ACID BASE BALANCE

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Objectives

1. Introduction to the basics.
2. ABG Components and normal values.
3. Interpretation of the numbers.
4. Examples of acid-base disorders.
5. Knowledge challenge questions!

Arterial blood gas

- An Arterial Blood Gas (ABG) lab test measures dissolved gases in, and other properties (pH, etc..) of, arterial blood.
- ABGs are most often used with patients in critical care settings.
- *In less critical settings, pulse oximetry is often used as it is less invasive, faster, and cheaper.*

Arterial blood gas (ABG)

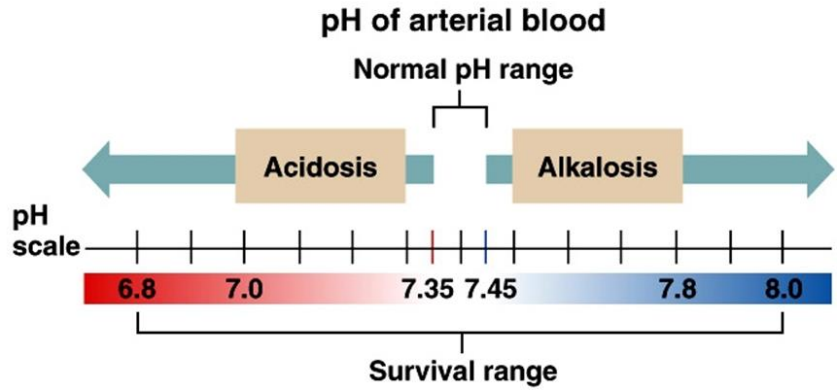
- Homeostasis of pH is tightly controlled
- < 6.8 or > 8.0 death occurs
- Acidosis (acidemia) below 7.35
- Alkalosis (alkalemia) above 7.45

Normal Values for ABG's:

pH : 7.35 - 7.45

CO_2 : 35 to 45 mmHg

HCO_3^- : 24 to 28 mEq/L



Acid –base homestasis

- The body is very sensitive to pH level.
  - Outside the acceptable range of pH, proteins are denatured and digested, enzymes lose their ability to function.
  - Therefore, the body's pH is tightly regulated.
    - The Respiratory System.
    - The Renal System.
    - Buffering Agents.

Carbonic Anhydrase

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO3^-$$

Le Châtelier's Principle

Respiratory compensation

Metabolic Acidosis

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO3^-$

Metabolic Alkalosis

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO3^-$

Respiratory chemoreceptors

There are two kinds of respiratory chemoreceptors: arterial chemoreceptors, which monitor and respond to changes in the partial pressure of oxygen and carbon dioxide in the arterial blood, and central chemoreceptors in the brain, which respond to changes in the partial pressure of carbon dioxide

Respiratory compensation

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO3^-$$

- Used to compensate for ***metabolic*** imbalances only

- Chemoreceptors respond to changes in **PH** concentrations → alters respiratory rate and depth

- This means
  - Metabolic ***acidosis*** causes an increase in rate and depth of ventilation as the body attempts to get rid of acid (CO_2)
  - Metabolic ***alkalosis*** causes a decrease in rate and depth of ventilation as the body attempts to retain acid (CO_2)
  - Respiratory mechanisms take several minutes to hours

Two kinds of acids are formed from metabolism: 1) volatile acid,

2) nonvolatile acid.

The volatile acid is the acid, which can be eliminated from lung (respiration).

The nonvolatile acid has to be eliminated from kidneys within urine.

Metabolic or renal compensation

Respiratory Acidosis

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO3^-$

Respiratory Alkalosis

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO3^-$

The Renal System

- Changes the retention and secretion balance of bicarbonate and hydrogen ions.
  - If the renal tubular cells retained more bicarb and secreted more H^+, then there would be an increase of the blood pH (alkalotic).
  - If the renal tubular cells secreted bicarb and retained H^+, then there would be a decrease of the blood pH (acidic).
- "Metabolic compensation", slower (12-24hours).


Thinking questions

SUMMARY

	pH	CO_2	HCO_3^-	H^+
Normal				
Respiratory Acidosis				
Respiratory Alkalosis				
Metabolic Acidosis				
Metabolic Alkalosis				

Easy way to remember:

1.

2.

Normal Values for ABG's:

pH : 7.35 - 7.45

CO_2 : 35 to 45 mmHg

HCO_3^- : 24 to 28 mEq/L

Carbonic Anhydrase

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO3^-$$

	pH	CO_2	HCO_3^-	H^+
Normal				
Respiratory Acidosis	↓	↑*	↑	↑
Respiratory Alkalosis	↑	↓*	↓	↓
Metabolic Acidosis	↓	↓	↓*	↑
Metabolic Alkalosis	↑	↑	↑*	↓

Easy way to remember:

1. "Respiratory values are "Re"versed
2. CO_2 + HCO_3^- always same direction

Normal Values for ABG's:

pH : 7.35 - 7.45
CO_2 : 35 to 45 mmHg
HCO_3^- : 24 to 28 mEq/L

PRACTICE QUESTIONS

1) Hypoventilation leads to

A) respiratory acidosis.

B) respiratory alkalosis.

C) metabolic acidosis.

D) metabolic alkalosis.

2) In response to respiratory acidosis,

A) kidneys secrete more hydrogen ions ONLY.

B) kidneys excrete more bicarbonate ions ONLY.

C) kidneys excrete fewer bicarbonate ions ONLY.

D) kidneys secrete more hydrogen ions and more bicarbonate ions.

E) kidneys secrete more hydrogen ions and fewer bicarbonate ions.

