Ventilation

Acid Base

In three easy steps

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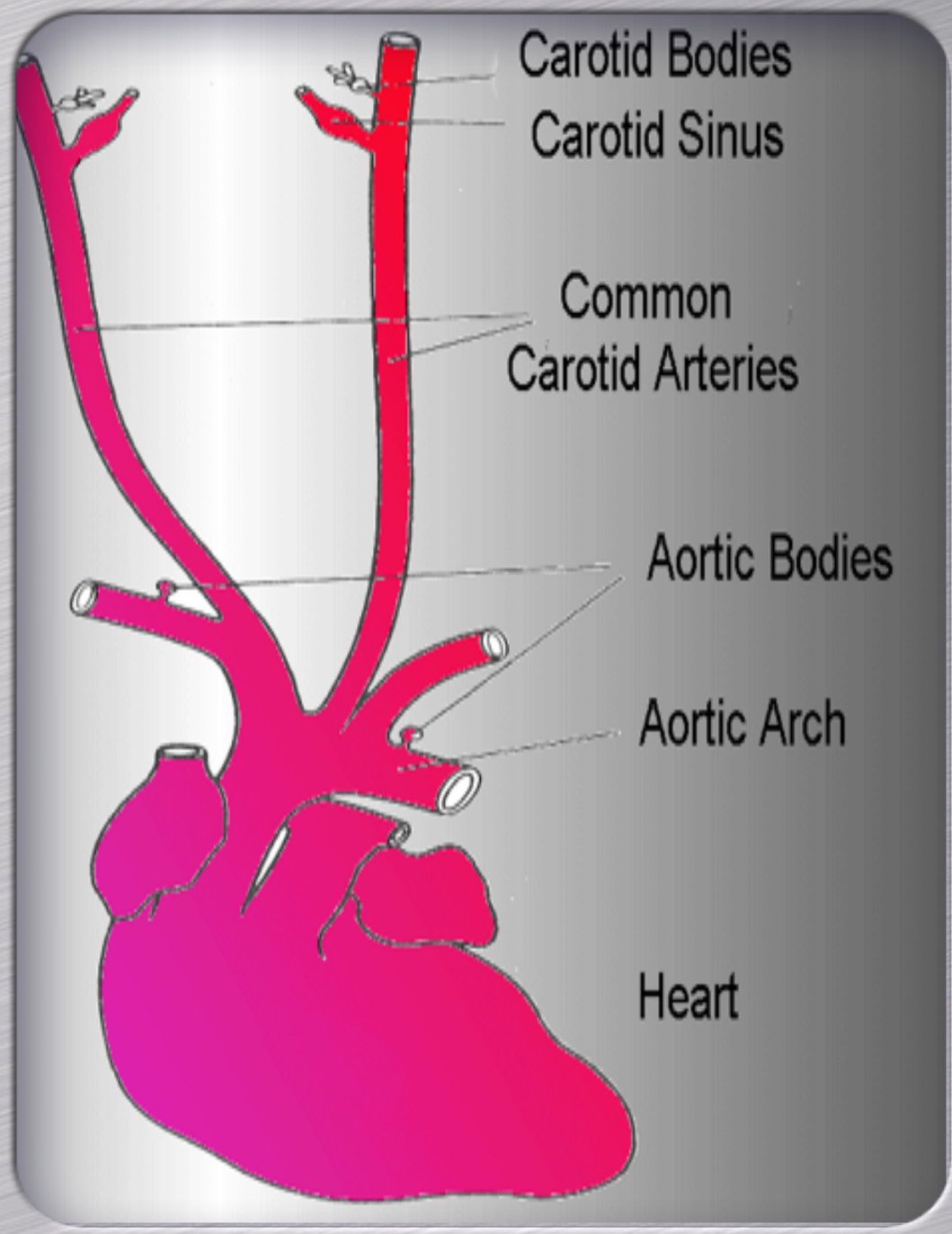
Outline

- Definitions
- Physiology of acid base
- Interpretation of acid base
  - Acidosis or alkalosis
  - Primary cause
  - Compensation
- Examples



Definitions

Definitions

Acid & Base

- Acid
  - Proton donor (H^+)
- Base
  - Proton recipient (OH^-)

