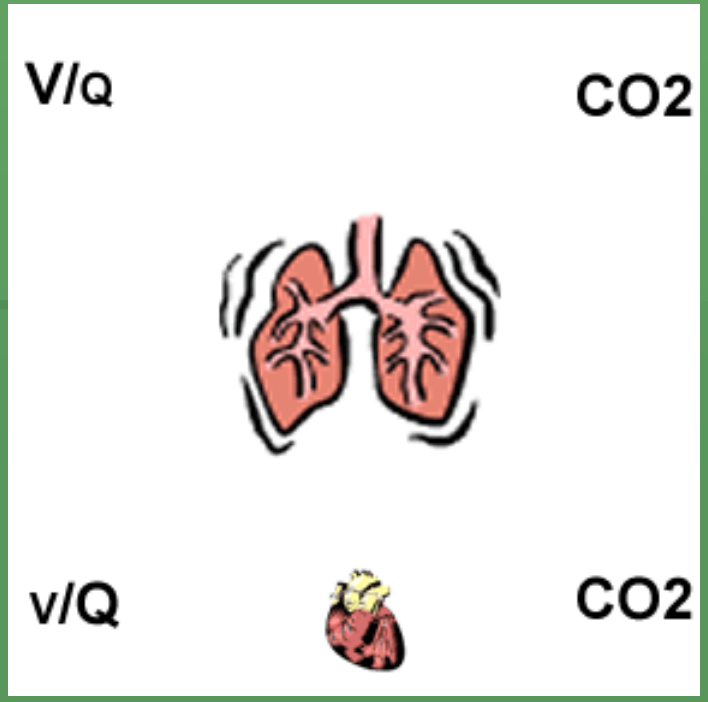
Phase III - Alveolar plateau

Alfa angle - Angle between phase II and phase III (V/Q status of lung).

Ventilation and Perfusion in the Lung



Lower part of lung is relatively more perfused than ventilated, resulting in spectrum of alveoli with higher V/Q ratio (lower CO_2) on the top of the lung, and lower V//Q (higher CO_2) at the bottom of the lung



Any factor that affects the V/Q ratio of the lung can influence

the height and slope of phase III.

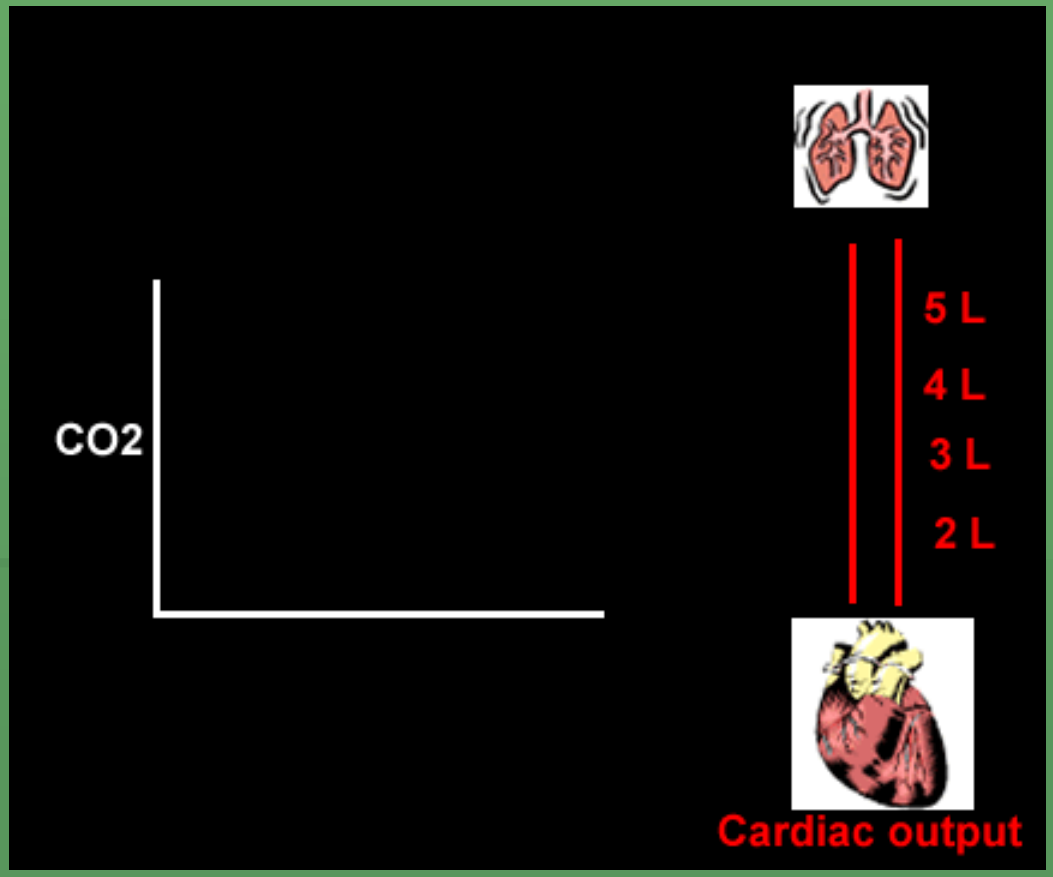
Cardiac output,

CO_2 production,

Airway resistance,

Functional residual capacity

How does cardiac output affect $PETCO_2$



ارتباط کاپنوگرام با حجم جاری

مشخص نمودن اجزا حجم جاری در کاپنو گرام

Increased (a-ET)CO_2

With advancing age

COPD

Hypovolemia

Pulmonary embolism

(a-ET)PCO_2 decreases

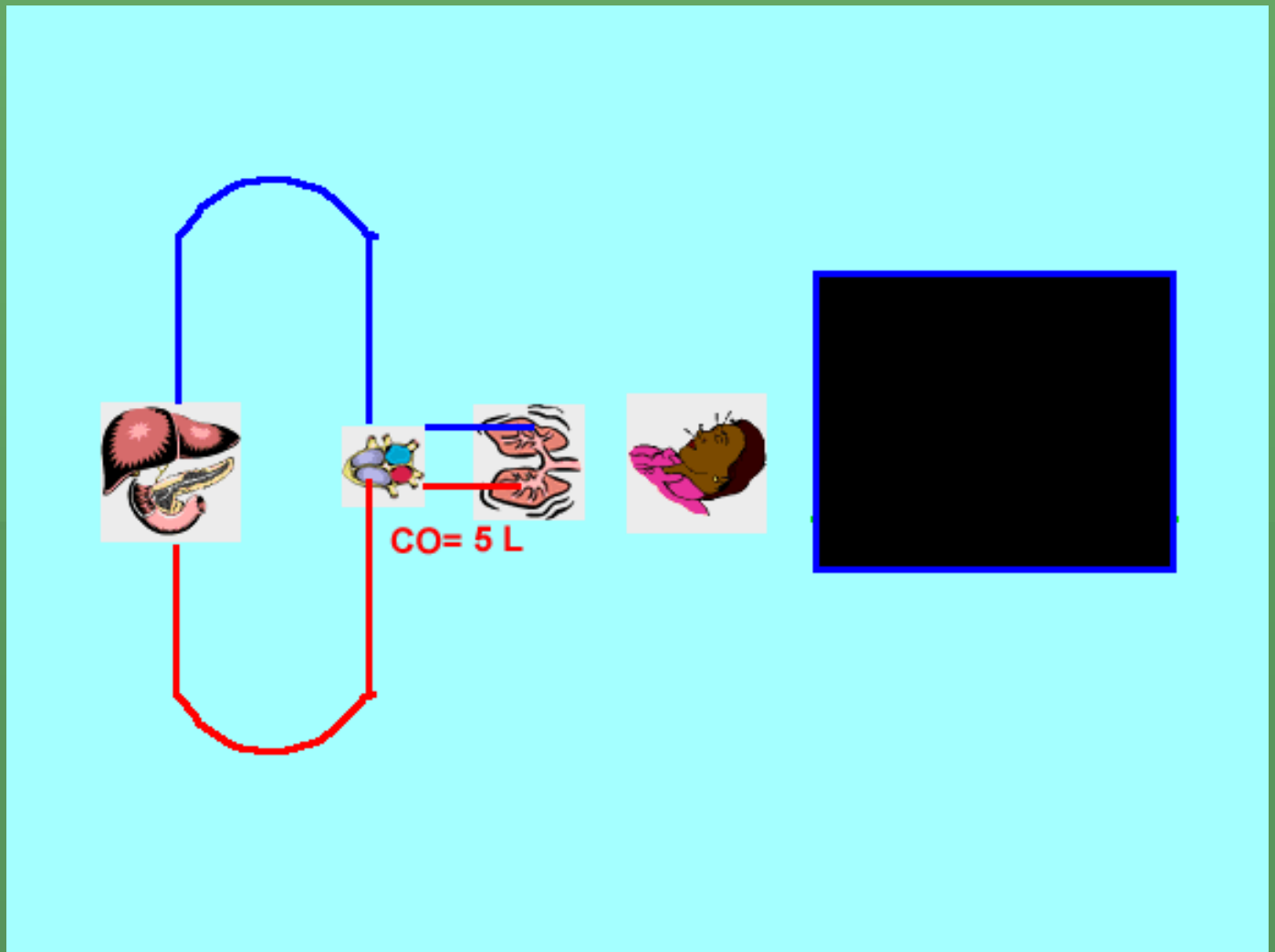
Low frequency, high tidal volume ventilation in healthy adults

Children

Pregnant Subjects

$(a\text{-}ET)PCO_2$

کاهش دبی قلب باعث افزایش فضای مرده الوئول می شود

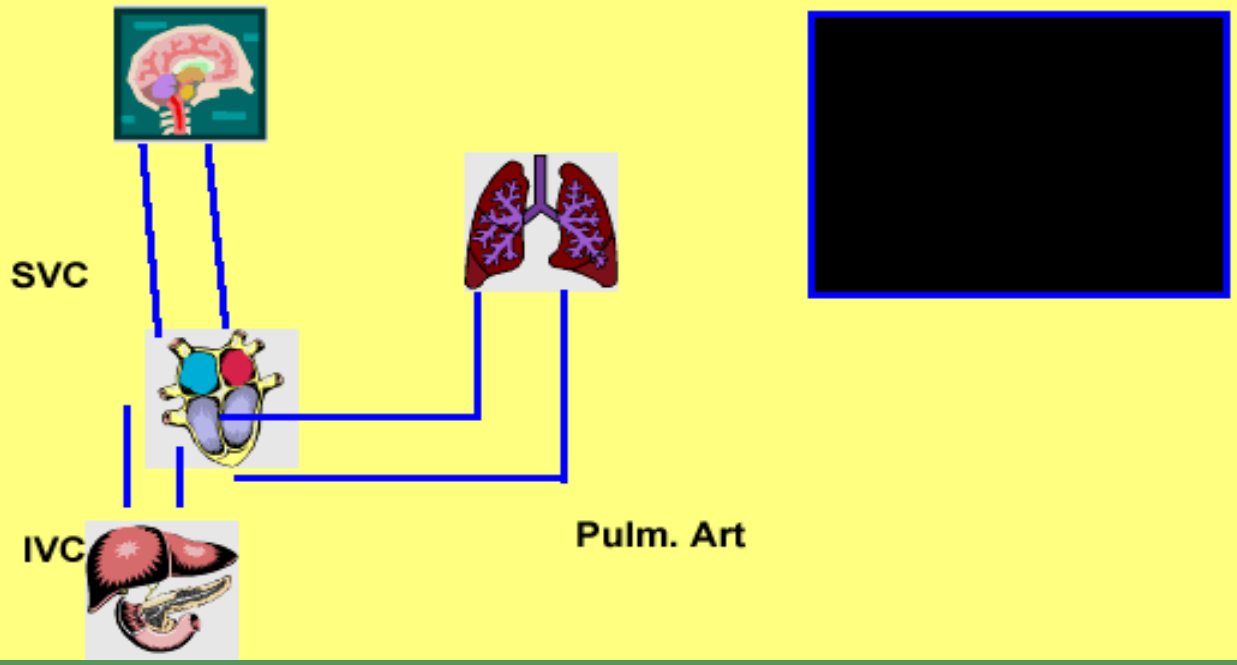


- امبولی هوائی

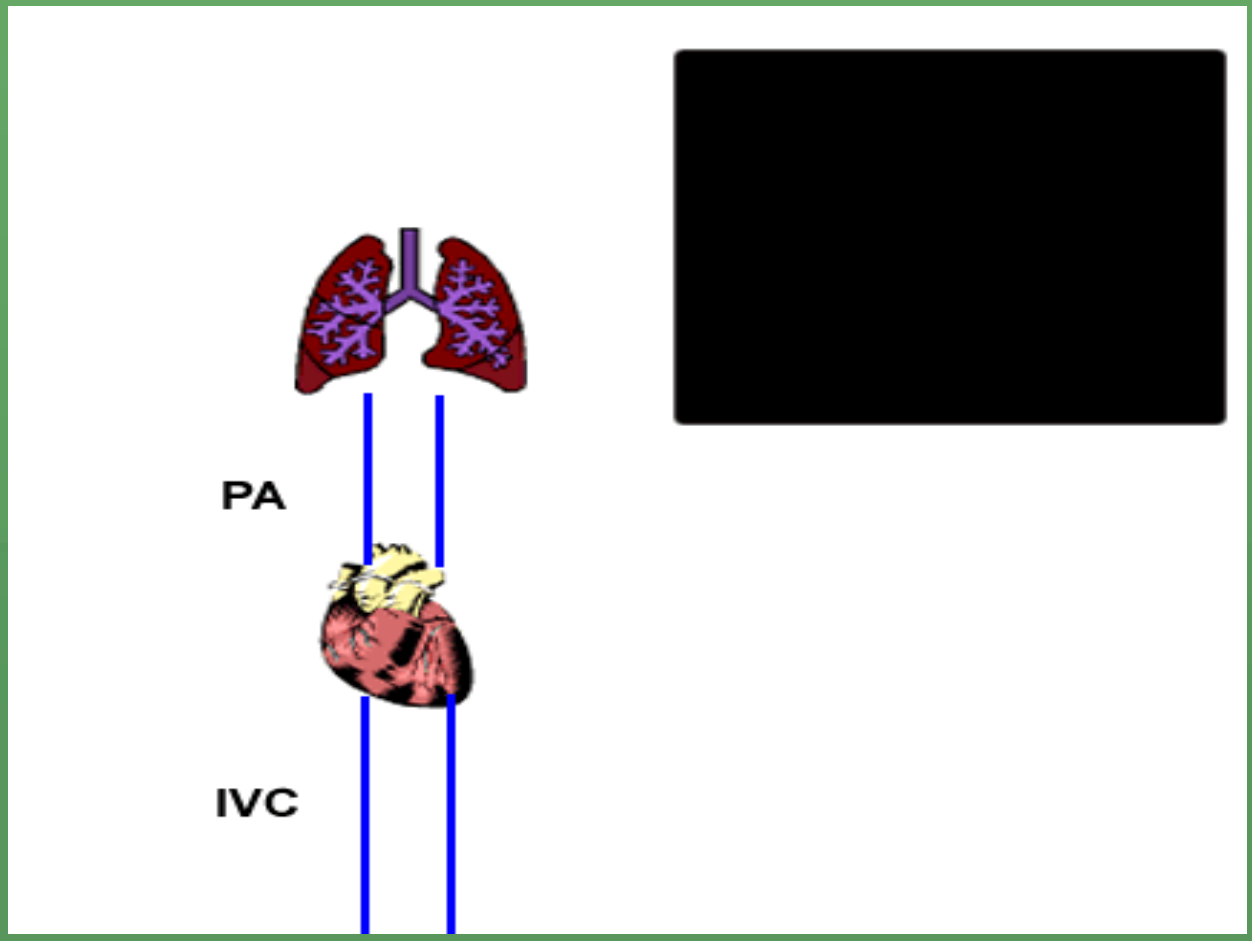
فضای مرده الوئول را زیاد

دی اکسید کربن را انتهای باز دمی را کم

a-Etco2 زیاد می کند

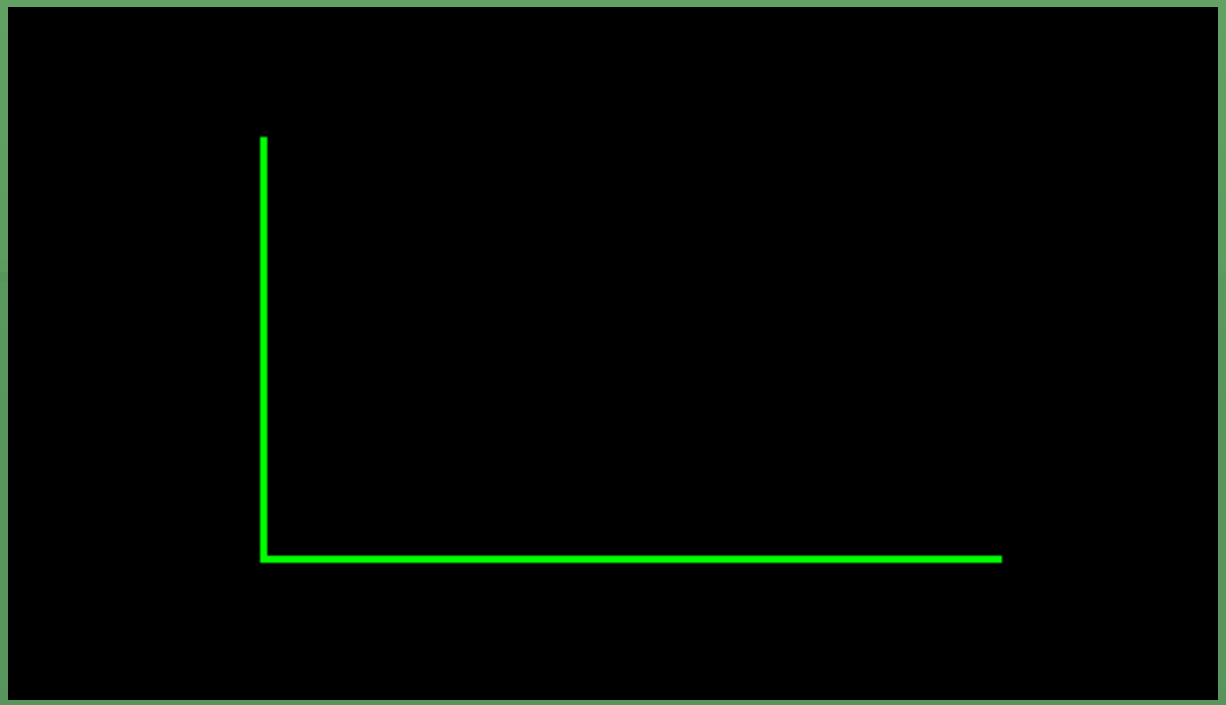


ترومبو امبولی
فضای مرده الوئول را زیاد
دی اکسید کربن را انتهای باز دمی را کم
زیاد می کند **a-Etco2**



PETCO2 as a non-invasive monitor of PaCO2

تا زمانی که فضای مرده الوئول ثابت است et co2 انعکاسی از aco2 است



Clinical applications of capnography

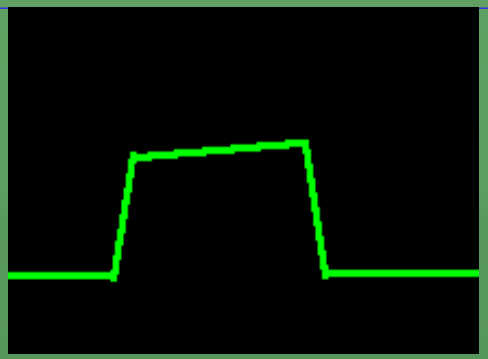
Capnography provides three sources of information

