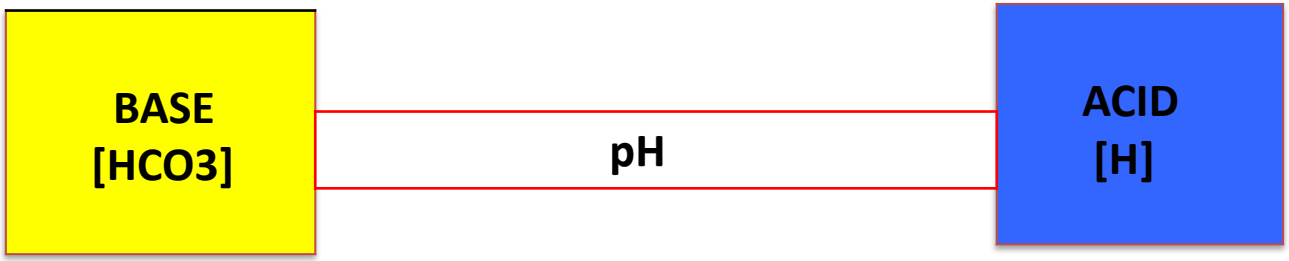
Introduction to Acid Base Disturbances

Dr. Riyadh Al Sehli ,MBBS, FRCPC
Transplant Nephrologist

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

- **pH = pK + Log (HCO3/H2CO3)**

pH = 6.1 + 1.3

pH= 7.4

* pH can never be less than 6.1

- pK = 6.1
- HCO3/H2CO3 ratio = 20/1 (26/1.3)
- H2CO3=0.03×PCO2

ACID

Exogenous

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

Endogenous

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

BASE

- HCO3 is the kidney favorite's player
- Liver produces HCO3 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%

$$H_2O + CO_2 = H_2CO_3 = H + HCO_3$$

Respiratory mechanism

- Very quick reaction
- PCO2 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
- pH = 6.1 + log (Bicarb/carbonic acid)

pH = 6.1 + log (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 !

- **<u>Anion Gap</u>**
- 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 + HCO3)
- 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 **metabloic acidosis**, the drop in HCO3 should match the elevation in AG

  Delta gap= ΔAG/ΔHCO3 = 1

- Delta gap < 1 = the drop in HCO3 is more than expected= 2 metabolic acidotic processes !
- Delta gap > 1 = the drop in HCO3 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 PCO2
Met alkalosis	High Bicarb	High	High PCO2
Resp alkalosis	Low PCO2	High	Low Bicarb
Respiratory acidosis	High PCO2	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	↓HCO3	1.2 drop in PCO2 for each 1 mmol decrease in HCO3
Met alkalosis	↑HCO3	0.7 rise in PCO2 for every 1 mmol rise in HCO3
Acute resp acidosis	↑PCO2	1 mmol rise in HCO3 for every 10 point increase in PCO2
Ch resp aciodosis	↑PCO2	3.5 mmol rise in HCO3 for every 10 point increase in PCO2
Acute resp alkalosis	↓PCO2	2 mmol drop in HCO3 for every 10 point fall in PCO2
Ch resp alkalosis	↓PCO2	4 mmol drop in HCO3 for every 10 point fal in PCO2

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	PCO2	HCO3
7.1	17	5

a. What is the acid base disorder?

b. What else do we need to know ?

c. What is the clinical diagnosis?

Na 130 mmol/l, Cl 105 mmol/l

Interactive Case-2

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

ABG showed :

pH	HCO3	PCO2
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 , PCO_2= 55 , HCO_3= 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 , PCO_2= 48 , HCO_3= 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 HCO_3= 8 , PCO_2= 21

Na= 133 , Cl=105

- Acidemia
- Metabolic acidosis
- Exp PCO_2 = 20
- AG = 20
- ΔAG =8
- ΔHCO_3 =16

- Dx: combined Gap and non-Gap metabolic acidosis (Diarrhea induced HCO_3 loss and Lactic acidosis)