Interpretation of Mixed Acid Base Disorders- No Da Vinci Code

by

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PNS SHIFA

ARTERIAL BLOOD GASES

- Measured on a Blood Gas Analyser.
- Sample of whole blood is directly injected into the analyser without delay

Site for Sample Collection

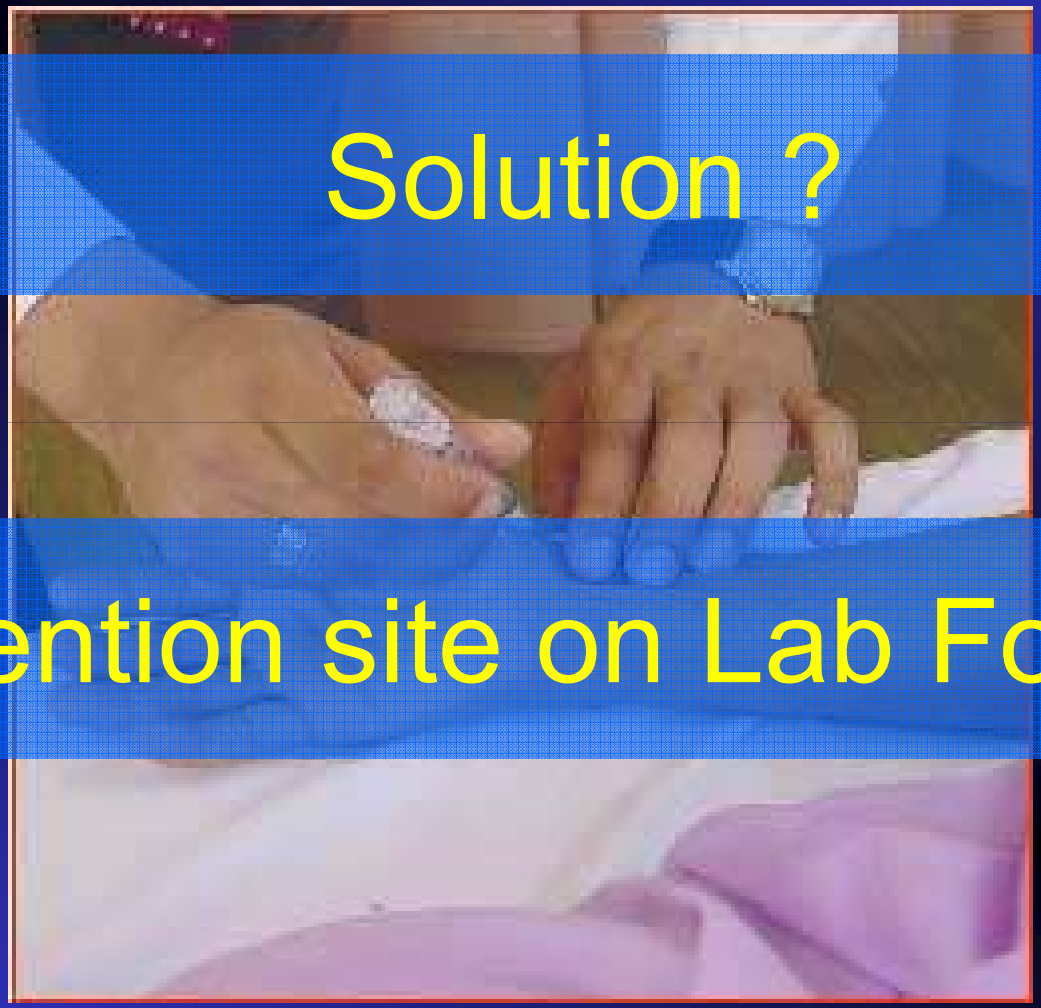
- Best site ?

- Why ?
- No vein adjacent to Radial Artery

Arterial or Venous Blood ??

	arterial blood	venous blood	COPD
pH	7.35-7.45	7.31-7.40	7.27
PCO2	35-45mmHg (4.7-6.0 kPa)	41-51mmHg (5.5-6.8kPa)	54mmHg
HCO3-	22-28mmol/l	25-29mmol/l	31mmol/l
PO2	> 80mmHg (>10.6kPa)	38-42 mmHg (5.1-5.6kPa)	40mmHg

Solution ?



Mention site on Lab Form

Measured and Calculated Tests

Measured parameters:

- pH
- *Partial Pressure of Carbon dioxide (PCO_2)*
- *Partial Pressure of oxygen (PO_2)*

• Calculated parameters:

- HCO_3 using Henderson Hasselbalch equation
- Base Excess (BE)