GO

From Numbers- $PETCO_2$ values- Capnometry

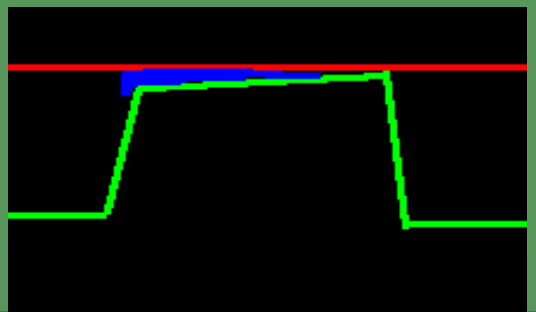
GO

From Lines and Curves-- Shapes of capnograms - Capnography



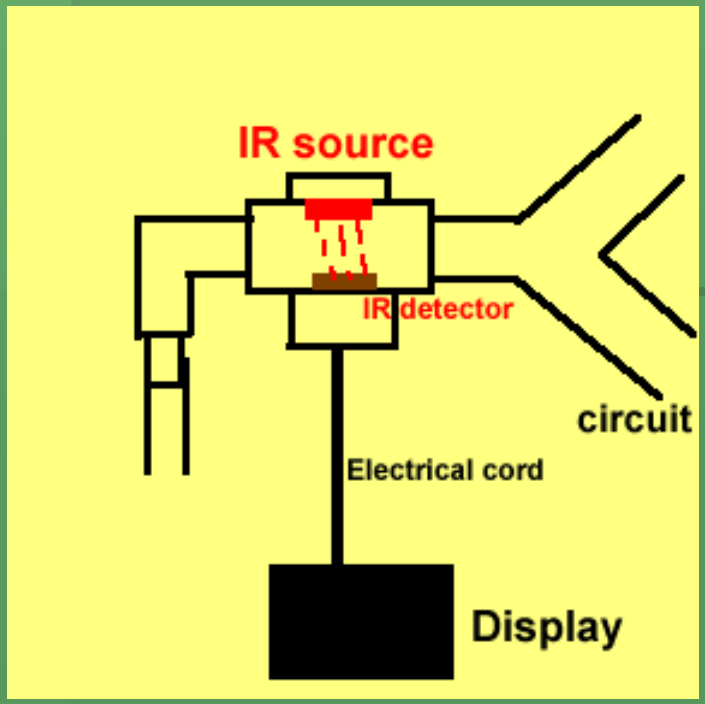
GO

From (a-ET)PCO_2 gradients or differences- Alveolar dead space

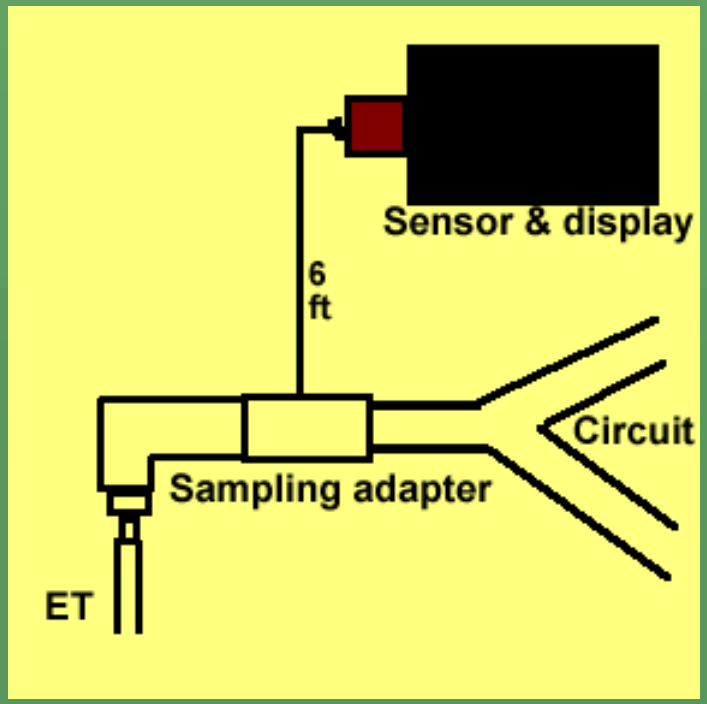


انواع کاپنو کراف ها

Main-stream capnographs



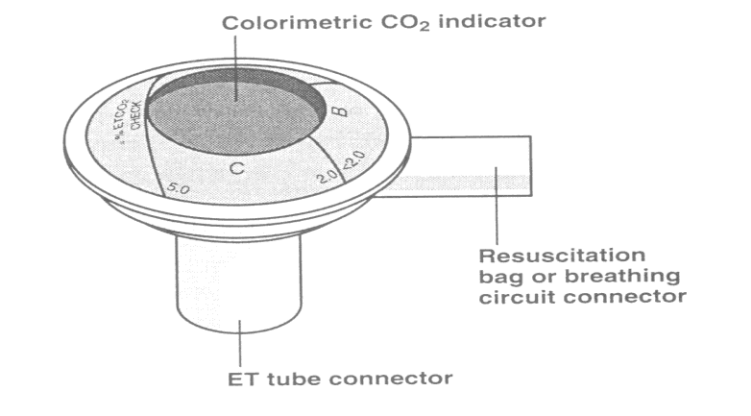
Side-stream capnographs



Physiology and terminology of capnography

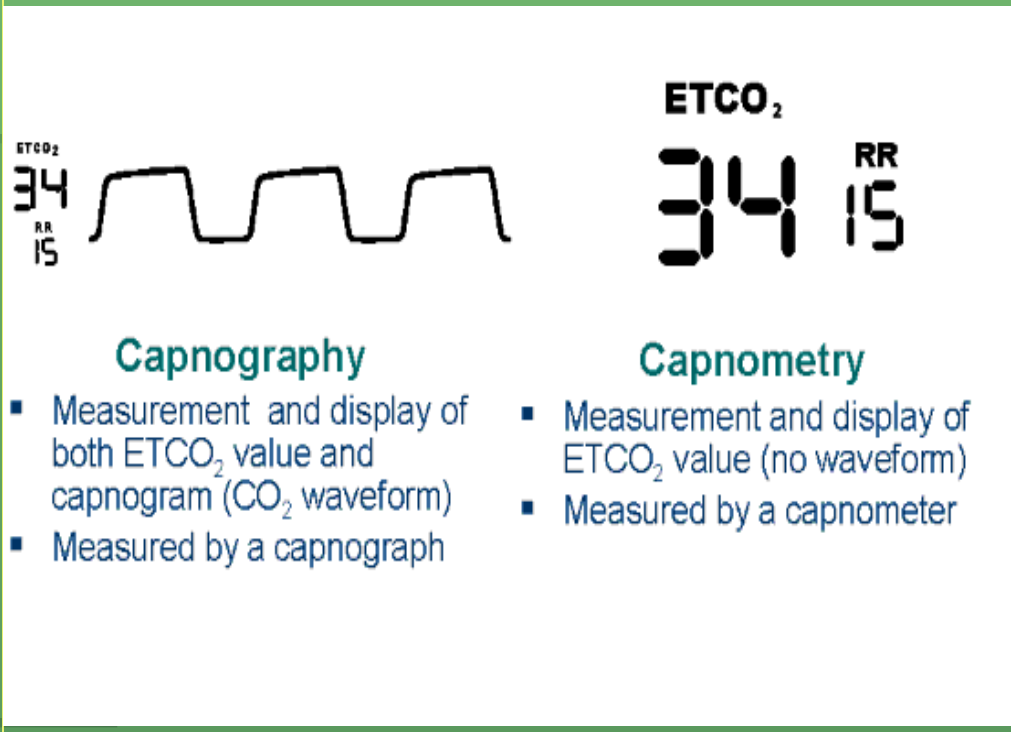
$EtCO_2$ - How is it Measured?

- Colormetric
- Capnometer
- Capnograph



what is Capnograhy?

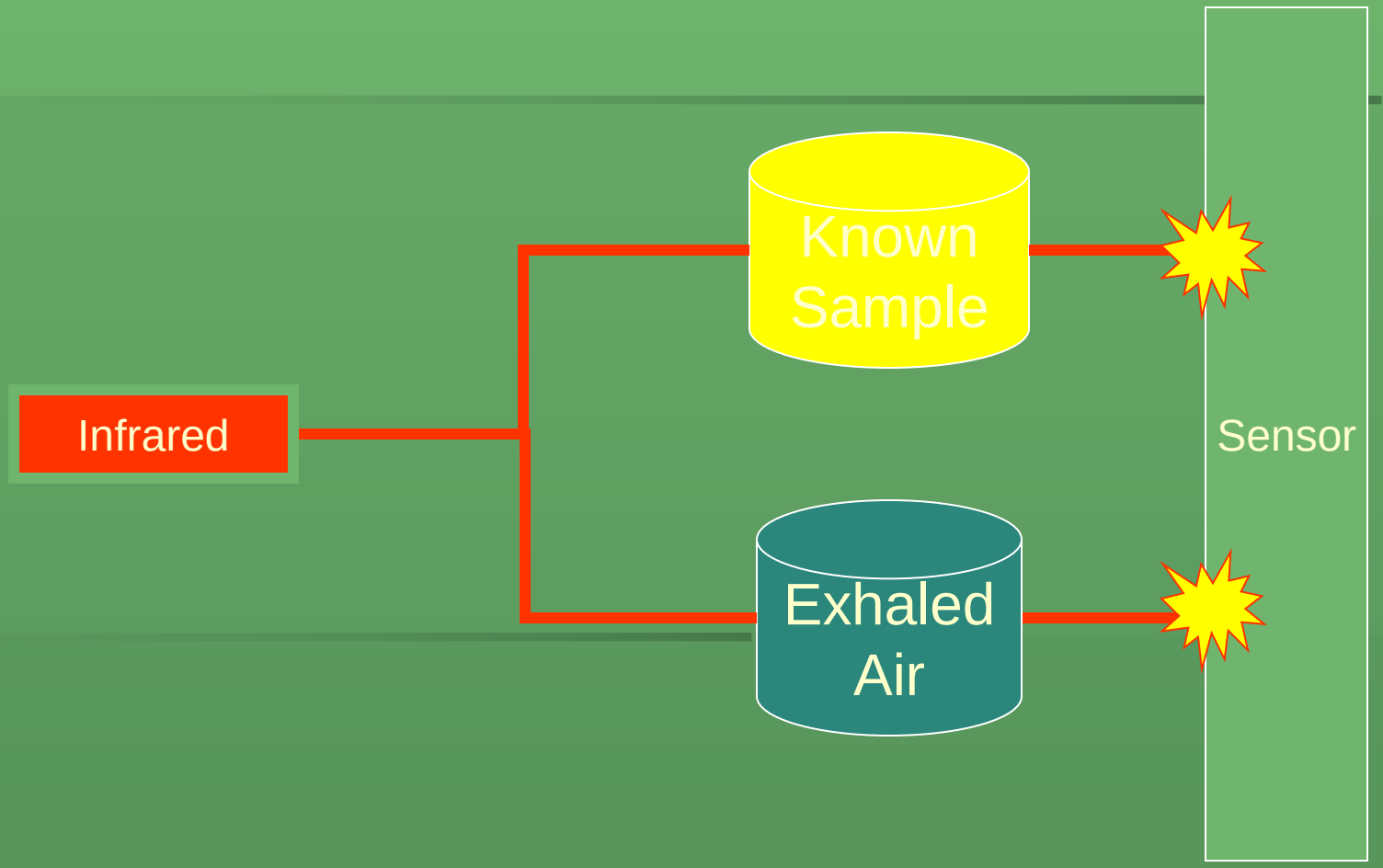
- ***Capnography-*** *Continuous analysis and recording of Carbon Dioxide concentrations in respiratory gases (I.E. waveforms and numbers)*
- ***Capnometry-*** *Analysis only of the gases no waveforms*



EtCO2 Values

Normal 35 – 45 mmHg
Hypoventilation > 45 mmHg
Hyperventilation < 35 mmHg

How Capnography Works



Techniques for Monitoring ETCO2

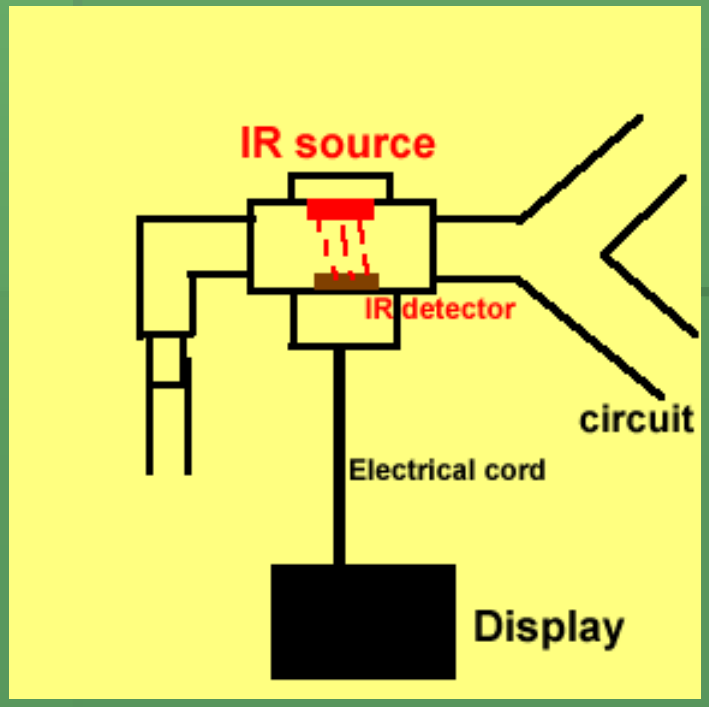
methods for obtaining gas sample of analysis:

- Mainstream Technology
- Sidestream Technology
- Microstream Technology

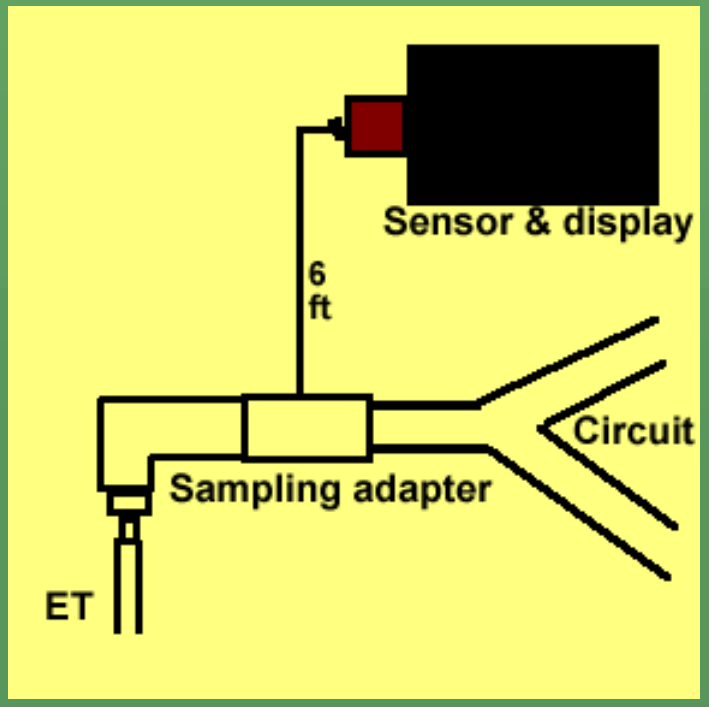
- Mainstream (Flow-through or In-line)
  - Adapter placed in the breathing circuit
  - No gas is removed from the airway
  - Adds bulk to the breathing system
  - Electronics are vulnerable to mechanical damage

capnographs

Main-stream capnographs



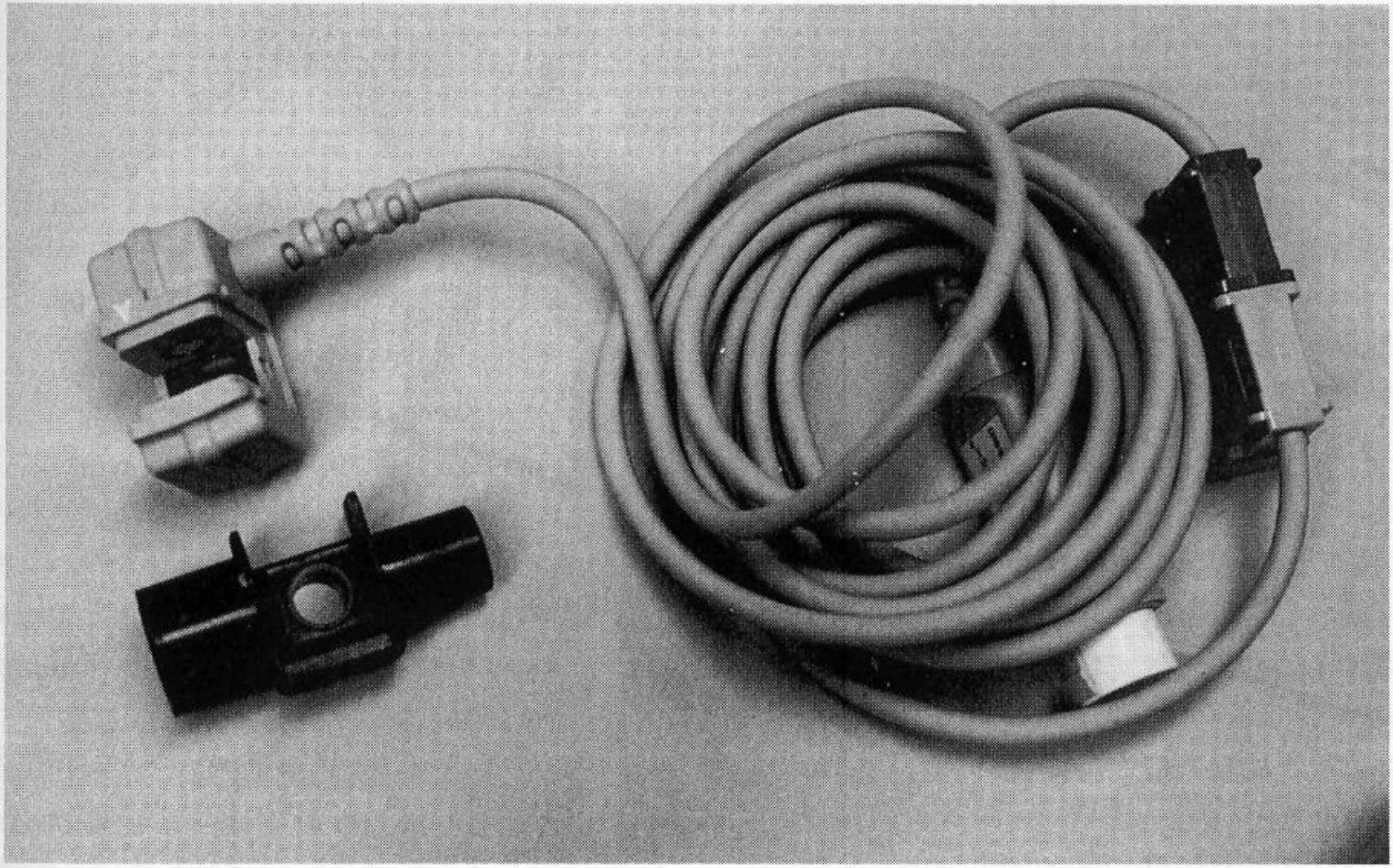
Side-stream capnographs



Mainstream

- For use on intubated patients
- Sensor on ETT; no lag time
- Sensor adds weight
- Sensors must be heated
- Sensors may cloud over or become fouled with secretions reducing accurate measurements