- Water and acid
  - H_2O = H-O-H = $H^+ + OH^-$

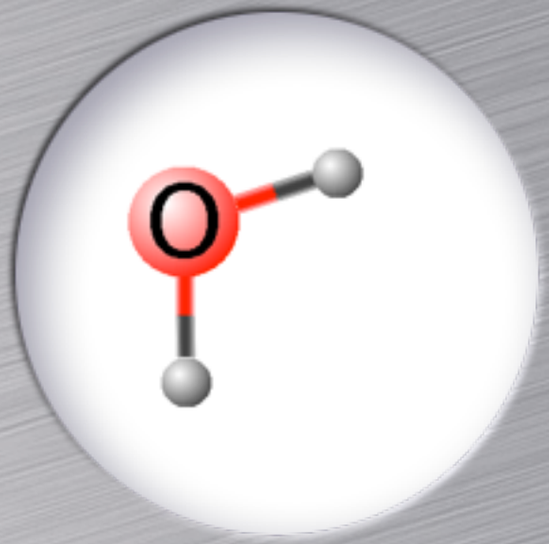
Definitions

pH

- pH = Negative log H^+ content of a solution
  - pH = 7.0 = very small amount of H^+
- 10^{-7} Molar of H^+ in water
  - = 1 in 10 000 000 molar

Water

- $H_2O \rightleftarrows H^+ + OH^-$
- Its the H^+ that counts
- pH 7.4 = 40 per billion H^+ ions



Definitions

Definitions

- Acidosis – A high amount of acid (⇑ H^+)
  - Lots of H^+
  - pH < 7.35
- Alkalosis – A low amount of acid (⇓ H^+)
  - Lots of OH^-
  - pH > 7.45

Physiology

Physiology

Outline

- Factors in acid base balance
- Regulation of respiration
- Regulation of metabolism
- Integration of both mechanisms
- Causes of acid base disturbances

Factors in Acid Base

Physiology

Physiology

- If its such a small amount of H^+, why is it so important?

- Because it affects the charge (+/-) of protiens, which changes the shape of a protien.

Physiology

Normals

- What is a normal and bad pH?
- Normal pH
  - 7.35 to 7.45
- Low pH (Acidosis)
  - If pH < 7.0, survival is unlikely.
- High pH (Alkalosis)
  - If pH > 7.6 severe

Physiology

Regulation

- What regulates our acid base balance?
- Two organs:
  - Lungs
  - Kidneys
- Both can independently affect pH

Lung Physiology

Physiology

Lungs and pH

- Ventilation controls CO_2 which controls H^+ ion levels

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

- Note: it's the H+ that counts for pH

Physiology

Lungs and pH

- Underventilation (→Acidosis)
  - CO_2 rises and therefore H^+ rises

$$\uparrow CO_2 + H_2O \rightarrow \uparrow H^+ + \uparrow HCO_3^-$$

Physiology

Lungs and pH

- Overventilation (→Alkalosis)
  - CO_2 falls and therefore H^+ falls
  - Therefore alkalosis results (ph Rises)

