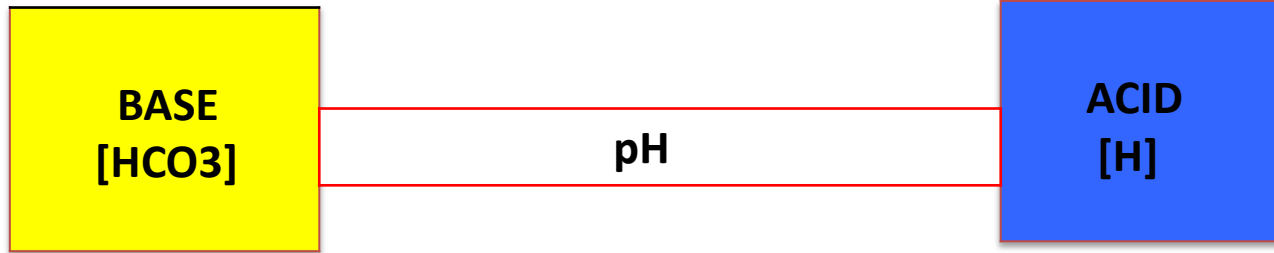


Introduction to Acid Base Disturbances

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Outline

- Components of Acid Base physiology
- Protective mechanisms that keep us alive
- How things can go wrong
- Acid Base interpretation with confidence
- Interactive cases



pH	7.8	7.7	7.6	7.5	7.4	7.3	7.2	7.1	7.0	6.9	6.8
H	16	20	26	32	40	50	63	80	100	125	160

- $\text{pH} = \text{pK} + \text{Log} (\text{HCO}_3/\text{H}_2\text{CO}_3)$

$$\text{pH} = 6.1 + 1.3$$

$$\text{pH} = 7.4$$

* pH can never be less than 6.1

- $\text{pK} = 6.1$
- $\text{HCO}_3/\text{H}_2\text{CO}_3$ ratio = 20/1 (26/1.3)
- $\text{H}_2\text{CO}_3 = 0.03 \times \text{PCO}_2$

ACID

Exogenous

- Physiological: Diet
- Pathological: toxins
(Methanol, Ethylene Glycol)

Endogenous

- Physiological: metabolism (volatile & non-volatile acids)
- Pathological : Ketoacids and lactate

BASE

- HCO_3^- is the kidney favorite's player
- Liver produces HCO_3^- from some precursors (Lactate, Citrate)

Life saving mechanisms

- Blood Buffers
- Respiratory reaction (ventilation)
- Kidney reaction (metabolic)

Blood Buffers

Bicarbonate-Carbonic acid system	53%
Hemoglobin	35%
Albumin	7%
Phosphate	5%



Respiratory mechanism

- Very quick reaction
- PCO_2 and H have a potent stimulatory effect on the respiratory centre

Renal mechanisms

Increase of HCO₃

- Absorption
- Generation

H acid secretion

- NH₃ synthesis

Response to Acid load

- If 10 mmol/l of Acid is added to the blood
- $\text{pH} = 6.1 + \log \left(\frac{\text{Bicarb}}{\text{carbonic acid}} \right)$

$$\text{pH} = 6.1 + \log \frac{(26-10)}{(1.3+10)}$$

$$= 6.1 + 0.15$$

pH = 6.25 (if no protective mechanism exists)

What can go wrong ?

- Impaired respiratory response
- Impaired renal response

Acid base interpretation

Major tools

- pH
- [H]
- [HCO₃]
- PCO₂
- Clinical data

Supplementary tools

The GAPs !

- Anion Gap
- Delta Gap
- Plasma osmolar Gap
- Urine anion Gap
- Urine osmolar Gap

Anion Gap

- **AG= Unmeasured anions - Unmeasured cations**
- **AG= measured Cations – measured anions**
- $AG = Na - (Cl + HCO_3)$
- Elevated Gap indicates excess acids in the blood = metabolic acidosis
- Watch out for hypoalbuminemia!
- For each 10 point drop in albumin, add 2.5 to the calculated AG

Delta Gap mystery

- In **metabolic acidosis**, the drop in HCO_3 should match the elevation in AG

$$\text{Delta gap} = \Delta\text{AG} / \Delta\text{HCO}_3 = 1$$

- **Delta gap < 1** = the drop in HCO_3 is more than expected = 2 metabolic **acidotic** processes !
- **Delta gap > 1** = the drop in HCO_3 is less than expected = additional metabolic **alkalotic** process is present !