Mainstream Analyzer

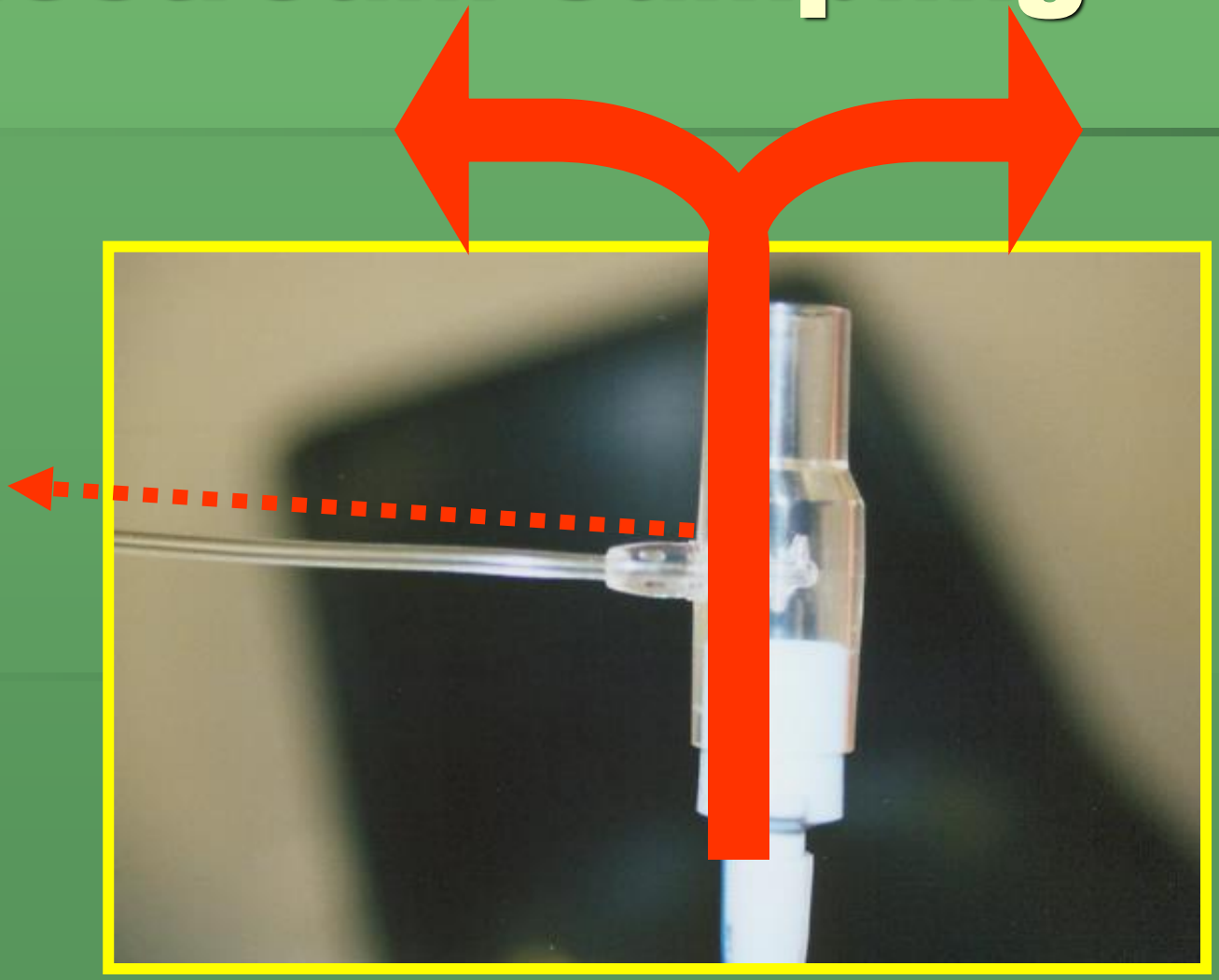


Mainstream Analyzer

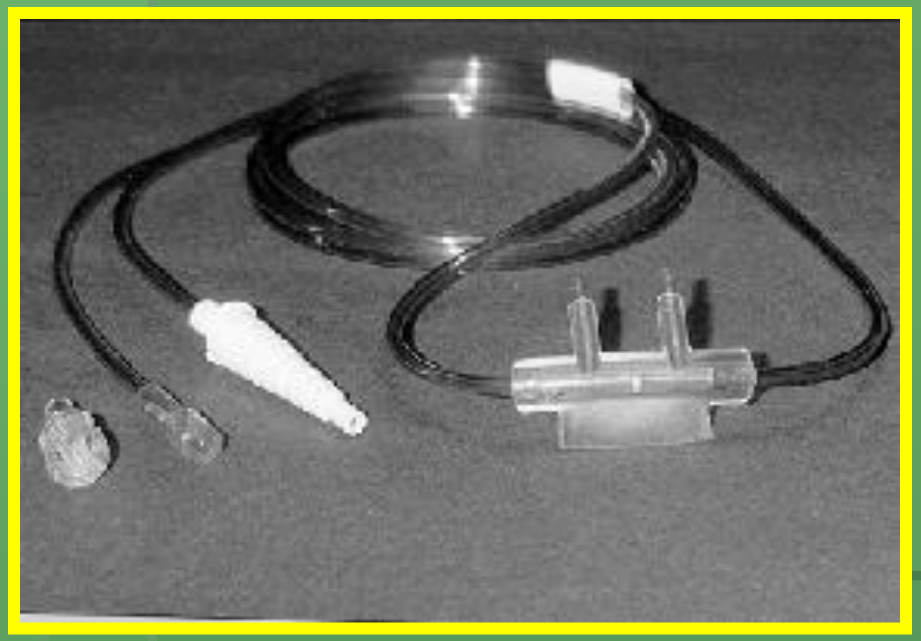
Sidestream

- Sensor in device at bedside; not the ETT
- Can be used on non-intubated patients
- Draws CO_2 from exhaled breath
- Utilizes 150 to 180 ml sampling rate
- Orientation of adapter & monitor critical to performance
- Not suitable for neonates due to high sampling flow rates

Sidestream Sampling

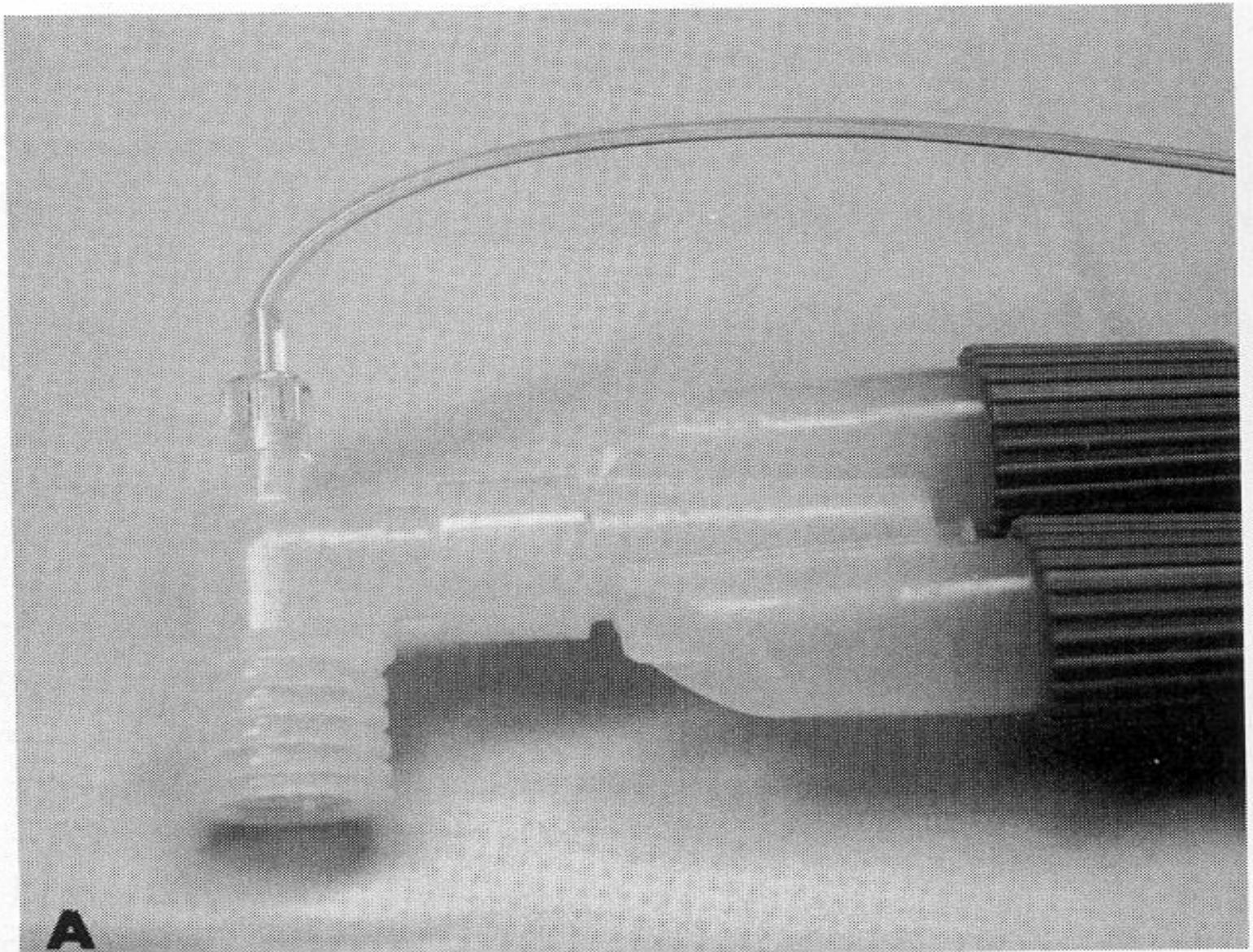


Sidestream Sampling



- A special type of sampling nasal cannula is available for use in spontaneously breathing patients

Sidestream Analyzer



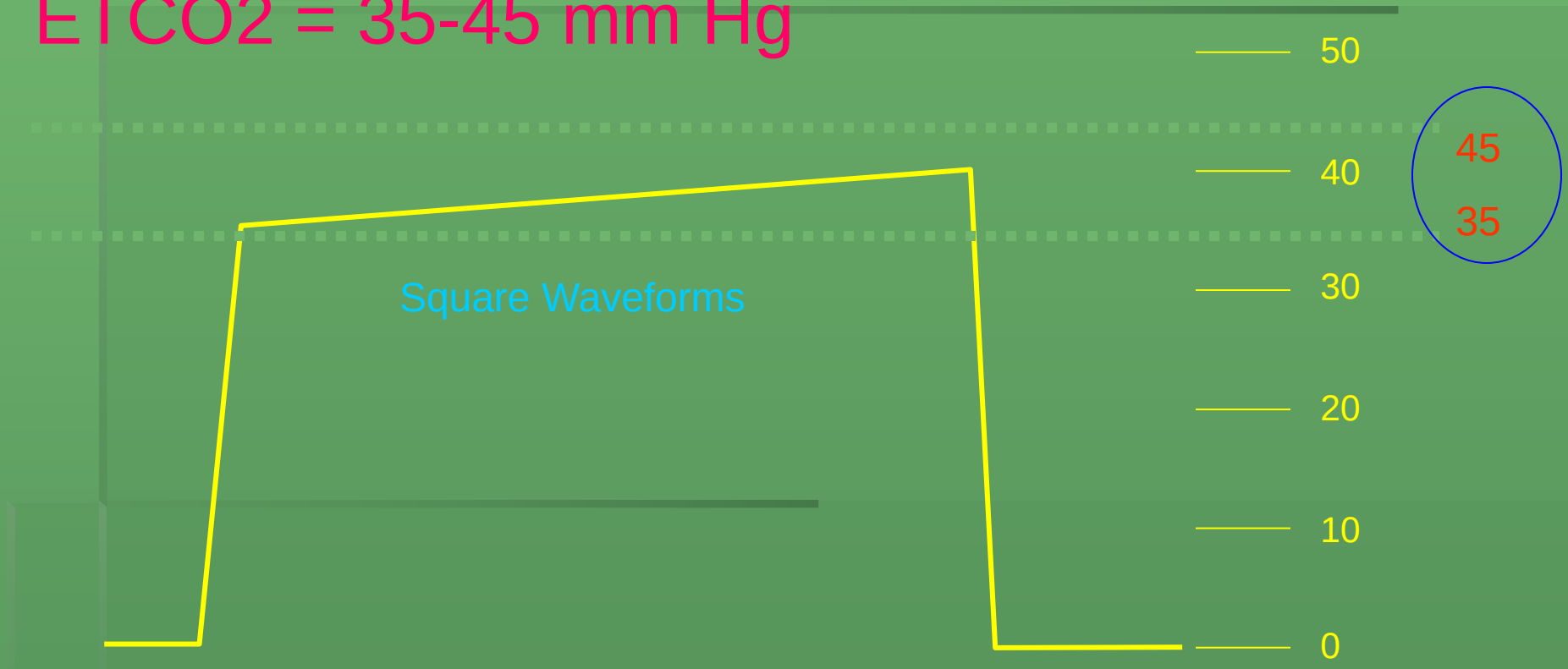
Microstream

- Latest release for capnography technology
- **C**ircuits sample $ETCO_2$ via an airway adapter or nasal cannula
- Requires lower sampling flowrates (50ml/min)
- Collects sample from middle of air stream
- Good for intubated/nonintubated patients
- Good for adults, paediatrics and neonates
- Fast response time
- Position independent adapters

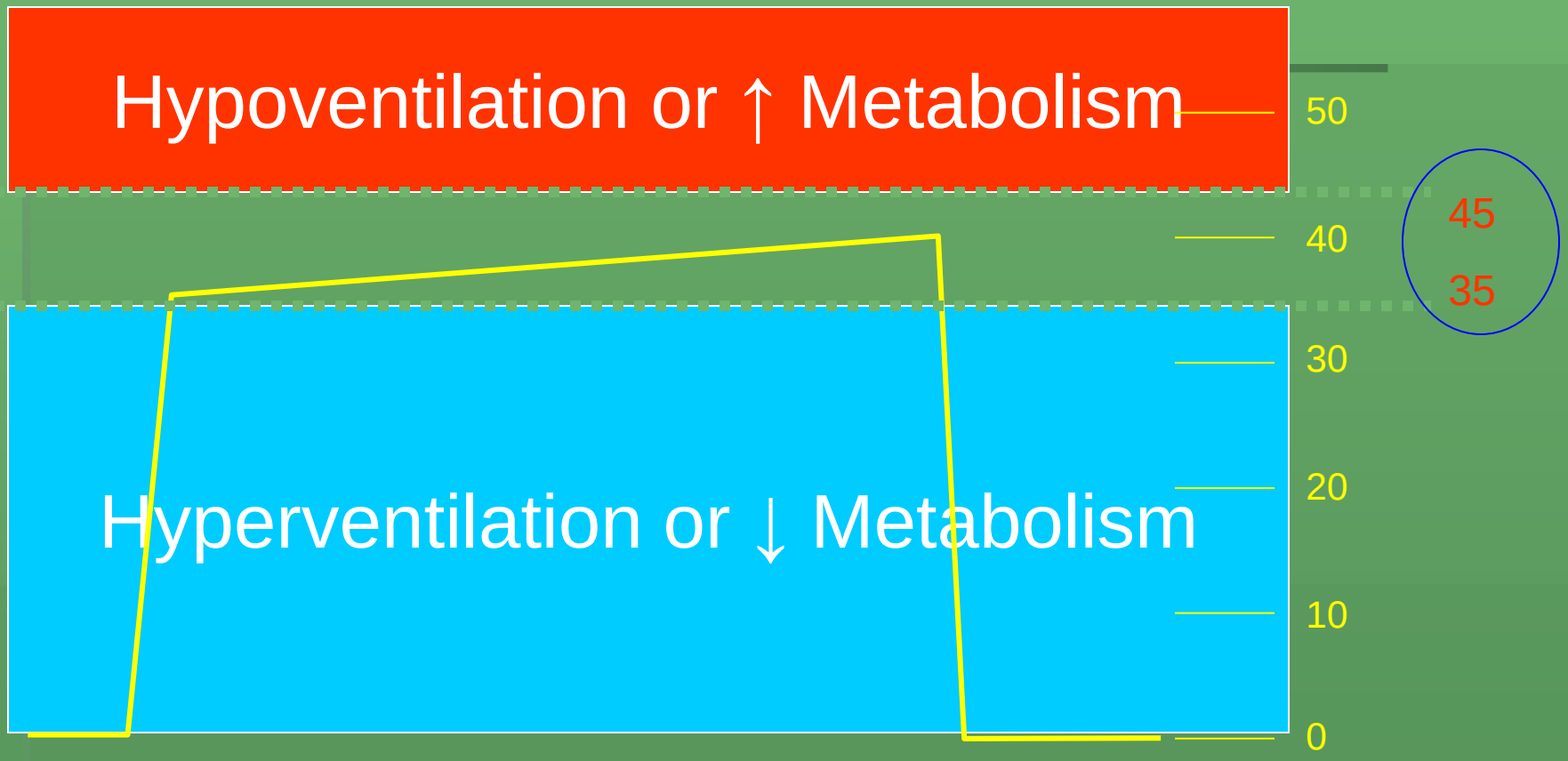
Normal and Abnormal Capnography Values

Capnography Values

ETCO2 = 35-45 mm Hg



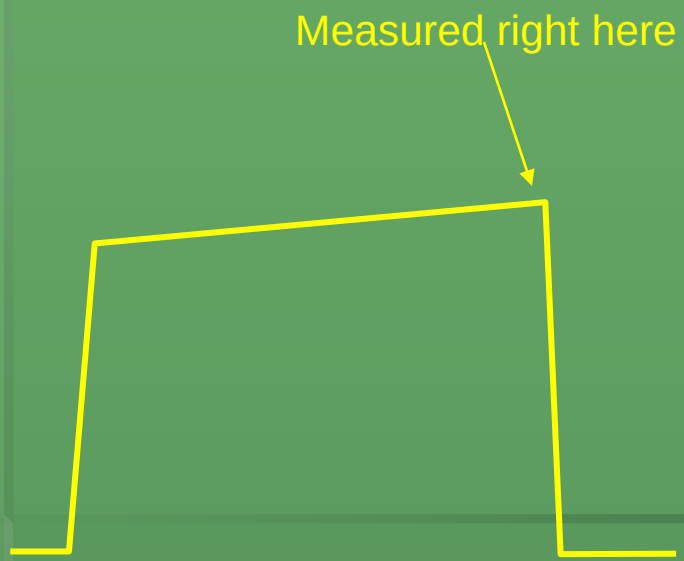
Capnography Values



Capnography Waveform

The entire cycle!

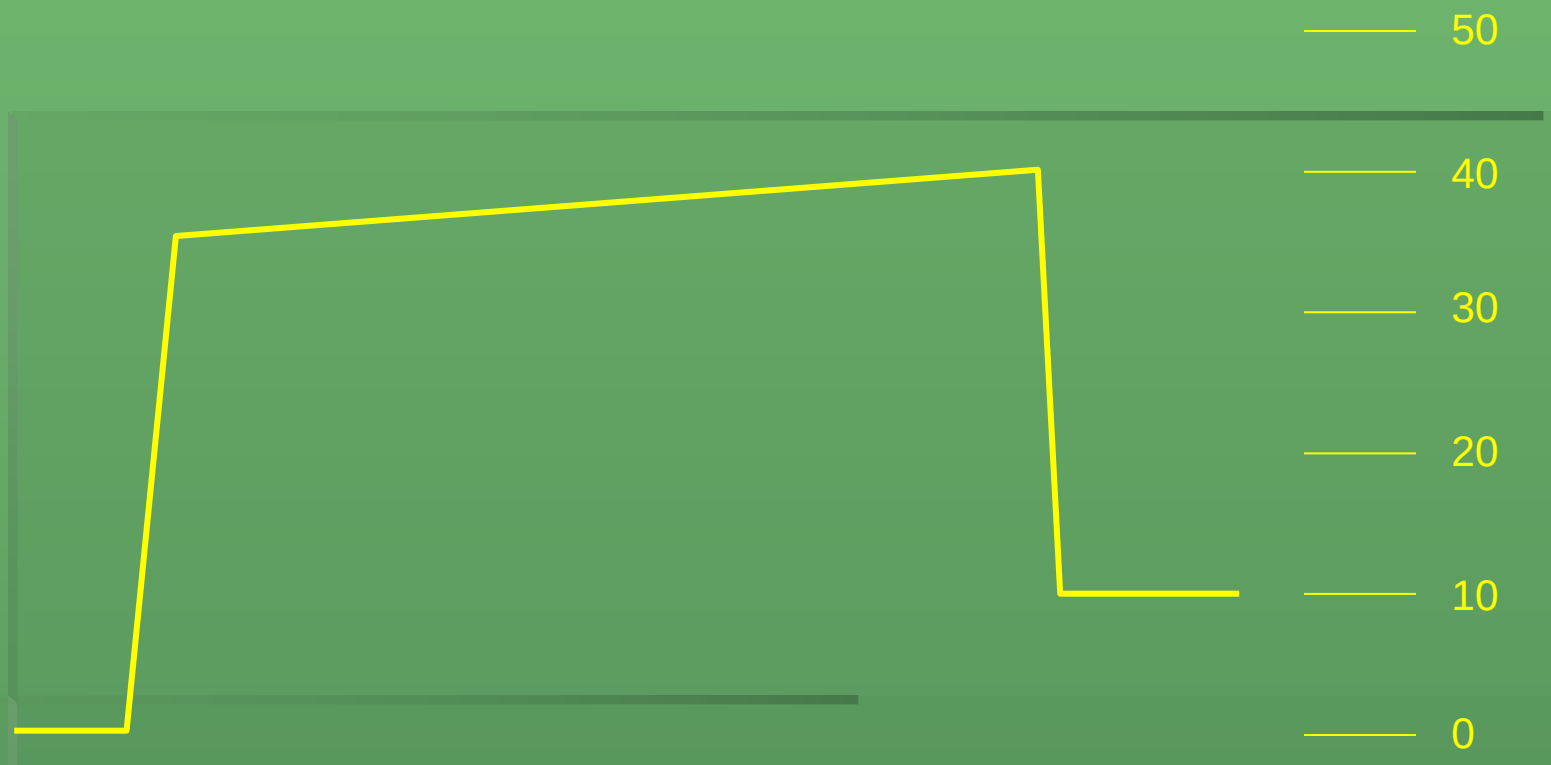
Capnometer is “End Tidal CO2”