$$\downarrow CO_2 + H_2O \leftarrow \downarrow H^+ + \downarrow HCO_3^-$$

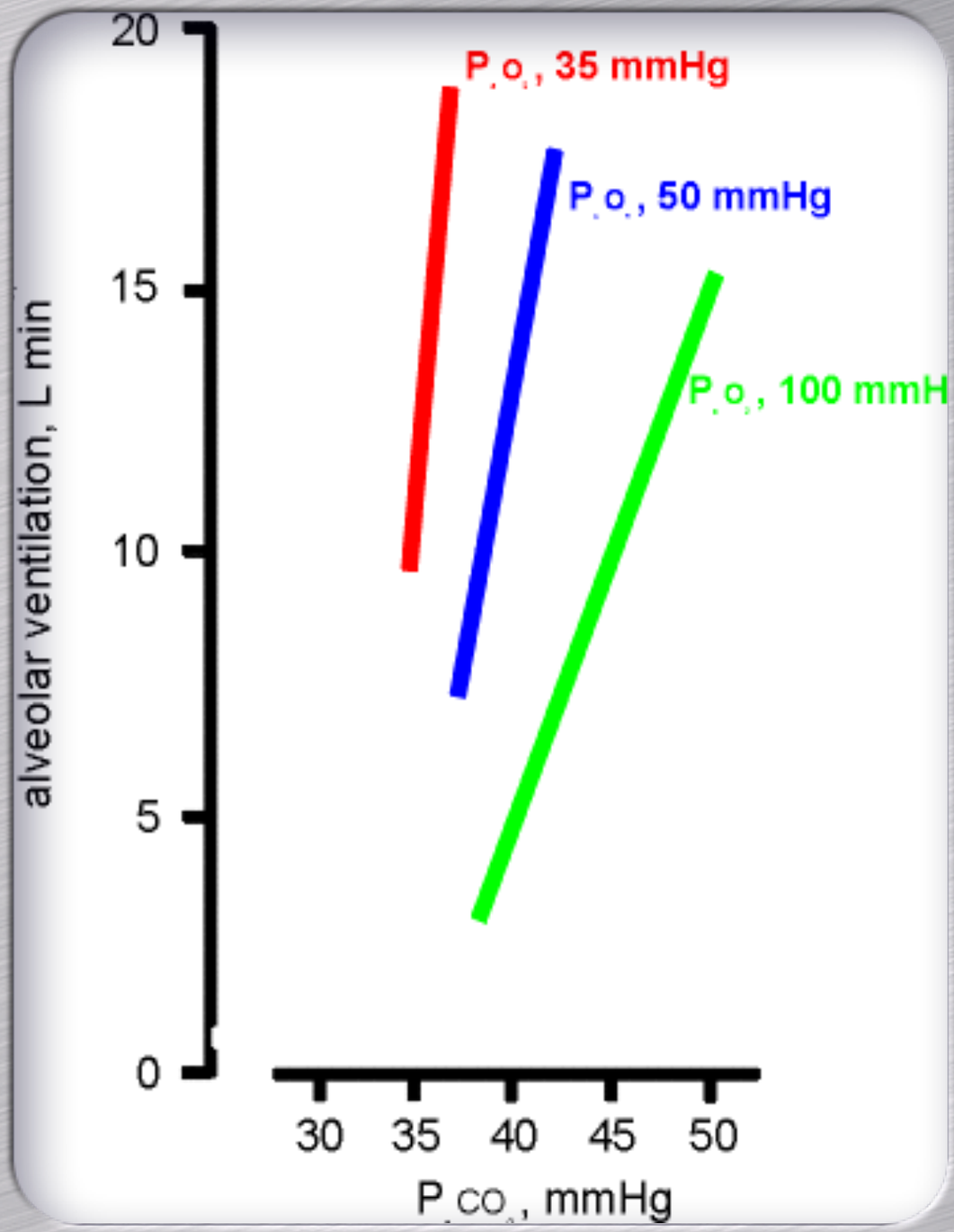
Regulation

- The lungs are regulated by the brainstem
  - Respiratory regulation is very dependent on a functioning nervous system and neuromuscular system.

- Normal CO_2 response keeps pH tightly controlled.
- CO_2 levels can change very quickly

Ventilatory Response

- Ventilatory response is linear
  - Modulated by pO_2
    - Aponeic threshold 32
- Small changes cause a big response



Physiology

Respiratory Acidosis

- Very common finding in hospitals
  - Usually due to sedation in critical care setting
- Several possible causes
  - Sedatives
  - Anaesthetics
  - Opiates
  - Muscle relaxants

Physiology

Respiratory Alkalosis

- Less common, due to overstimulation of respiratory centres
  - Pain
  - Fever
  - Hypoxia
  - Anaemia
  - Drug overdosage (Aspirin, Doxapram)

Renal Physiology

Physiology

pH & Bicarbonate

- Acid depletes bicarbonate
  - Metabolic acidosis lowers bicarbonate
- Base restores bicarbonate
  - Metabolic alkalosis raises bicarbonate

Physiology

Kidneys and pH

- The most important organ in regulation of pH is the kidney.
  - Excretes H^+ ions in various forms
    - Ammonium (NH_4^+)
- Features of renal control of acid-base
  - Is autonomous in function (unlike lungs)
  - Response requires urine formation
    - Change takes hours – days

Physiology

Metabolic Acids

- Aside from CO_2, there are many acids in the body.
- The net effect of all these other acids are reflected in the Bicarbonate level.
- Any changes in metabolic acid load will be reflected in the bicarbonate level.

Physiology

Metabolic Alkalosis

- Causes
  - Loss of acid
    - Renal - Diuretics
    - Gut - Vomiting
  - Addition of alkalii
    - Metabolic
    - Exogenous

Physiology

Metabolic Acidosis

- Very common finding in hospitals
  - Usually due to renal impairment or overwhelming illness
  - Many causes for this – need to look further once a metabolic acidosis is diagnosed
- Due to either
  - Loss of Base (Uncommon)
  - Failure to excrete acid (Common)

Physiology

Anion Gap

- Helps you reduce the number of possible causes
- Anion gap
  - = [Na] + [K] - ([Cl] + [HCO3])
  - = [other anions] - [other cations]
- Normal values is 8-16 mmol/L
  - (4-13 if potassium not used in formula)

Physiology

Normal Anion Gap Acidosis

- Renal Causes
  - Renal tubular acidosis
  - Carbonic anhydrase inhibitors
- GIT causes
  - Severe diarrhoea, small bowel fistula
  - Uretero-enterostomy or Obstructed ileal conduit
  - Drainage of pancreatic or biliary secretions
- Other Causes
  - Recovery from ketoacidosis
  - Addition of HCl, NH_4Cl