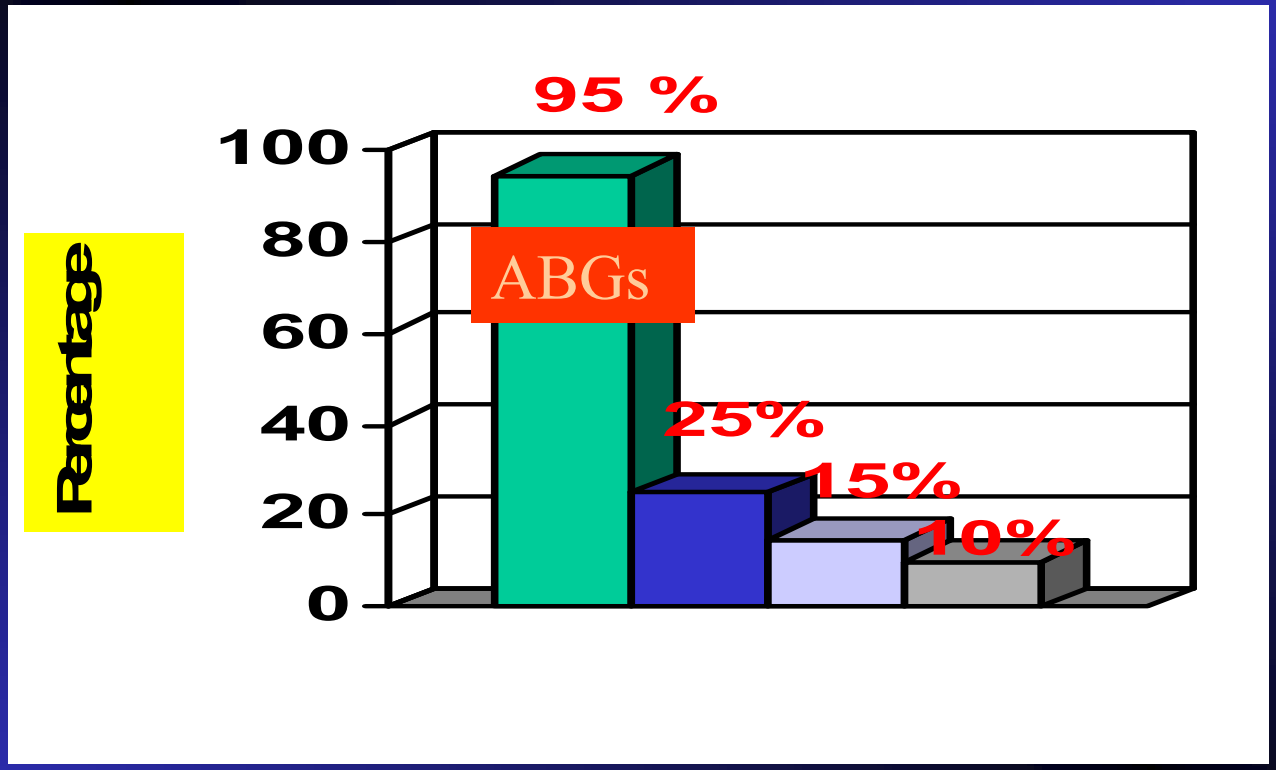
ABG measurement – Some unique things

- Samples to reach lab within 15 minutes
- No incubation or reagent mixing
- Instant results
- Invalid if result delayed
- “bedside use” with some precautions

ABG measurement – An expensive test

- Quite expensive investigation
- Under-utilized
- Cost of even one test per day is also very high
- Proper interpretation is required for optimum use

ABG measurement – High diagnostic yield



Types of Acid Base Disorders

- Single (simple) disorders
- Double (mixed) disorders
- Triple (mixed) disorders

Simple (Single) Disorders

- Metabolic Acidosis
- Metabolic Alkalosis
- Respiratory Acidosis
- Respiratory Alkalosis

Double Disorders

- Metabolic and Respiratory Acidosis
- Metabolic and Respiratory Alkalosis
- Metabolic Alkalosis and Respiratory Acidosis
- Metabolic Acidosis and Metabolic Alkalosis