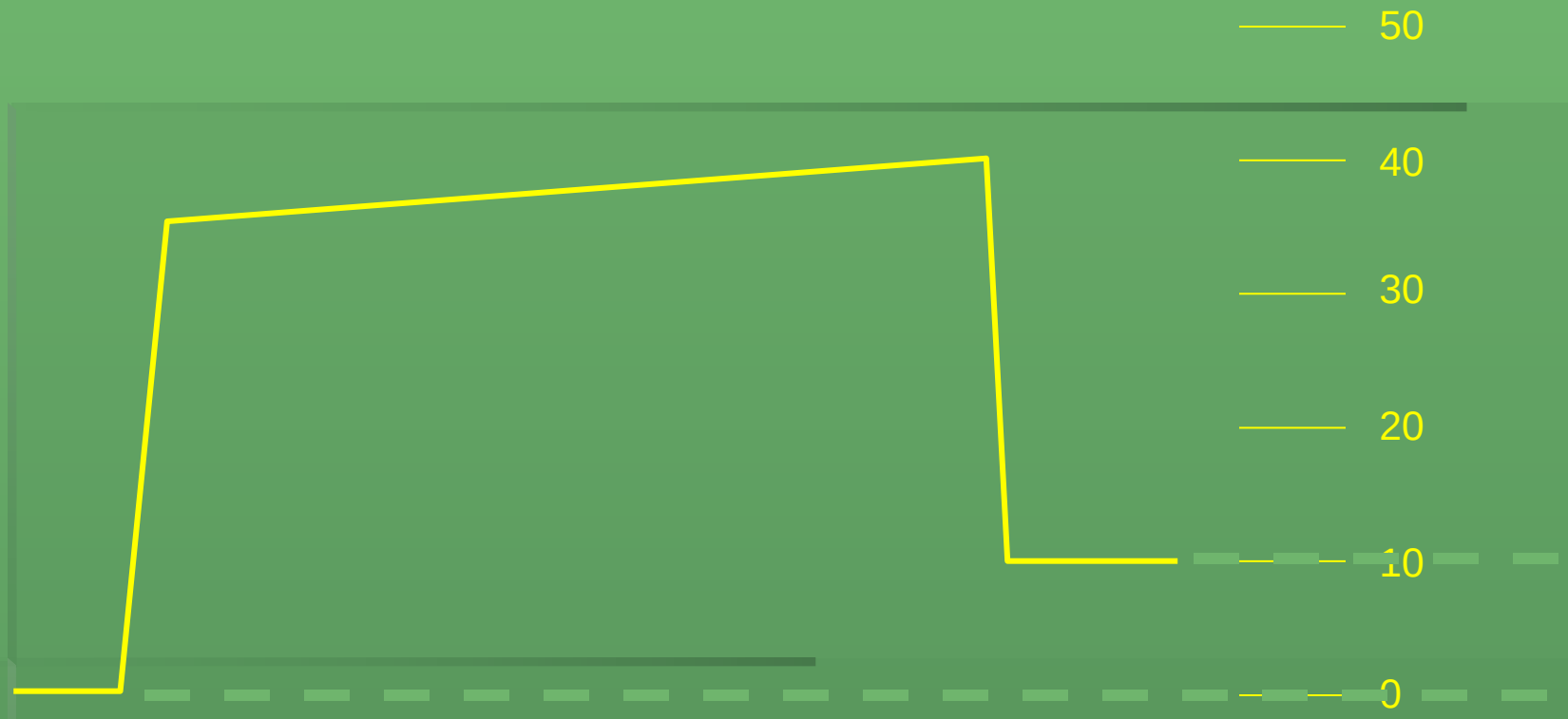
Abnormal Capnogram Patterns

If the waveform is abnormal, there **IS** an airway problem

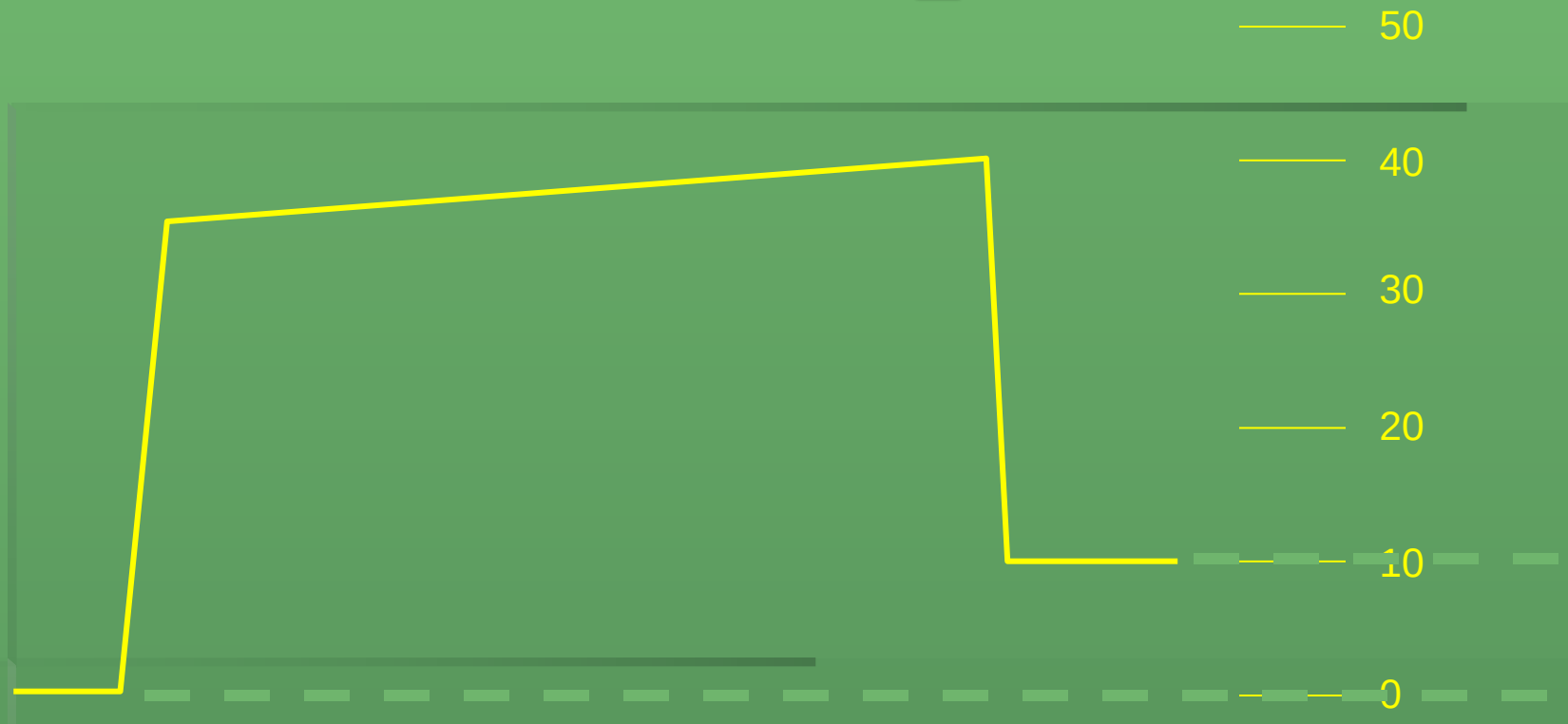
What is Wrong Here?



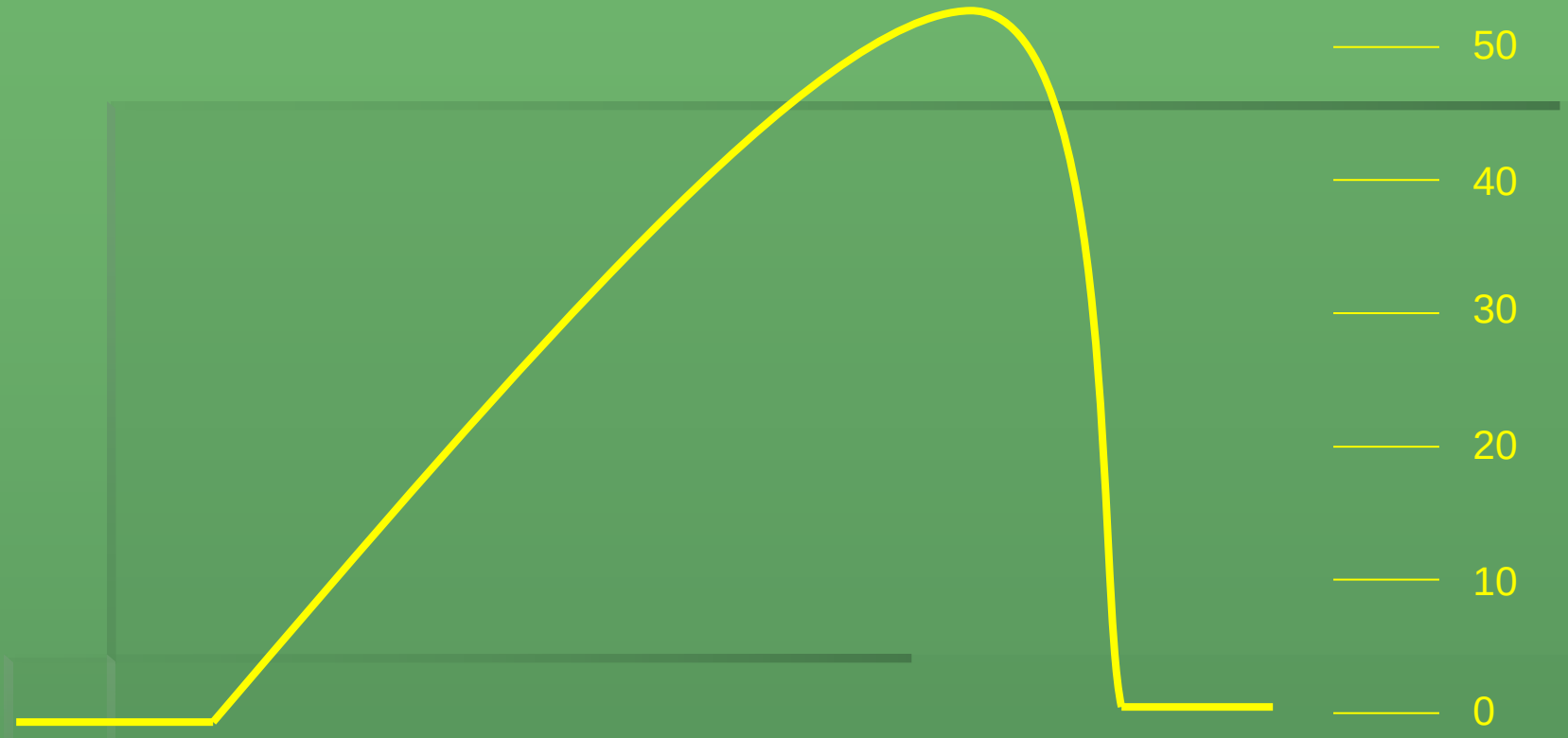
Rising Baseline



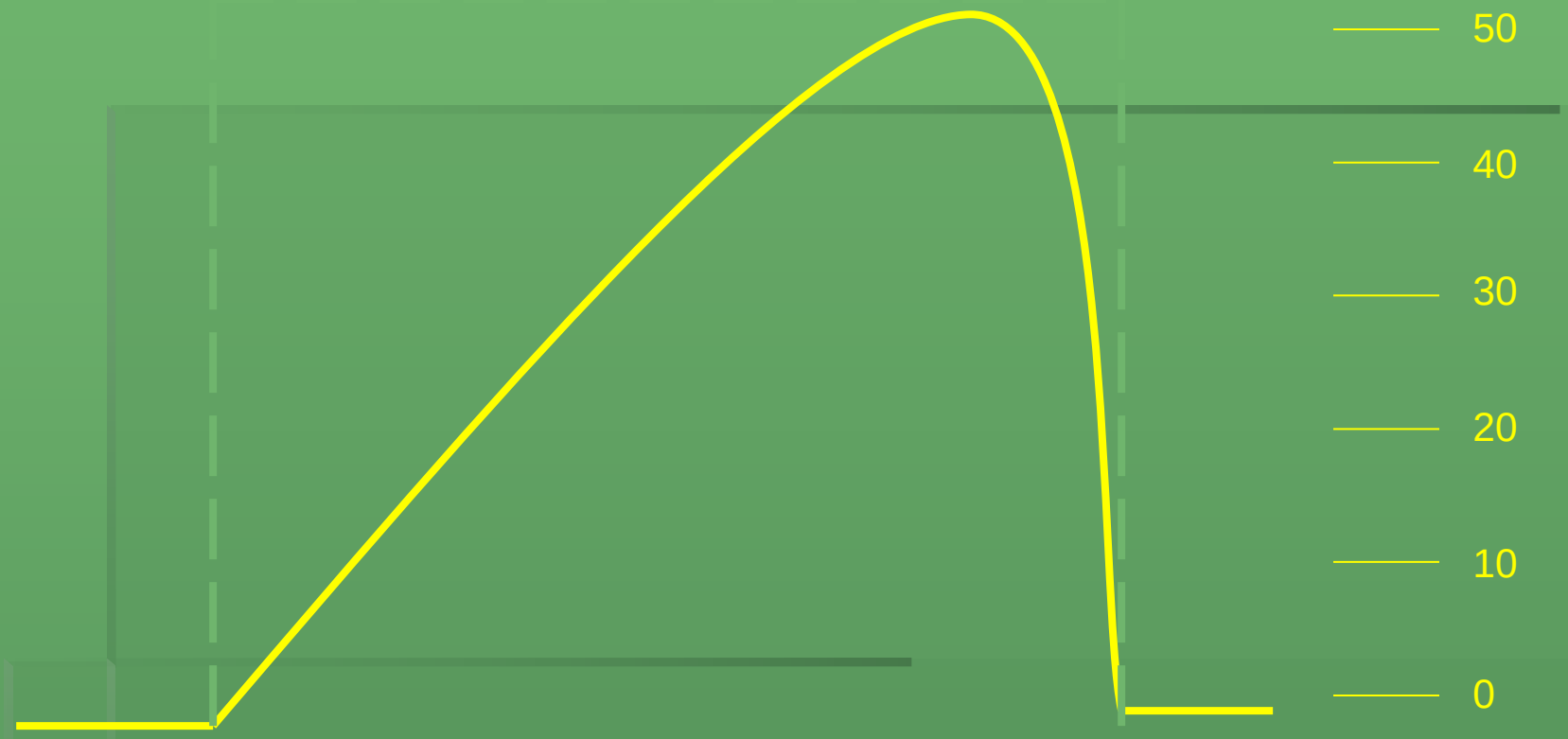
Rebreathing CO_2



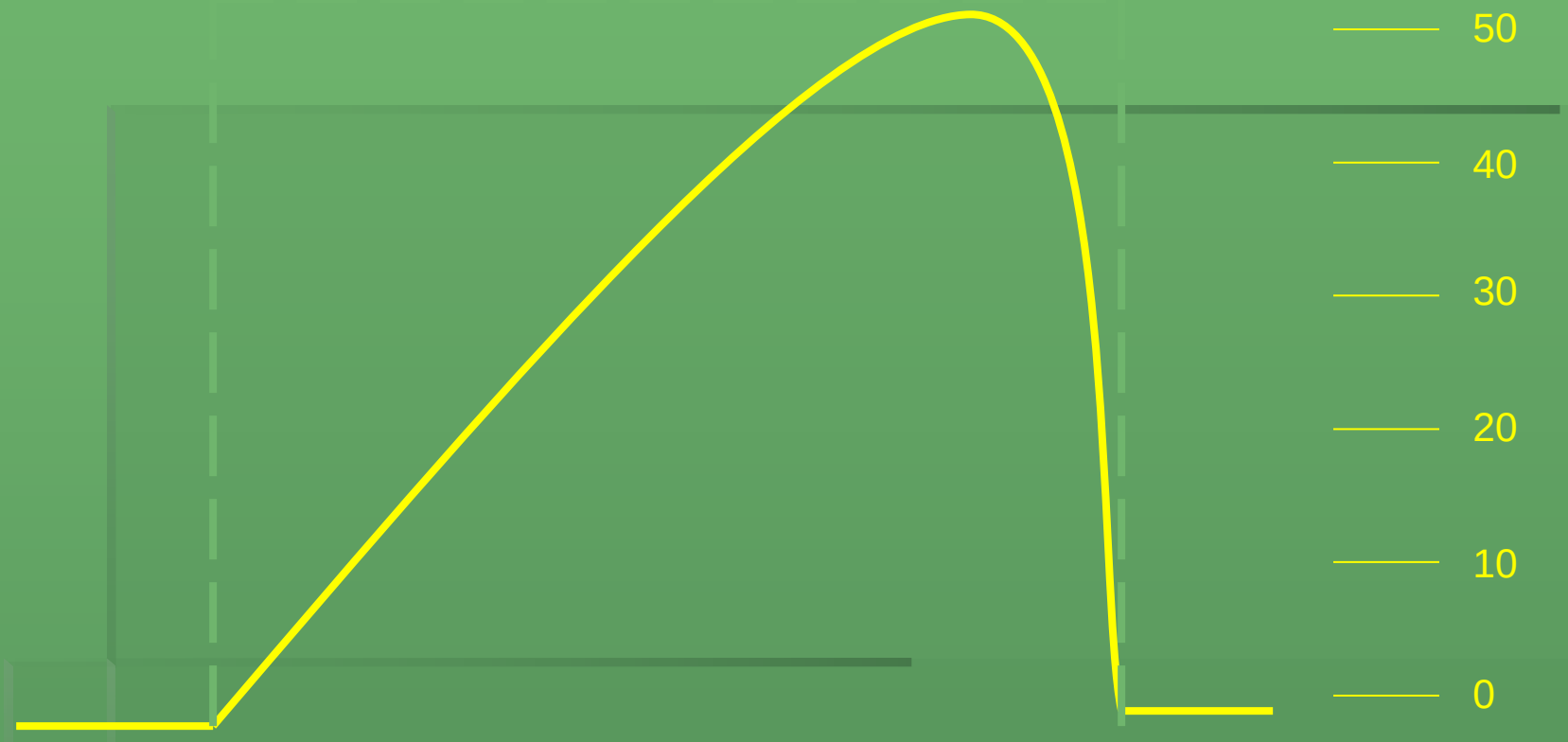
What is Wrong Here?