Physiology

Raised Anion Gap Acidosis

- Bulk Acids
  - Diabetic ketoacidosis
  - Alcoholic ketoacidosis
  - Starvation ketoacidosis
  - Lactic acidosis
- Renal Failure
  - Uraemic acidosis or other ions (eg sulphate)
- Toxins
  - Ethylene glycol
  - Methanol
  - Salicylates

Physiology

Summary of Physiology

- There are two regulators of pH:
  - Lungs / brainstem
  - Kidneys
- Each can be monitored by a test:
  - CO_2 – Lungs
  - Bicarbonate – Kidneys

Summary

- Factors in acid base balance
- Regulation of respiration
- Regulation of metabolism
- Integration of both mechanisms
- Causes of acid base disturbances

Interpretation

Interpretation of Acid-Base

- So, you do a blood gas.
- How do you interpret it?

- Simple – Ask three questions
  - What is the problem?
  - What is the cause of the problem?
  - Is there compensation?

Interpretation

First Question

- What is the problem?
- Answer – Look at the pH
  - Low pH (< 7.35) = Acidosis
  - High pH (>7.45) = Alkalosis
- "Acidosis or Alkalosis"

Interpretation

Second Question

- What is causing the problem
- Acidosis
  - High CO_2 (> 45) OR
  - Low Bicarbonate (< 22)
- Alkalosis
  - Low CO_2 (<35) OR
  - High Bicarbonate (>26)
- "Metabolic, Respiratory or Combined"

Interpretation

Third Question

- Combined, uncompensated or compensated?

- Acidotic pH
  - Both lungs and kidneys acidotic – Combined
  - One organ system normal – Uncompensated
  - One organ system alkalotic – Compensated

Interpretation

Third Question

- Combined, uncompensated or compensated?

- Alkalotic pH
  - Both lungs and kidneys alkalotic– Combined
  - One organ system normal – Uncompensated
  - One organ system acidotic - Compensated

Interpretation

Summary

- Analysis of ABG's is easy.

Do it in steps:

1. Acidosis or Alkalosis
2. Metabolic or Respiratory
3. Combined, Uncompensated or Compensated

Interpretation

Summary

- Describing Acid-Base is easy.
- Make a short sentence
- Reverse the word order
  - Eg. Compensated Metabolic Alkalosis
  - Eg. Uncompensated Respiratory Acidosis

Examples

Examples

- Sepsis
- Sedation
- Vomiting gastric contents

Example Sepsis

Examples

Sepsis

- 24 year old IV drug user with fever, tachycardia and hypotension.

- ABG
  - PH = 7.20
  - pCO_2 = 25
  - Bicarbonate = 12

Examples

Sepsis

- Question one (pH = 7.20)
  - Acidosis or Alkalosis?
- Question two (pCO_2 = 25, Bicarb = 12)
  - Metabolic or Respiratory?
- Question three
  - Combined, Uncompensated or Compensated?

Examples

Sepsis

- 24 year old IV drug user with fever, tachycardia and hypotension.
- ABG
  - PH = 7.20
  - pCO_2 = 25
  - Bicarbonate = 12
- "Compensated Metabolic Acidosis"

Example Sedation

Examples

Sedation

- 45 Year old lady in ED. Drowsy, history of possible suicide attempt.

- ABG
  - pH = 7.25
  - pCO_2 = 55
  - Bicarbonate = 24

Examples

Sedation

- Question One (pH = 7.25)
  - Acidosis or alkalosis?
- Question two (pCO_2 = 55, Bicarb = 24)
  - Metabolic or Respiratory?
- Question three
  - Combined, Uncompensated or Compensated?

Examples

Sedation

- 45 Year old lady in ED. Drowsy, history of possible suicide attempt.
- ABG
  - pH = 7.25
  - pCO_2 = 55
  - Bicarbonate = 24
- "Uncompensated Respiratory Acidosis"

Example Vomiting

Examples

Vomiting

- 78 year old man with abdo pain, nausea and vomiting. Not passing wind or faeces

- ABG
  - PH = 7.55
  - pCO_2 = 50
  - Bicarbonate = 32

Examples

Vomiting

- Question one (pH = 7.55)
  - Acidosis or Alkalosis?
- Question two (pCO_2 = 50, Bicarb = 32)
  - Metabolic or Respiratory?
- Question three
  - Combined, Uncompensated or Compensated?

Examples

Vomiting

- 78 year old man with abdo pain, nausea and vomiting. Not passing wind or faeces
- ABG
  - PH = 7.55
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- "Compensated Metabolic Alkalosis"

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veltman.org/education/ABG/