Name the disorder (choices for #'s 3 and 4 below):

- Respiratory acidosis (with or without renal compensation)
- Respiratory alkalosis (with or without renal compensation)
- Metabolic acidosis (with or without respiratory compensation)
- Metabolic alkalosis (with or without respiratory compensation)

3) ABG's: pH 7.31 PCO_2 55 mm Hg HCO_3^- 28 mEq/L

resp. acidosis ↓ ↑ reversed normal w/o renal comp.

4) ABG's: pH 7.31 PCO_2 55 mm Hg HCO_3^- 35 mEq/L

resp. acidosis ↓ ↑ ↑ w/ comp.

Late Distal convoluted duct and collecting duct

Principle cells

Larger in number

Taller

Collecting duct

Aldosterone

Na and H2O reabsorption

H2O reabsorption (ADH) vasopressin

alpha intercalated cells

- Fewer in number
- Shorter
- Collecting and DCT

Acid base balance

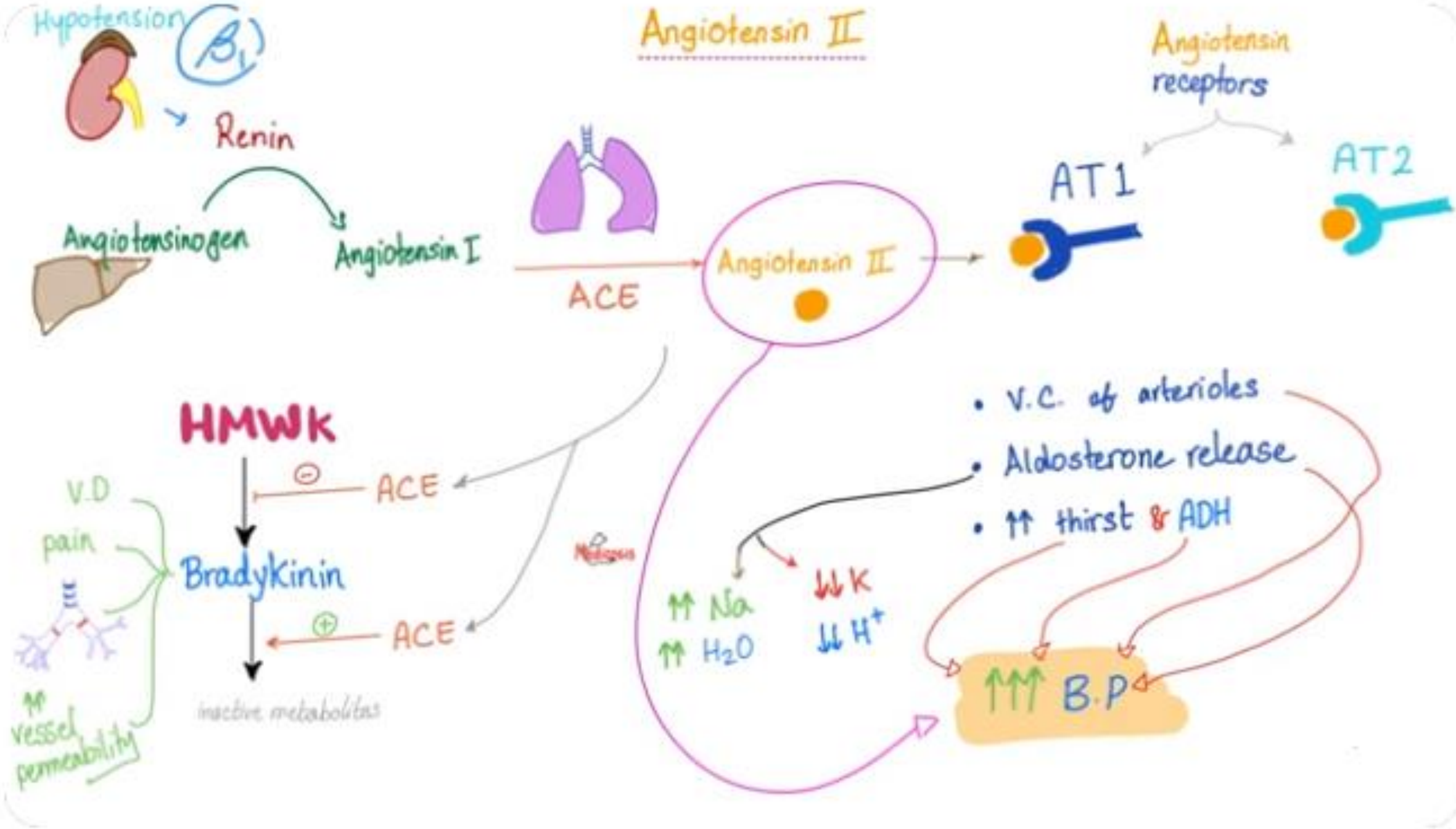
aldo

H and K secretion Apical NH3 NH4

HCO3 reabsorption and Cl- dump basolateral membrane NH4Cl

- Ammonium chloride (titratable acid)

NH4CL


Hypotension
β_1
Renin
Angiotensinogen
Angiotensin I
ACE
Angiotensin II
Angiotensin II
Angiotensin receptors
AT1
AT2
HMWK
ACE
V.D
pain
Bradykinin
ACE
inactive metabolites
vessel permeability
Medulla
↑↑ Na
↑↑ H_2O
↓↓ K
↓↓ H^+
• V.C. of arterioles
• Aldosterone release
• ↑↑ thirst & ADH
↑↑↑ B.P