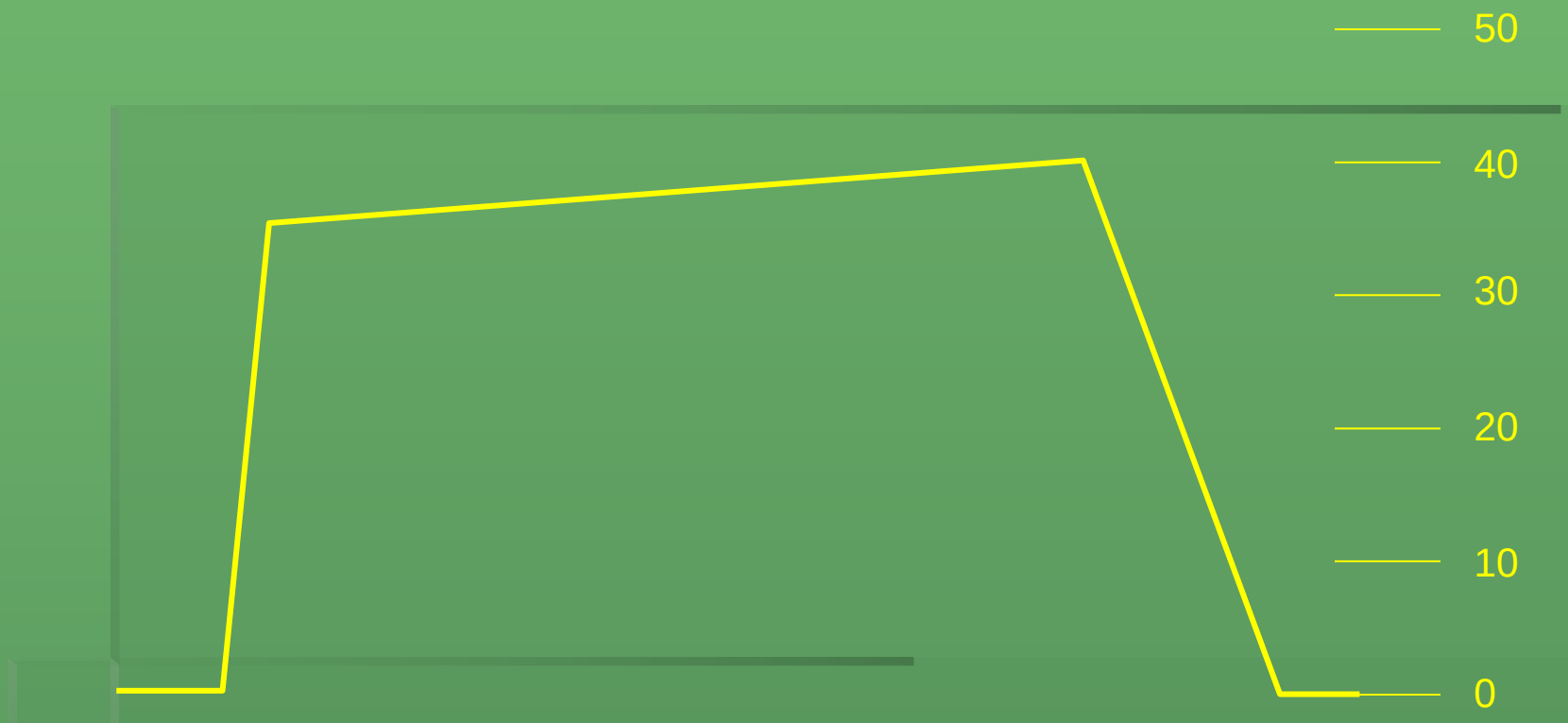
Delayed Upstroke



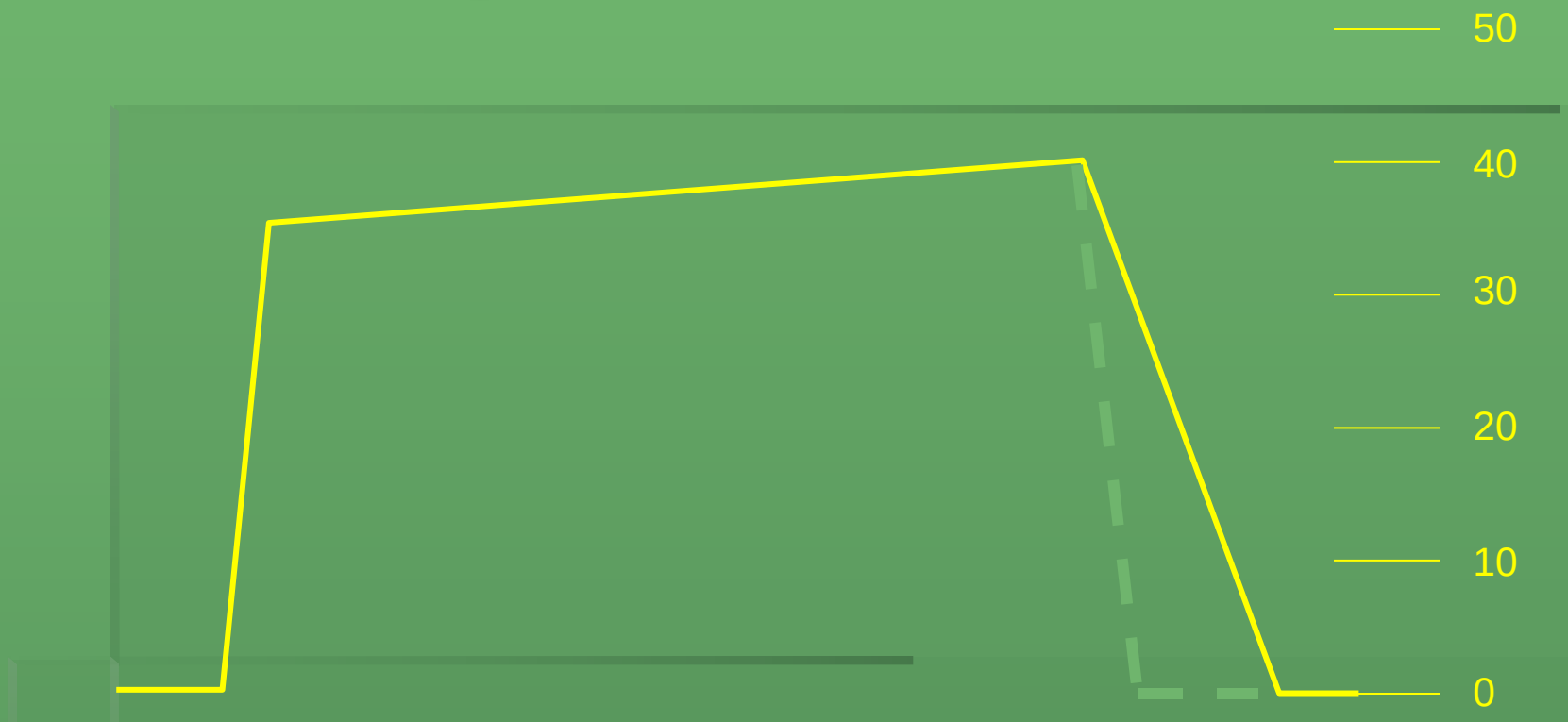
Bronchoconstriction



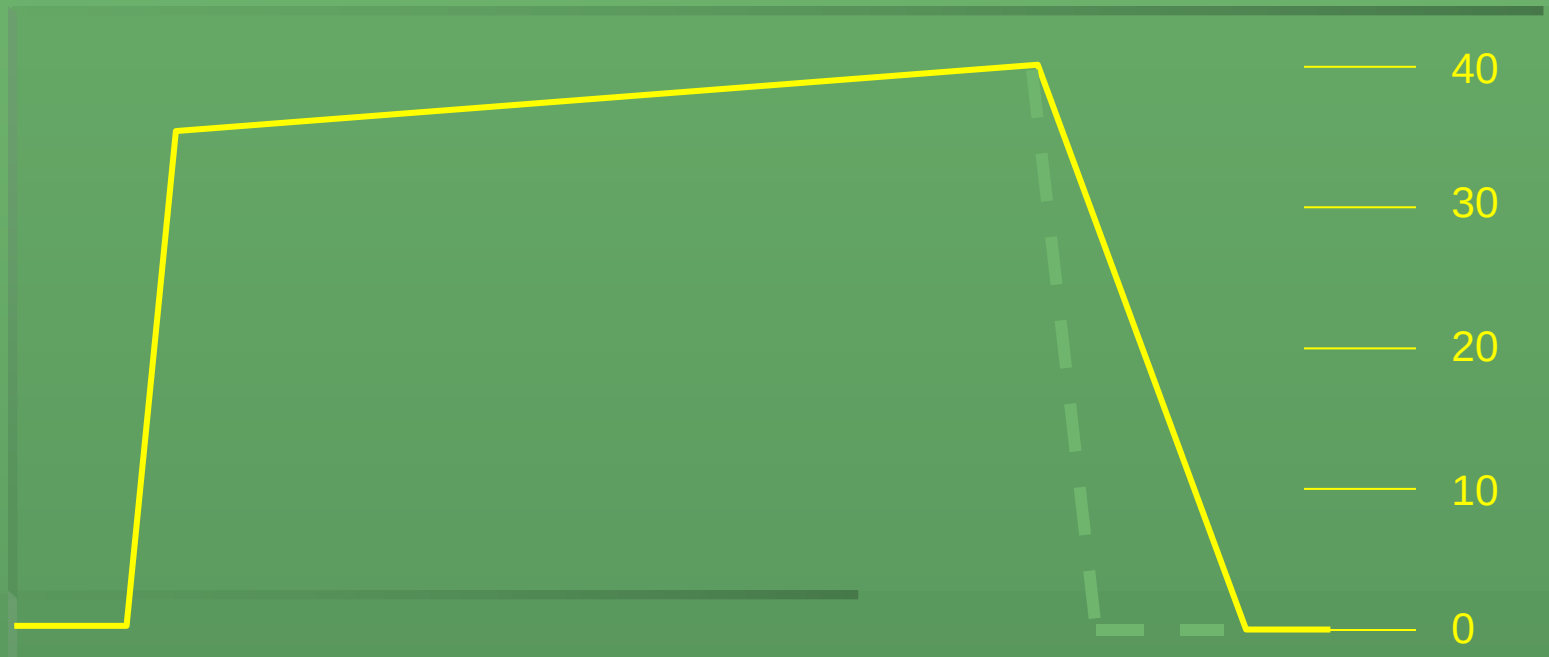
What is Wrong Here?



Prolonged Phase IV



Deflated ETT Cuff or (in peds) ETT too Small

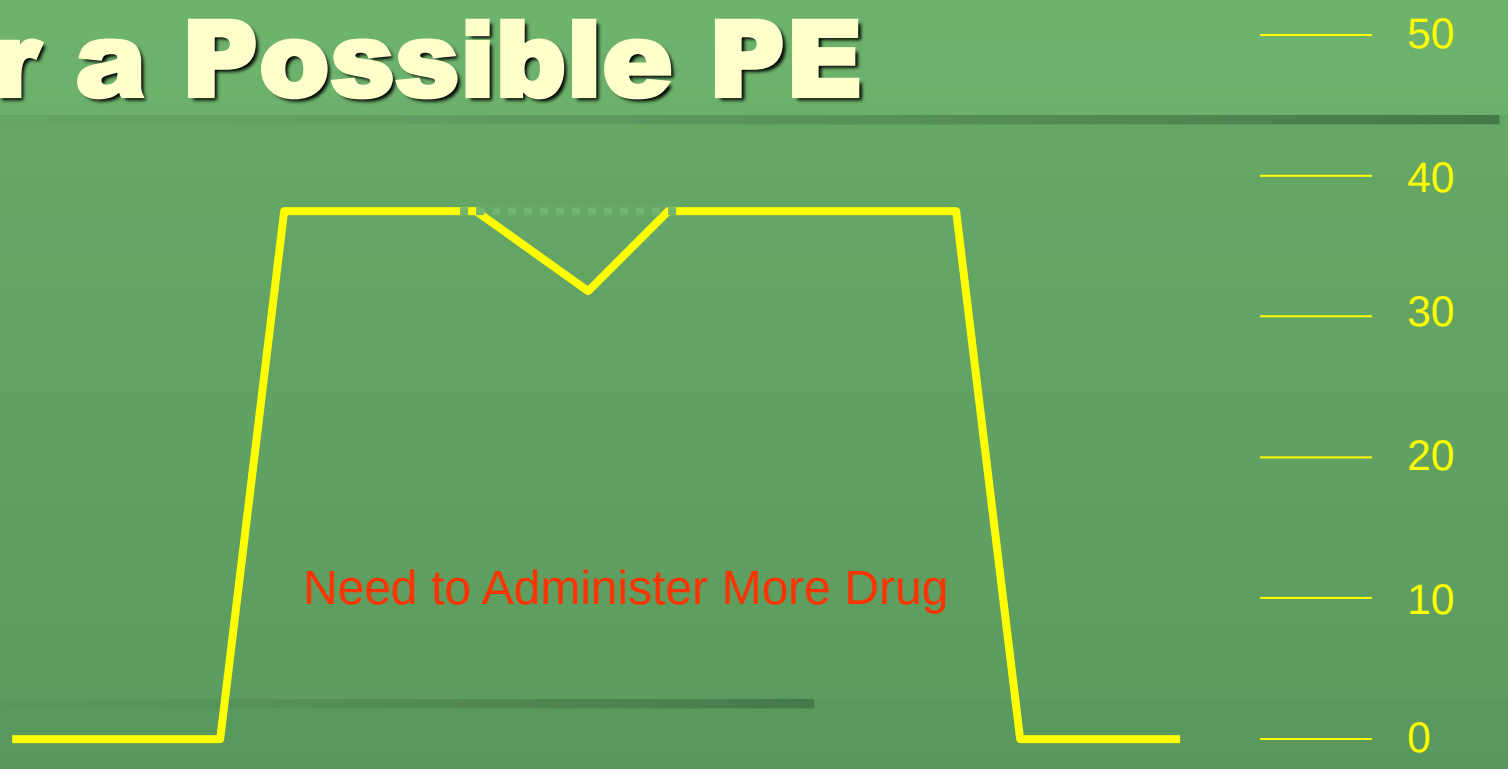


What is Wrong Here?

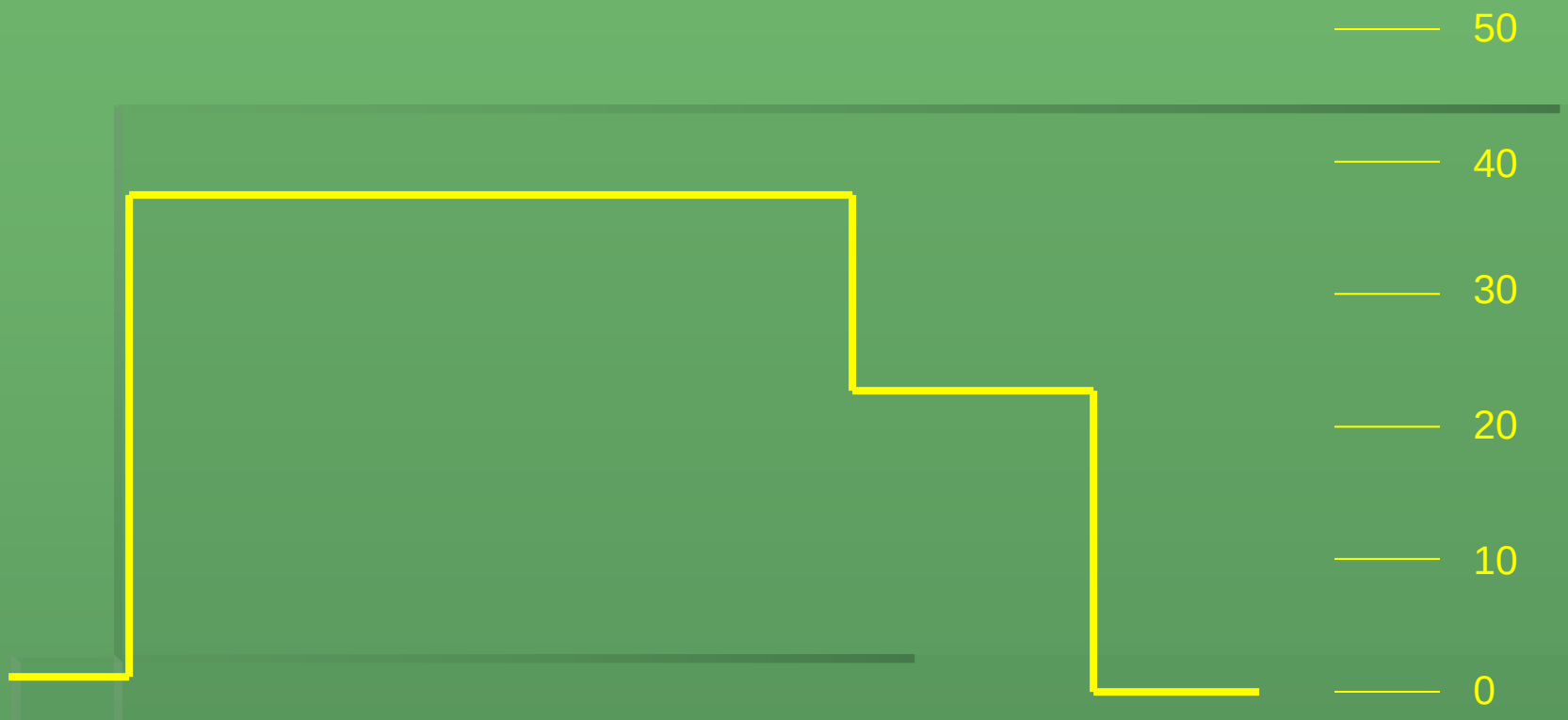
Notched Alveolar Plateau

"Curare Cleft"

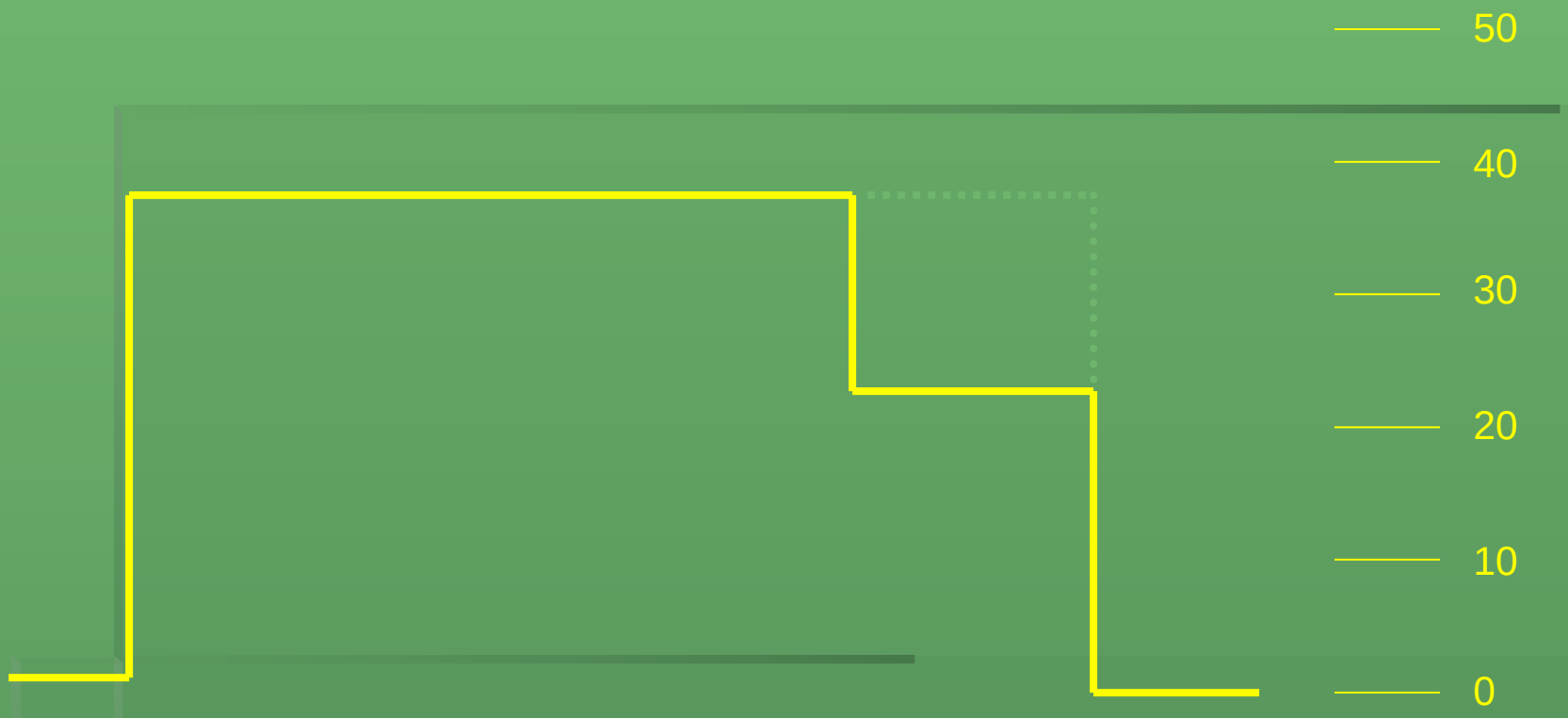
Paralytic Medication Wearing Off
Or a Possible PE



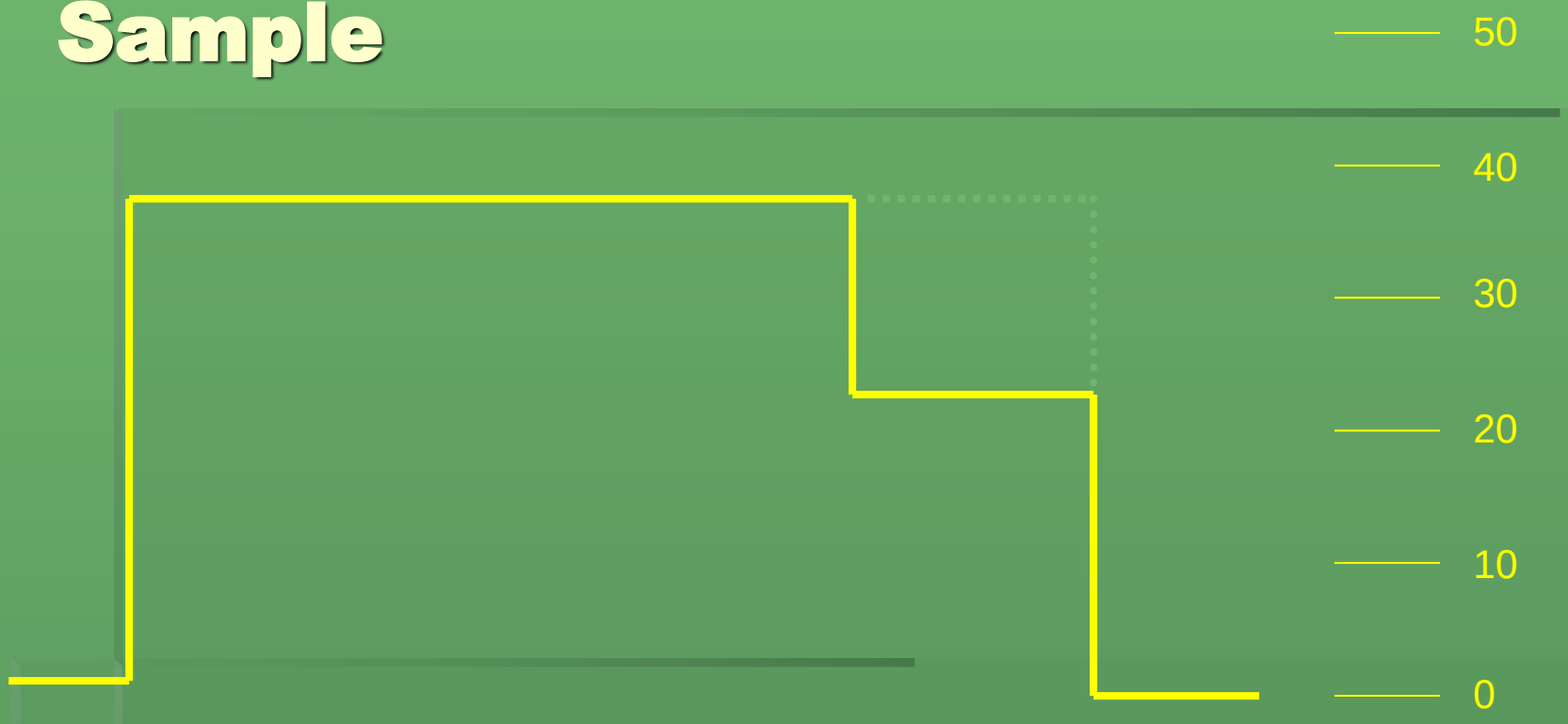
What is wrong here?