Compensatory mechanisms

Acid base defect	Primary defect	pH	Compensation
Met acidosis	Low Bicarb	Low	Low PCO ₂
Met alkalosis	High Bicarb	High	High PCO ₂
Resp alkalosis	Low PCO ₂	High	Low Bicarb
Respiratory acidosis	High PCO ₂	Low	High Bicarb

Normal Values

- pH = 7.4
- [H] = 40 nmol/l
- [HCO₃] = 24 mmol/l
- PCO₂ = 40 mmHg
- Anion Gap = 12
- Albumin = 40 g/l
- Delta Gap = 1
- Osmolar Gap < 10

Acid base disorder	Primary defect	Compensation
Met acidosis	↓HCO ₃	1.2 drop in PCO ₂ for each 1 mmol decrease in HCO ₃
Met alkalosis	↑HCO ₃	0.7 rise in PCO ₂ for every 1 mmol rise in HCO ₃
Acute resp acidosis	↑PCO ₂	1 mmol rise in HCO ₃ for every 10 point increase in PCO ₂
Ch resp acidosis	↑PCO ₂	3.5 mmol rise in HCO ₃ for every 10 point increase in PCO ₂
Acute resp alkalosis	↓PCO ₂	2 mmol drop in HCO ₃ for every 10 point fall in PCO ₂
Ch resp alkalosis	↓PCO ₂	4 mmol drop in HCO ₃ for every 10 point fall in PCO ₂

Take the basic steps

- Describe the pH
- Identify the primary drive for pH
- Predict the compensatory response
- Assess the actual compensatory response
- Calculate the Anion gap (AG)
- Correct the AG for albumin
- Calculate the Delta Gap (DG)
- Look for Osmolar gap (OG)

After reading a blood gas

- What is the primary disorder?
- Is it adequately compensated?
- Am I dealing with a single disorder or mixed disorders?

What is the acid base disorder?

	pH (7.4)	PCO₂ mmHg (40)	HCO₃ mmol/L (24)
A	7.32	28	14
B	7.47	20	20
C	7.51	49	38
D	7.08	49	14

Interactive Case-1

- 15 year old boy with abdominal pain,

pH	PCO ₂	HCO ₃
7.1	17	5

a. What is the acid base disorder?

b. What else do we need to know ?

Na 130 mmol/l, Cl 105 mmol/l

c. What is the clinical diagnosis?

Interactive Case-2

23 year old man with a 3 day history of diarrhea.

ABG showed :

pH	HCO ₃	PCO ₂
7.28	12	26

Na= 135, Cl=110, K= 3.2

Interactive Case-3

- 55 yo man k/c of BA. In ER with SOB and cough for 2 days
- ABG : pH= 7.32 , PCO₂= 50 , HCO₃= 25
- Na= 134 , K= 4.5 , Cl= 100

What is the acid base disorder ?

Interactive Case-4

- 55 yo man with COPD. Admitted for elective hernia repair. Pre operative ABG showed :
- pH= 7.37 , PCO₂= 55 , HCO₃= 31
- Na= 136, K= 3.5, Cl= 96

What is the disorder?

Interactive Case-5

- 40 yo woman with repeated vomiting for 1 day. ABG showed :
- pH= 7.49 , PCO₂= 48 , HCO₃= 35
- Na= 130 , K= 2.8 , Cl= 85

What is the disorder ?

Interactive case-6

- 28 yo man with abdominal pain and diarrhea. He is clinically volume depleted (low BP, tachycardia..)

ABG :

pH= 7.29 HCO₃= 8 , PCO₂= 21

Na= 133 , Cl=105

- Acidemia
- Metabolic acidosis
- Exp PCO₂ = 20
- AG = 20
- Δ AG = 8
- Δ HCO₃ = 16

- Dx: combined Gap and non-Gap metabolic acidosis (Diarrhea induced HCO₃ loss and Lactic acidosis)