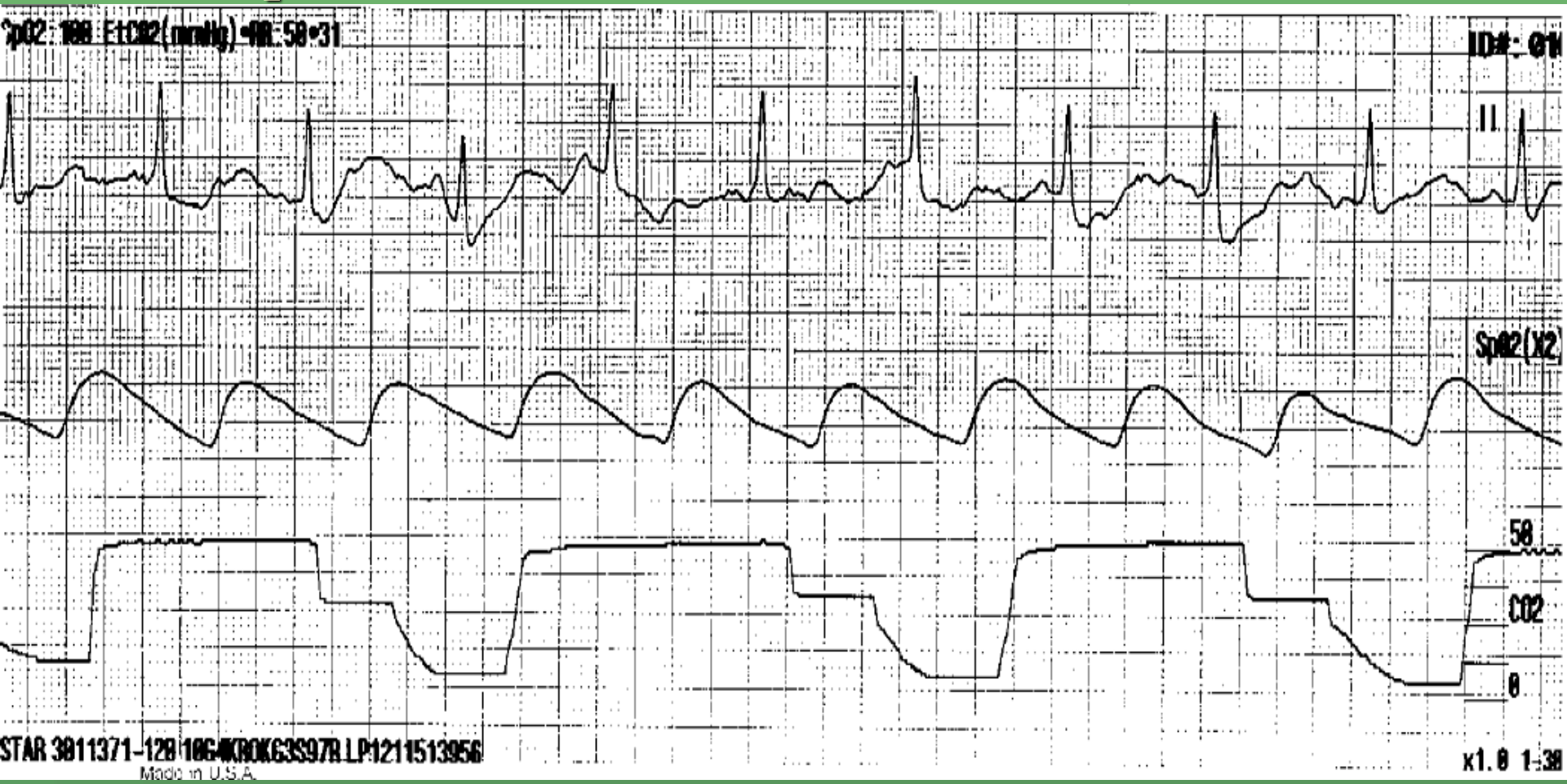
Stair Step Alveolar Plateau



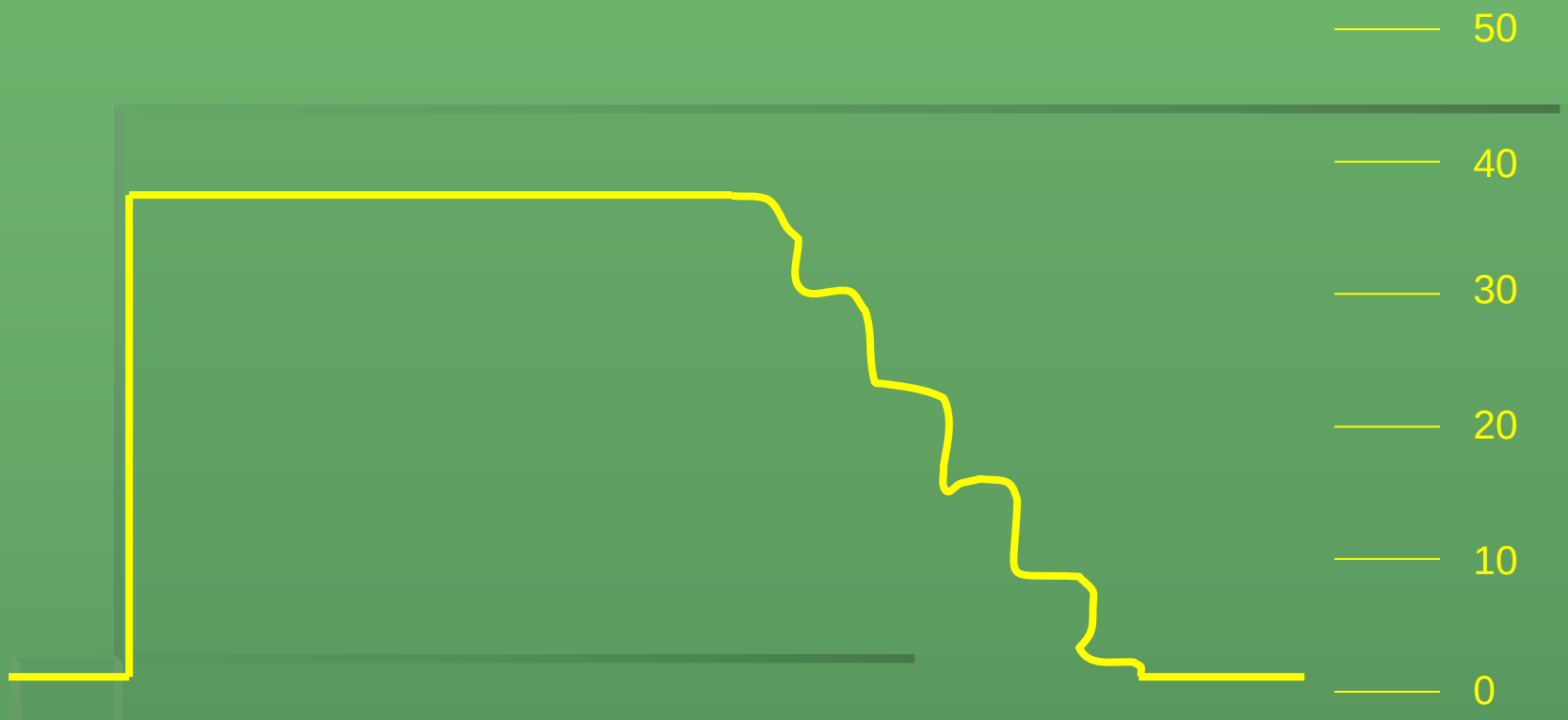
Pressure of Expelled Air Decreasing Allowing Oxygen to Dilute the Sample



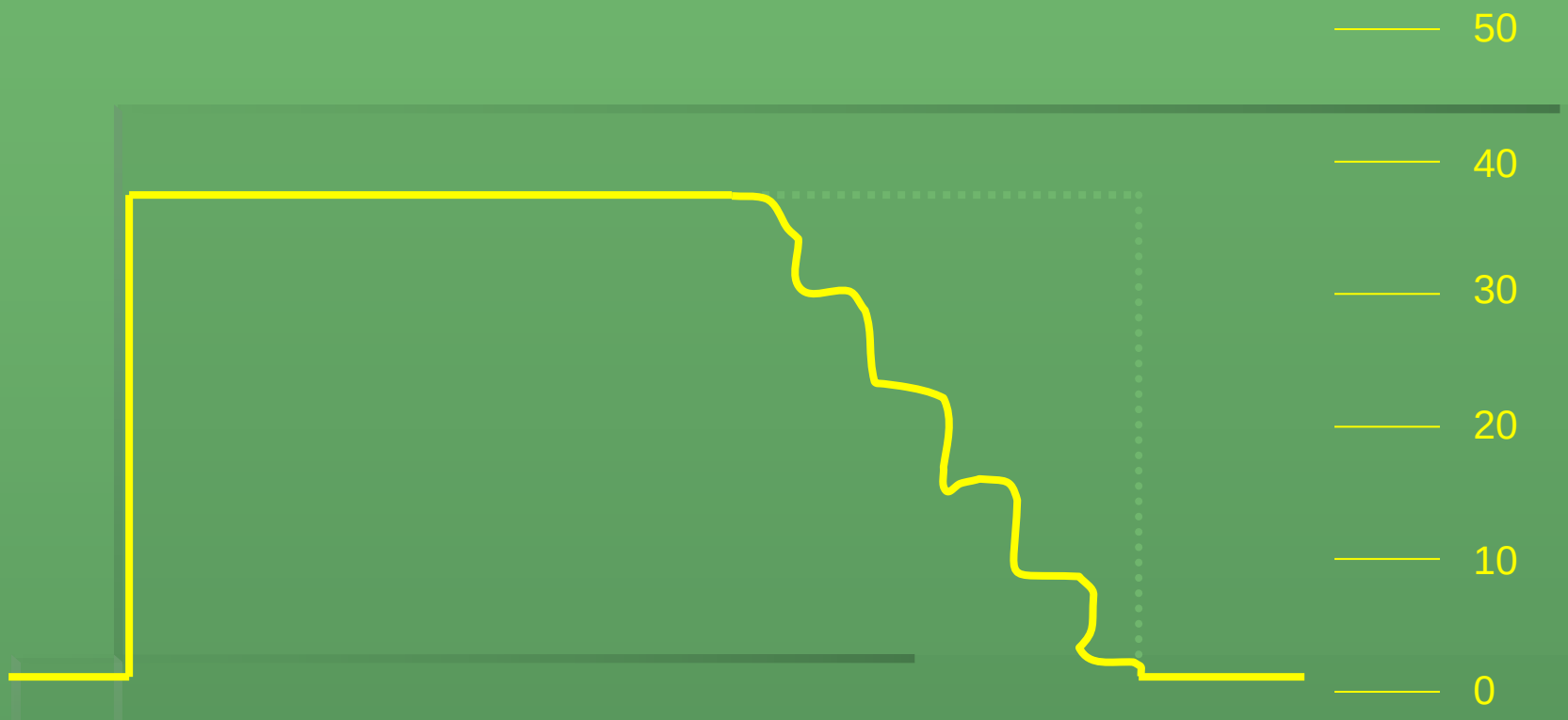
Pressure of Expelled Air Decreasing Allowing Oxygen to Dilute the Sample



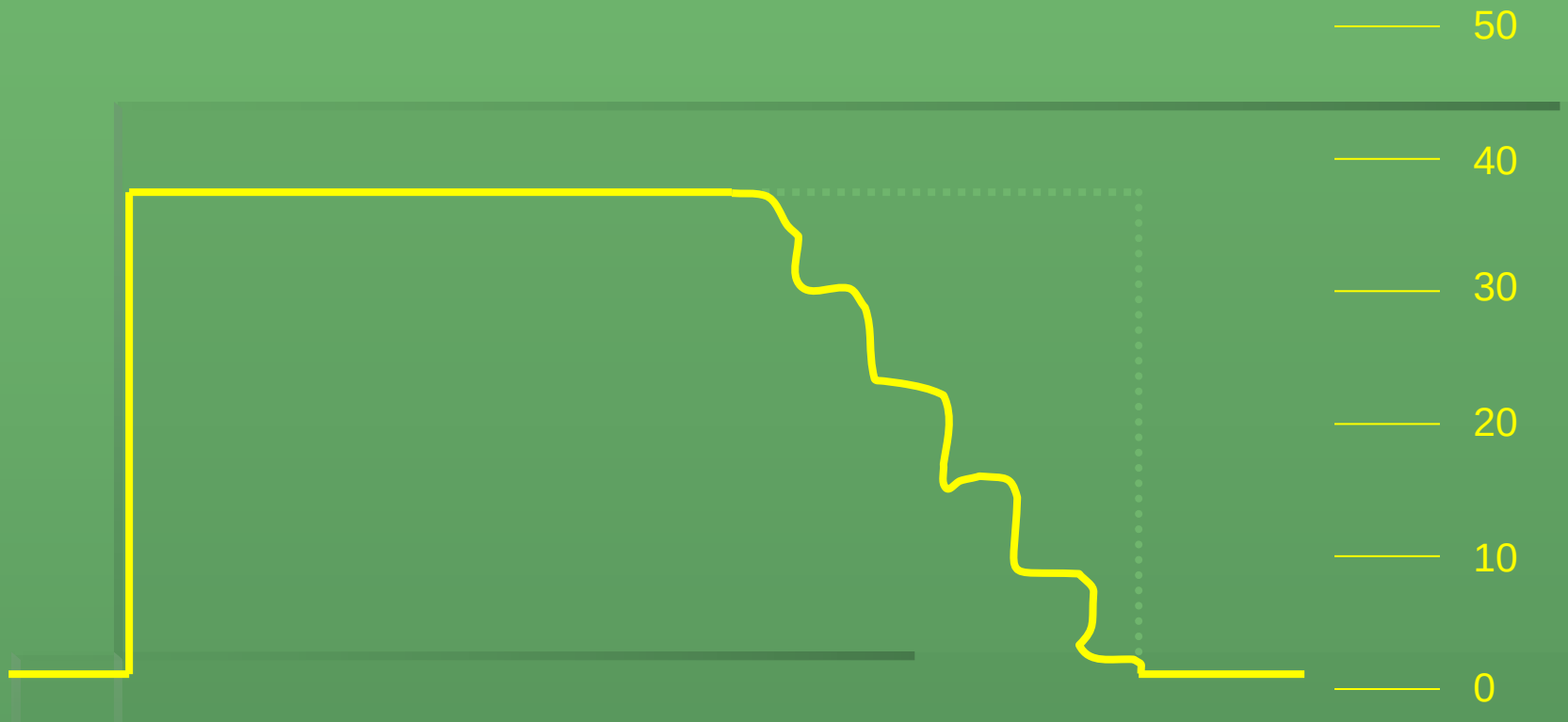
What is wrong here?



Ripple Effect

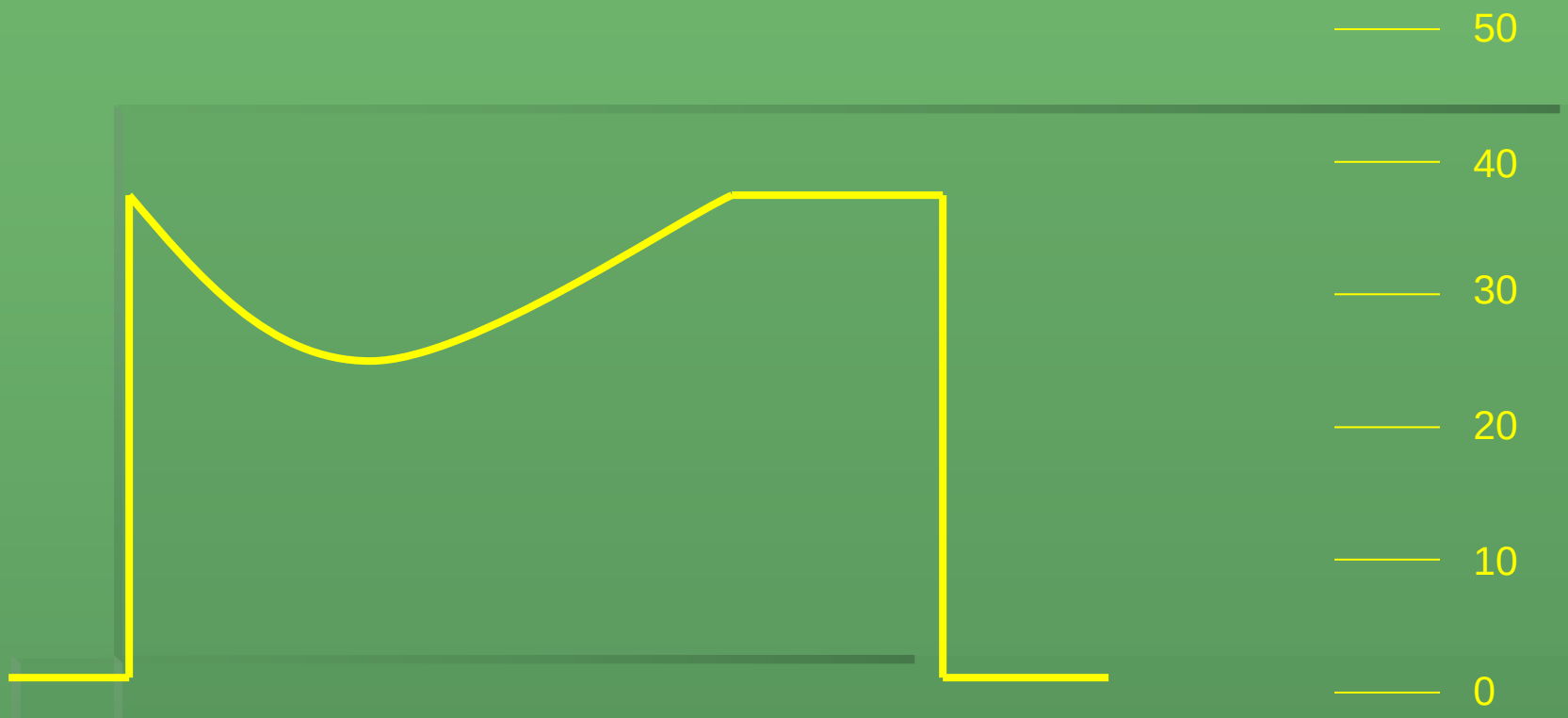


Cardiogenic Oscillations

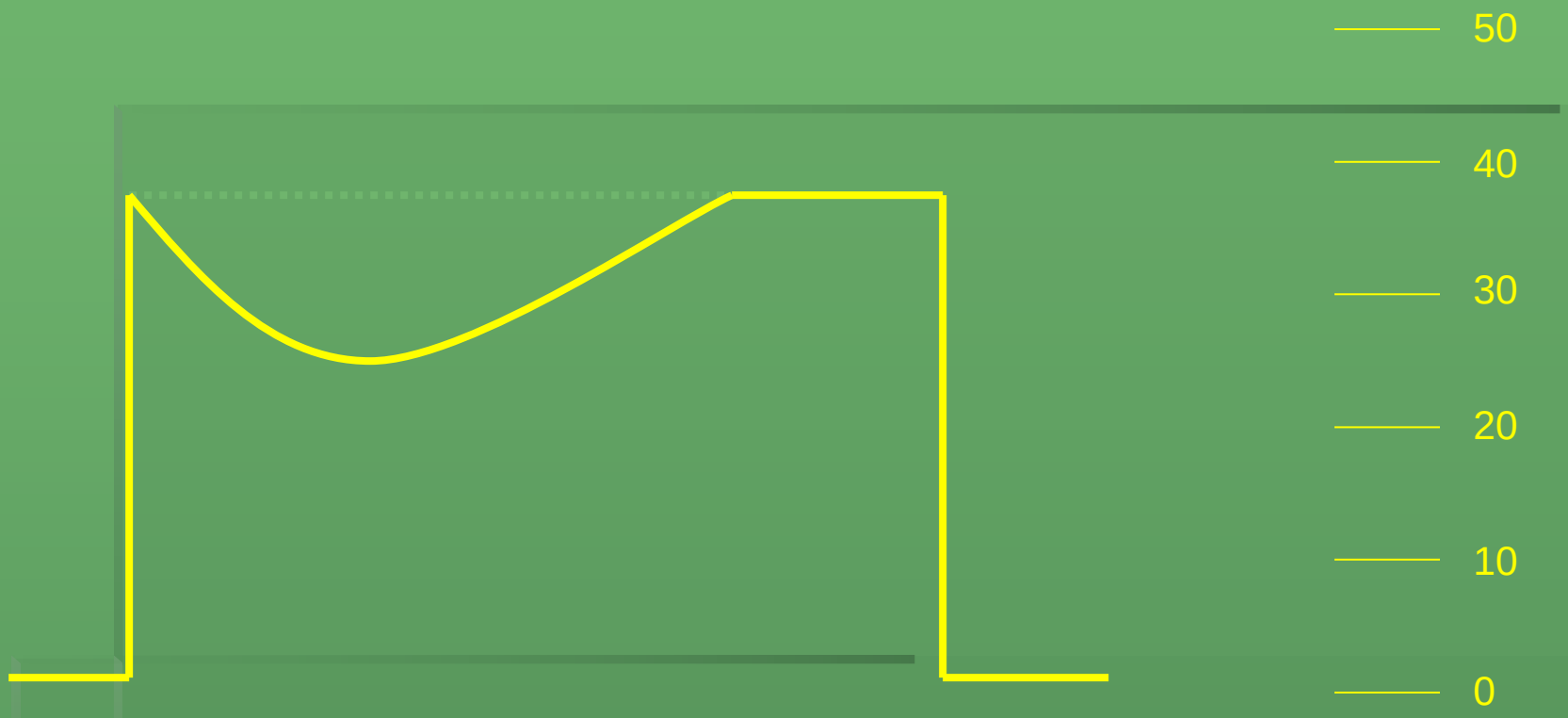


Due from cardiac pulsations

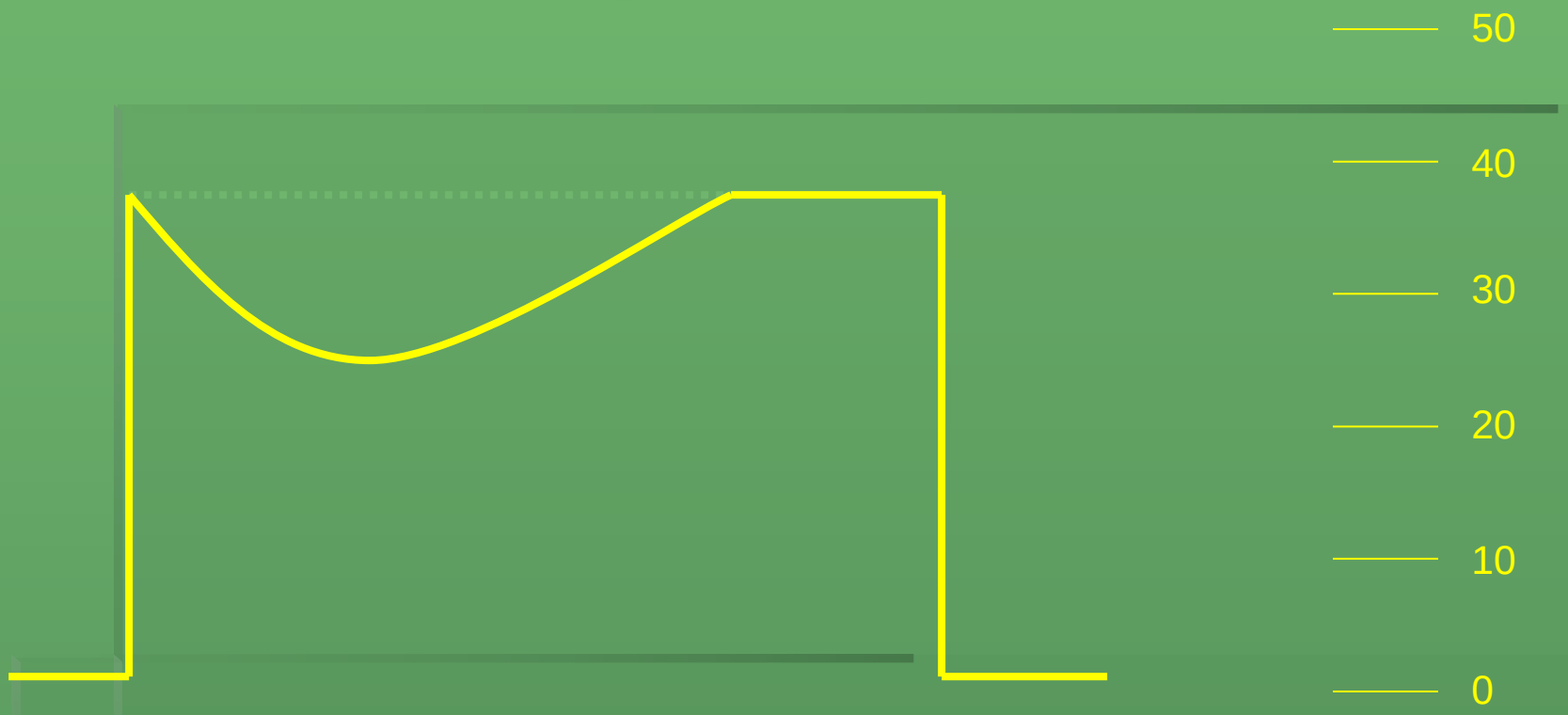
What is wrong here?



Biphasic Alveolar Plateau



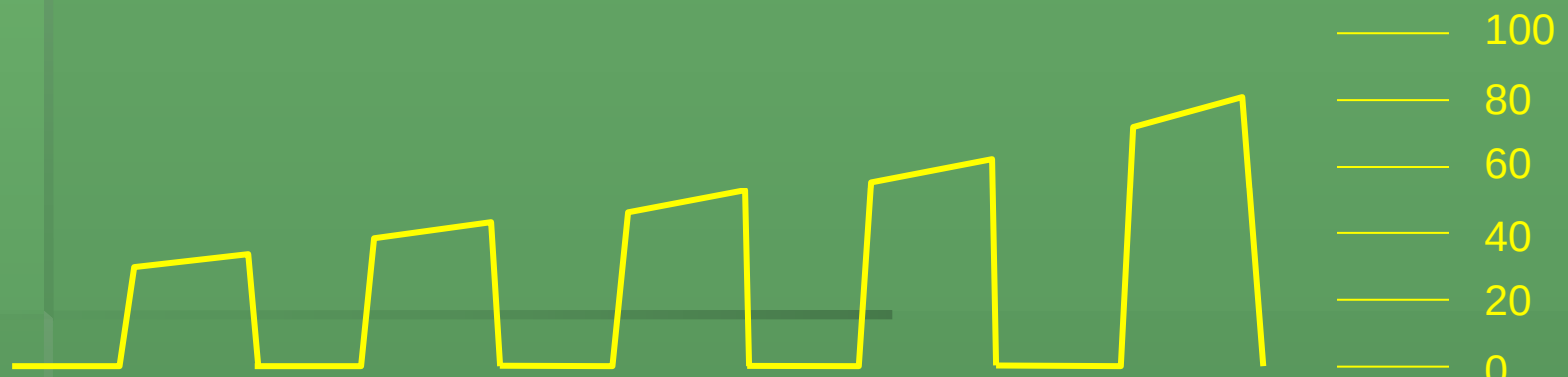
Severe Kyphoscoliosis



Due from a compressed lung.

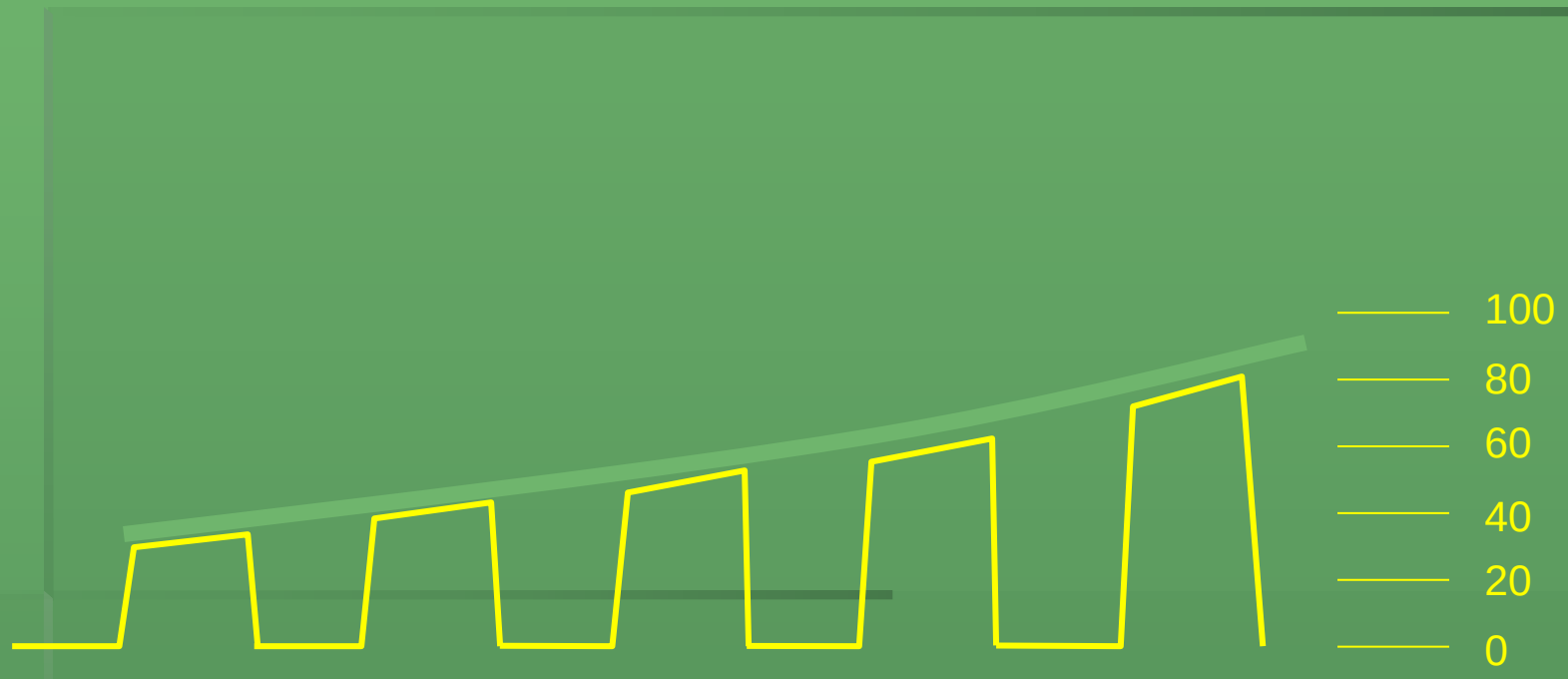
Normal Waveform, but……

What is Wrong Here?

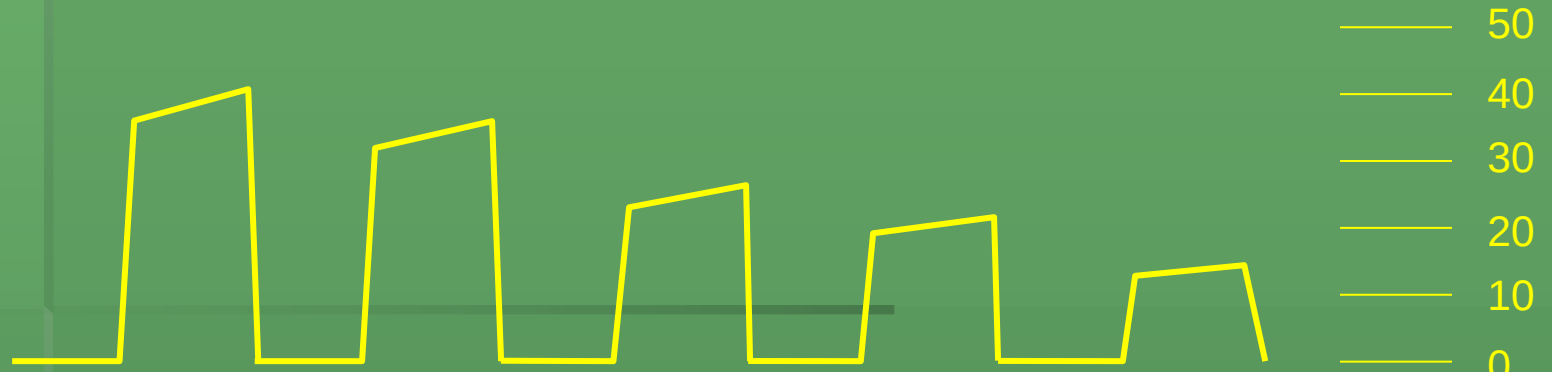


Respiratory Rate is 6 bpm

Hypoventilation



What is Wrong Here?

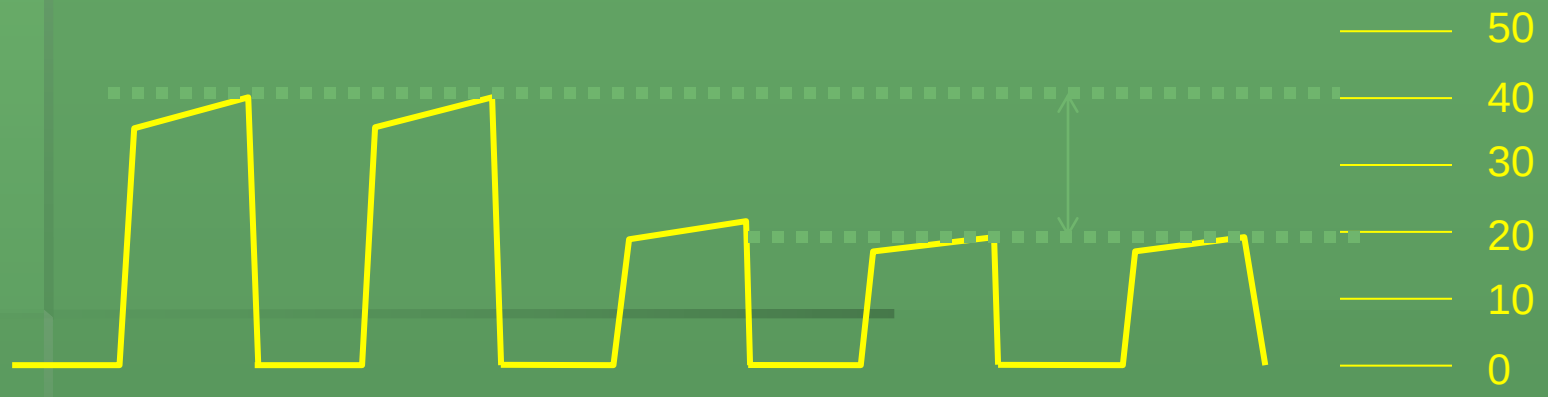


Respiratory Rate is 40 bpm

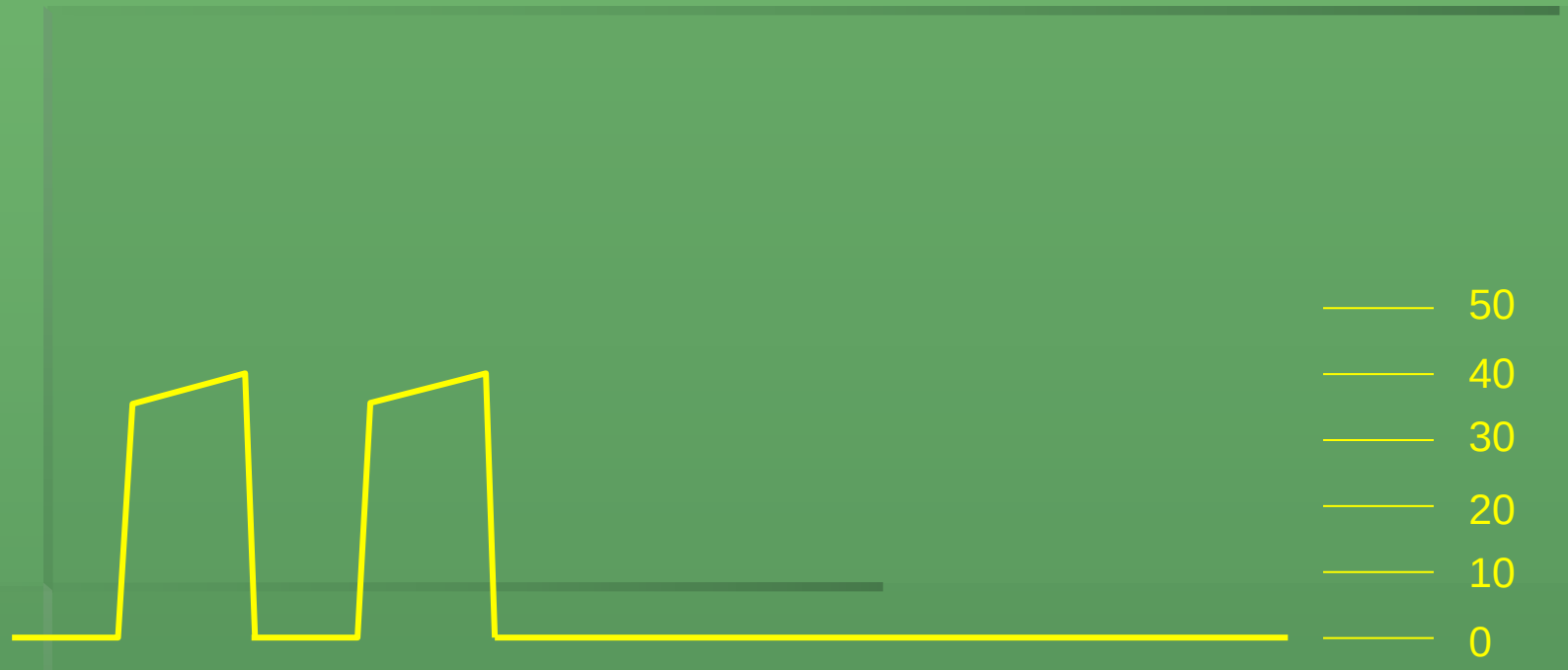
Hyperventilation

What is Wrong Here?

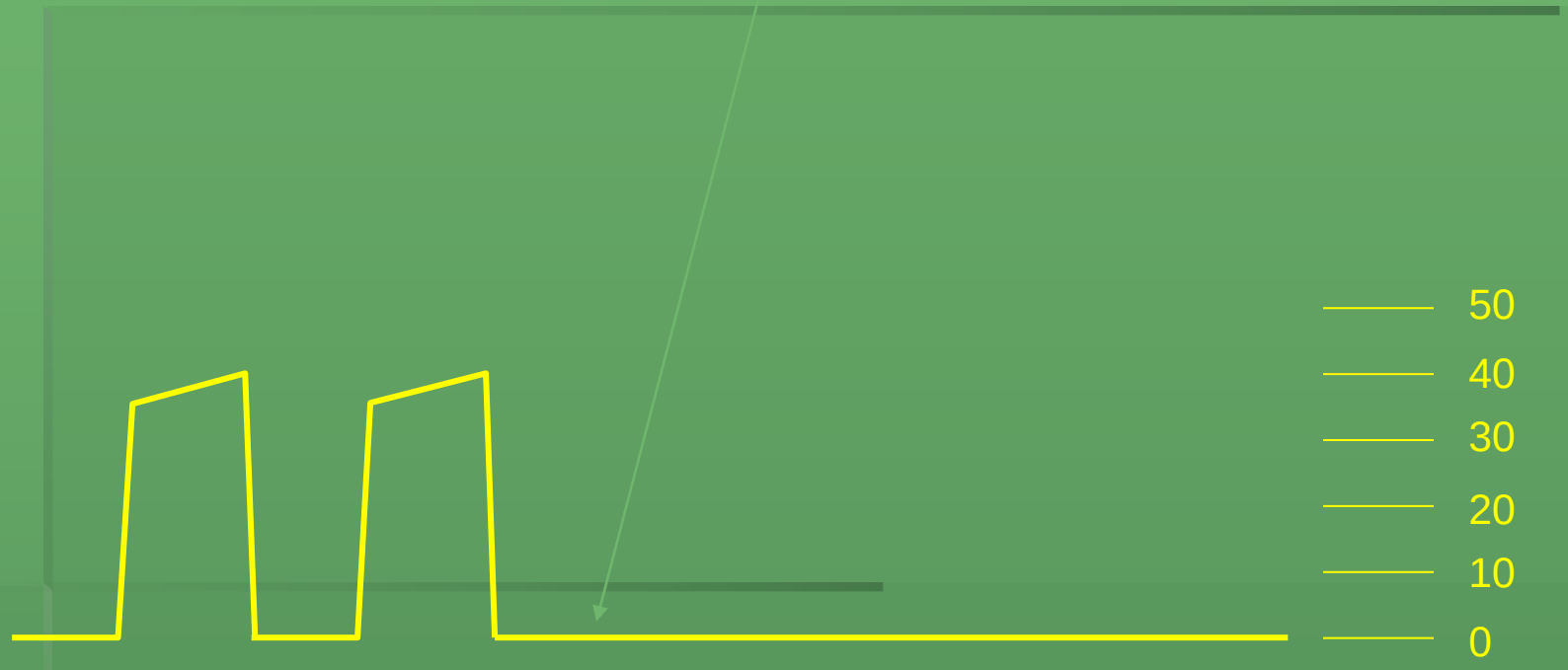
Sudden Drop in Cardiac Output



What is Wrong Here?



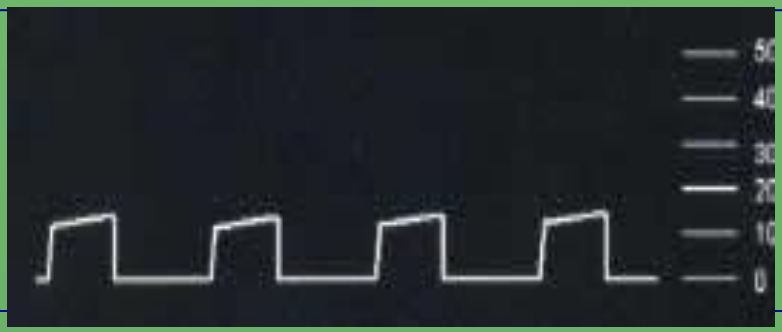
Apnea or ETT Dislodged



Capnography (End tidal carbon dioxide)

PaCO2-PetCO2 gradient =Usually <6mm Hg

CPR



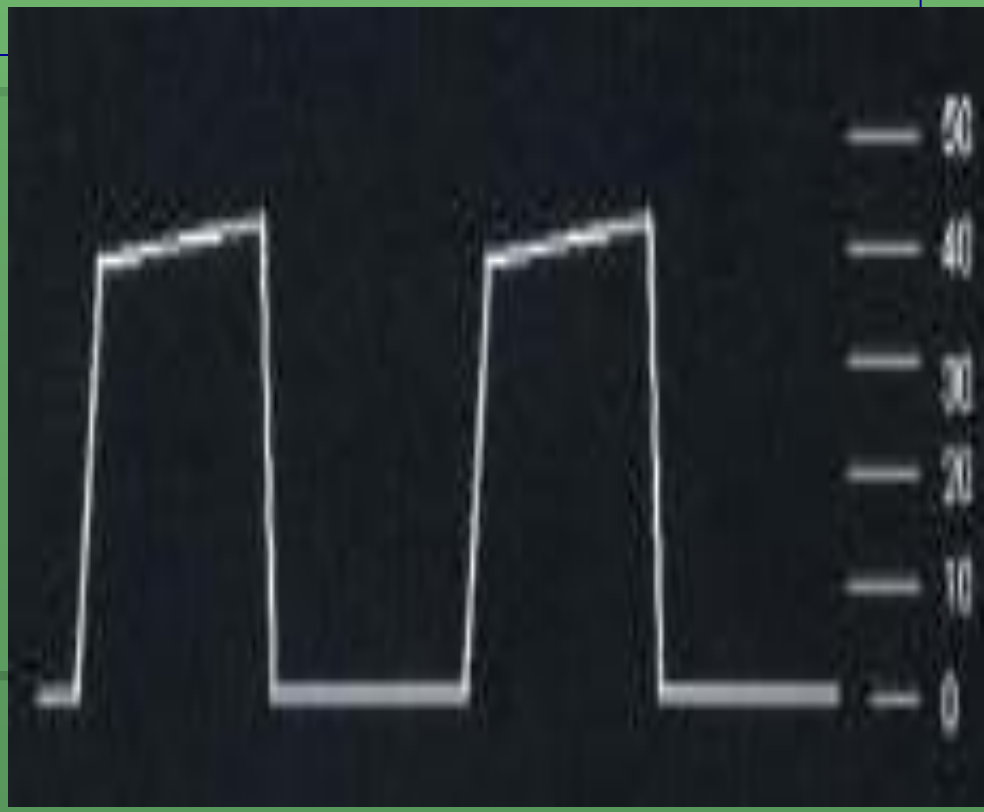
- Square box waveform
- ETCO2 10-15 mm Hg (possibly higher) with adequate CPR
- Management: Change Rescuers if ETCO2 falls below 10 mm Hg


NIBP 120
80
SpO2% 98
ECG II x2 120
CO2 38 24RR
ECG
MONITOR
00:01
Param
Wave 2
IDF
Alarms
12 Lead
LEAD
SIZE
ALARM SUSPEND
RECORDER
CHARGE
2
ANALYZE
ENERGY SELECT
SHOCK
MONITOR
OFF
PACER
PACER OUTPUT mA
41
PACER RATE ppm
CHARGER ON
SUMMARY
CODE MARKER
NIBP


NONINVASIVE BP
PRESS TO OPEN
IBP1
IBP2
TEMP
CO2
SPO2
All Patient Connections Electrically Isolated
I Memo
II Rec
Mute
PACER
Mode
Rate
Start/Stop
Output
POWER
BP
120
80
100
Manual
HR
78
BPM
ECG
3 LEAD
AUTO
x1
SpO2
98
%
Signal OK
PACING STOP
60BPM
30mA
DEMAND
12
Resp Rate
98.6 °F
CO2
38
mmHg
Intubate
IV
EPI
Treatment Summary
LIDO
ATROP
Sample
Clear
Next
Selected Energy
200 J
Energy Select
1
2
Charge
Sync
Disarm
DEFIBRILLATOR
Welch Allyn
MONITOR
Size
Lead
Hold

Normal Wave Form

- Square box waveform
- ETCO2 35-45 mm Hg
- Management: Monitor Patient



ABNORMALITIES

- Gradual ↓
  - Hyperventilation
  - Decreasing temp
  - Gradual ↓ in volume
- Sudden increase in $ETCO_2$
  - Sodium bicarb administration
  - Release of limb tourniquet
- Gradual increase
  - Fever
  - Hypoventilation
- Increased baseline
  - Rebreathing
  - Exhausted CO_2 absorber

Dislodged ETT

- Loss of waveform
- Loss of ETCO2 reading
- Management: Replace ETT

Esophageal Intubation

- Absence of waveform
- Absence of ETCO2
- Management: Re-Intubate

Obstructive Airway

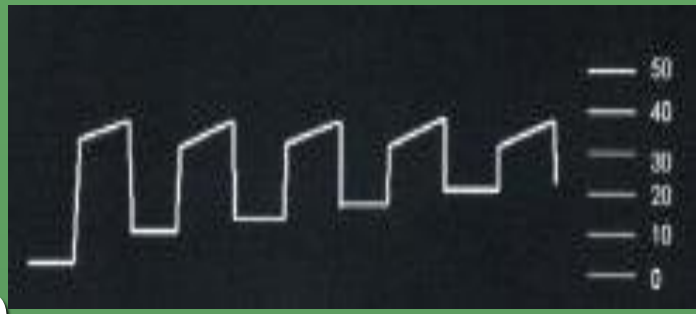
- Shark fin waveform
- With or without prolonged expiratory phase
- Can be seen before actual attack
- Indicative of Bronchospasm(asthma, COPD, allergic reaction)
- Management: Bronchodilators (albuterol, atrovent, or Epinephrine)

ROSC (Return of Spontaneous Circulation)

- During CPR sudden increase of ETCO2 above 10-15 mm Hg
- Management: Check for pulse

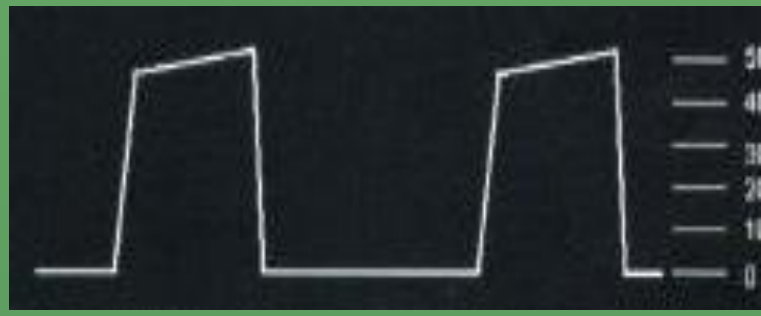
Rising Baseline

- Patient is re-breathing CO2
- Management: Check equipment for adequate oxygen flow
- If patient is intubated allow more time to exhale



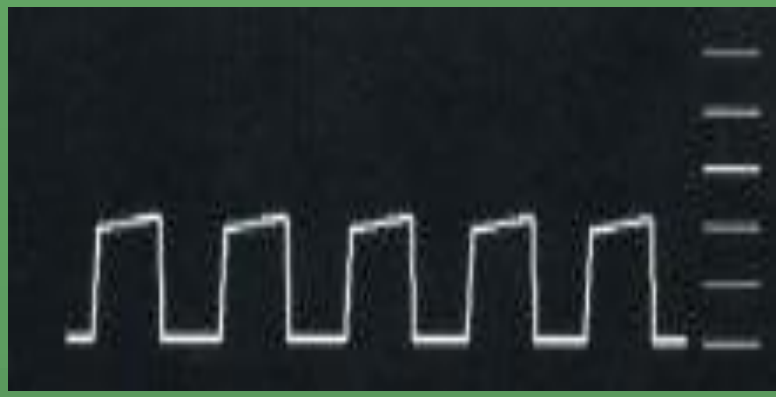
Hypoventilation

- Prolonged waveform
- ETCO2 >45 mm Hg
- Management: Assist ventilations or intubate as needed



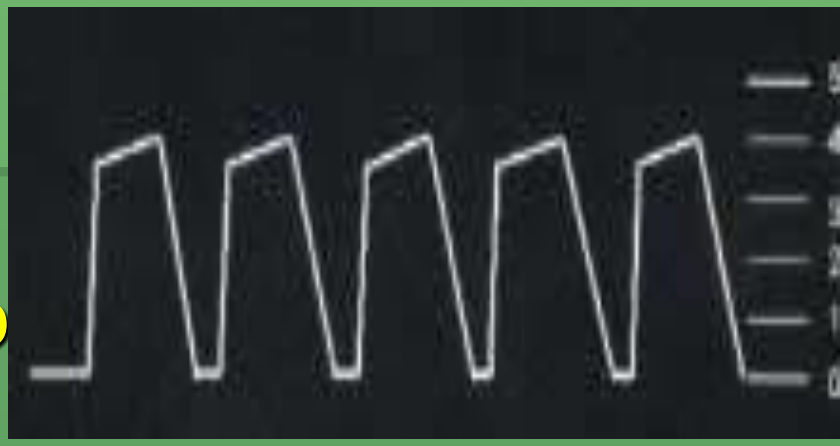
Hyperventilation

- Shortened waveform
- ETCO2 < 35 mm Hg
- Management: If conscious gives biofeedback. If ventilating slow ventilations
- If ventilations are high and ETCO2 is high consider other causes (DKA, sepsis, TCA overdose, acute renal failure, methanol ingestion, salicylate poisioning)



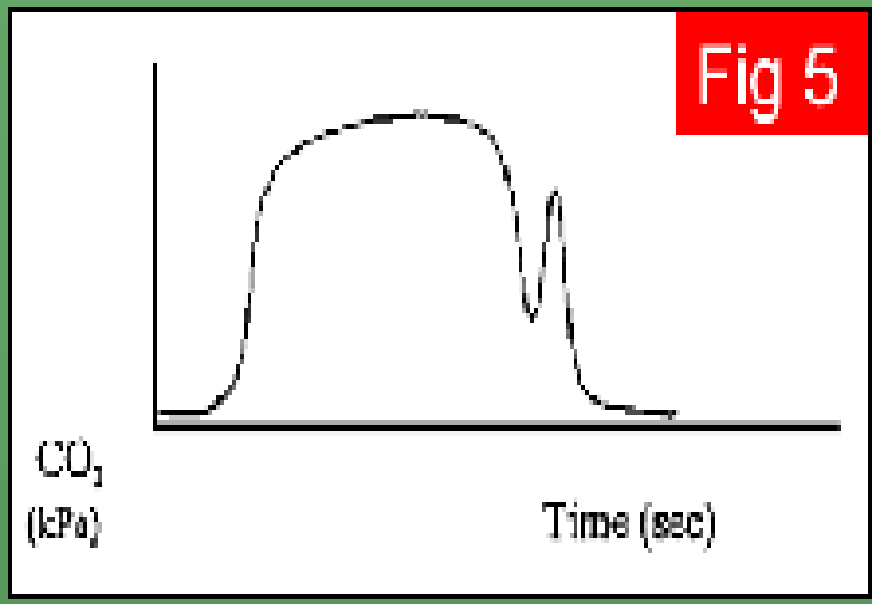
Patient breathing around ETT

- Angled, sloping down stroke on the waveform
- In adults may mean ruptured cuff or tube too small
- In pediatrics tube too small
- Management: Assess patient, Oxygenate, ventilate and possible re-intubation



Curare cleft

- Curare Cleft is when a neuromuscular blockade wears off
- The patient takes small breaths that causes the cleft
- Management: Consider neuromuscular blockade re-administration



Now what does all this mean to me?

- **ETCO2 is a great tool to help monitor the patients** breath to breath **status.**
- **Can help recognize airway obstructions or disconection before the patient has signs of attacks**
- **Helps you control the ETCO2 of head injuries**
- **Can help to identify ROSC in cardiac arrest**

Capnometry

Various factors result in either increased or decreased/absent $PETCO_2$.

$PETCO_2$ increased

CO_2 output Fever	Pulmonary perfusion	Alveolar Ventilation	Technical errors Machine faults Exhausted CO_2 absorber Inadequate fresh gas flows Leaks in breathing system Faulty ventilator Faulty valves
Malignant hyperpyrexia Sodium bicarbonate Tourniquet release Venous CO_2 embolism	Increased cardiac output Increased blood pressure	Hypoventilation Bronchial intubation Partial airway obstruction Rebreathing	

$PETCO_2$ decreased

CO_2 output	Pulmonary perfusion	Alveolar Ventilation Hyperventilation	Technical errors Machine faults
Hypothermia	Reduced cardiac output Hypotension Hypovolemia Pulmonary embolism Cardiac arrest	Apnea Total airway obstruction Partial airway obstruction Accidental tracheal extubation	

Capnography

Capnography is superior to capnometry for three reasons

Confirming adequate sampling

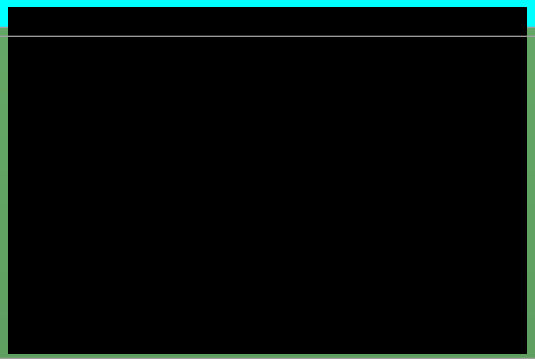
Capnography may be the only guide to detect the adequacy of gas sampling

Normal	Sampling leaks/dilution of expired gases
	

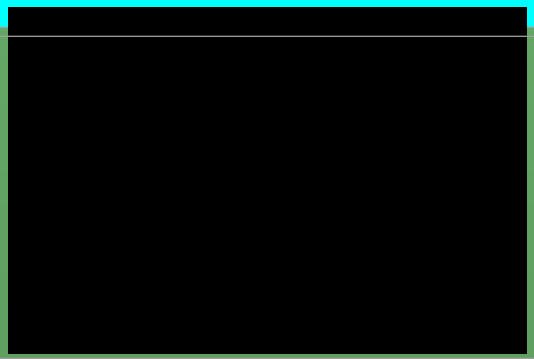
Diagnostic aid

Characteristic abnormal waveforms can help in the diagnosis of underlying clinical or technical abnormalities

Normal



Bronchospasm



Apnea / Circuit disconnection / Accidental tracheal extubation / ventilator failure

Inspiratory valve malfunction

Therapeutic aid

The efficacy of remedial measures undertaken can be assessed from the continuous evaluation of capnograms

Before treatment with bronchodilators	After treatment with bronchodilators
	

How to analyze CO_2 waveforms?

The shape of a capnogram is identical in all humans with healthy lungs. Any deviations in shape must be investigated to determine a physiological or a pathological cause of the abnormality

Five characteristics of capnogram should be evaluated

Frequency

Rhythm

Height

Baseline

Shape

Hyperventilation

کاهش تدریجی پلاتو و فاز II

خط پایه در صفر

↓CO2

Hypoventilation

افزایش تدریجی فاز II

خط پایه ثابت

Spontaneous Ventilation

پلاتوی کوتاه

تعداد منحنی زیاد

Cardiogenic Oscillations

اثرات ضربان قلب
وائورت

Curare Cleft

اثر شل کننده در کاپنوگرام

Bronchospasm
Airway Obstruction
COPD

افزایش فاز II , III

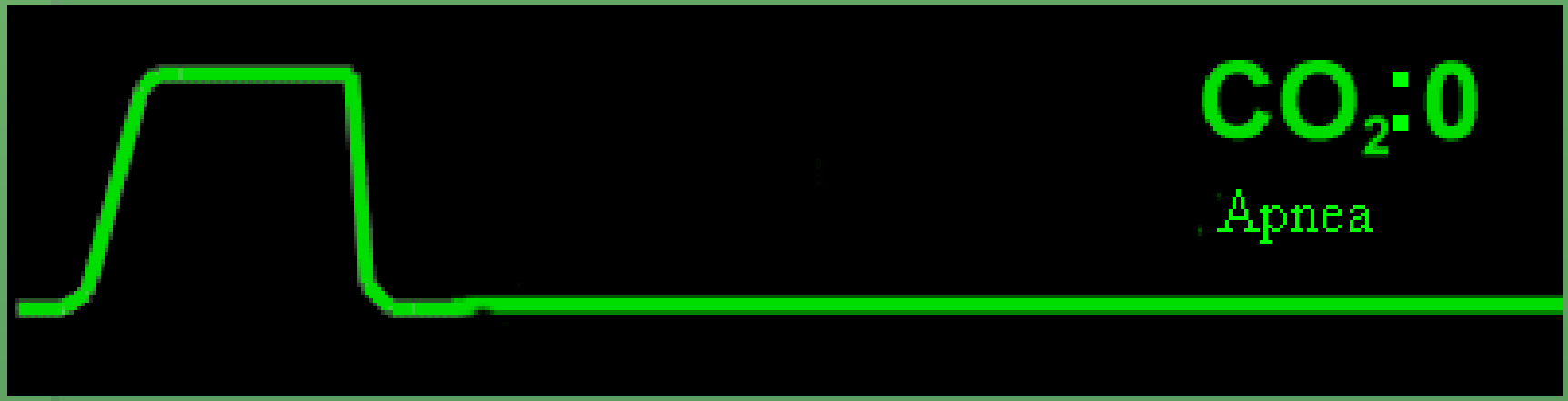
باز شدن زاویه الفا

Rebreathing of Soda Lime Contamination with CO_2

Elevation of Phase II segment and baseline

Progressive elevation of Phase II and baseline

Elevation of baseline and Phase II, smaller inspiratory efforts



Images reprinted from Capnography.com homepage

Designed by Bhavani Shankar Kodali

Thank You