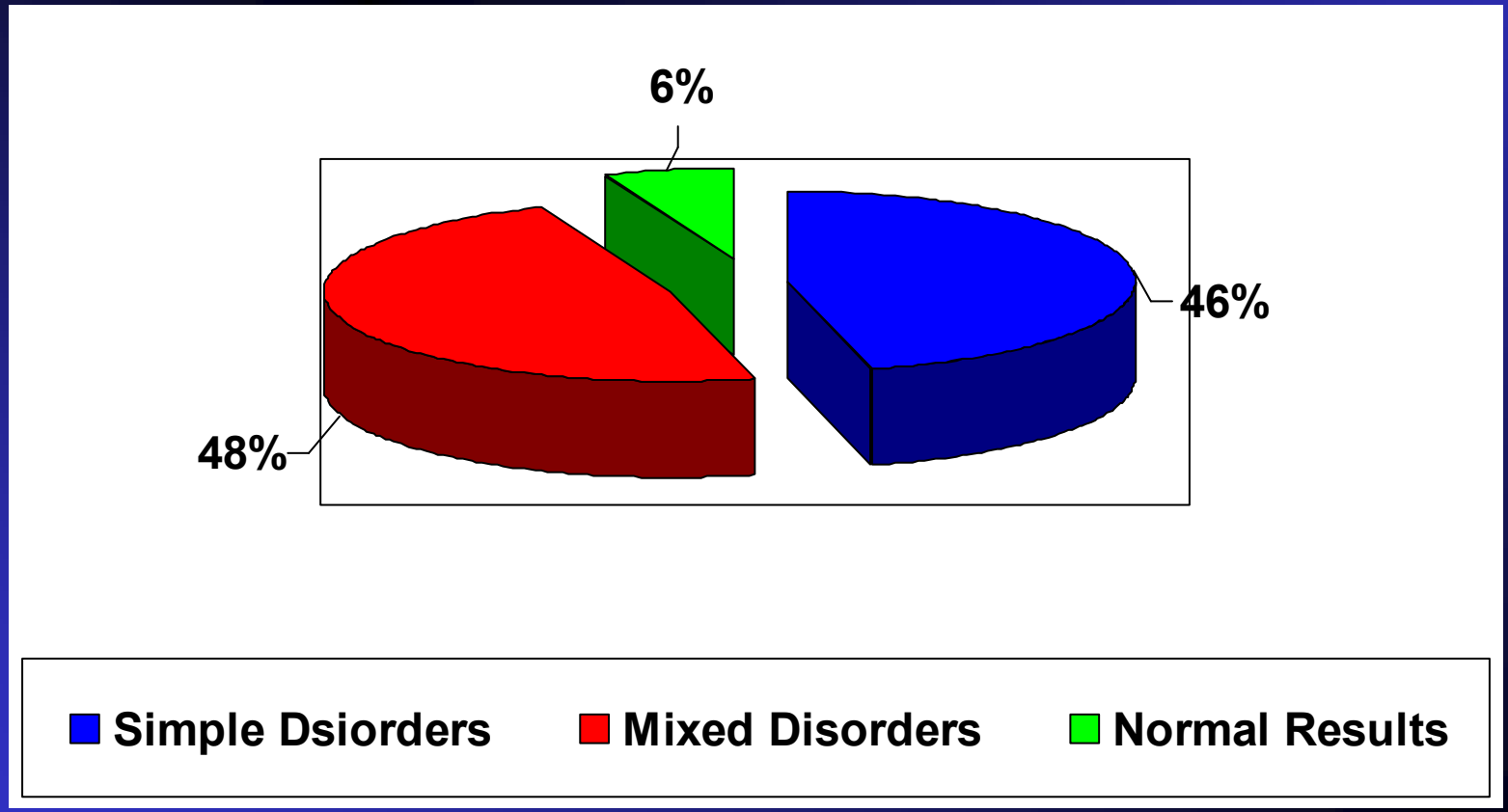
Triple Disorders

Metabolic Acidosis, Metabolic Alkalosis and Respiratory Alkalosis:

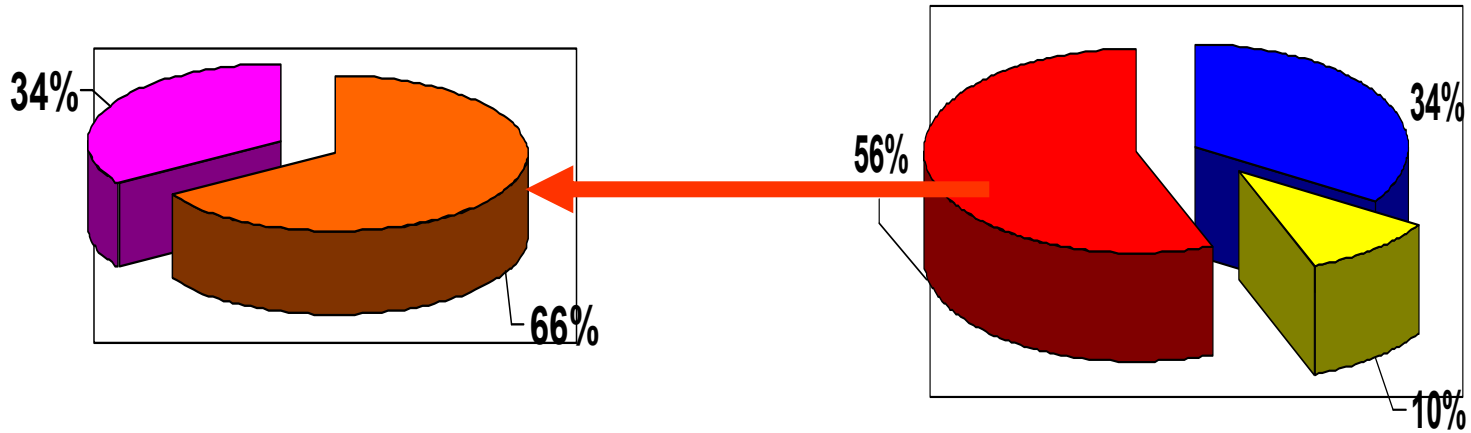
beyond “salicylate poisoning”

Any high anion gap acidosis complicated by vomiting and hyperventilation can cause this disorder

Pattern of ABG results from CCU,ICU and NICU in 45 days (n=114)



Distribution of Mixed Acid Base Disorders in a Critical Care Units (PNS SHIFA) in 45 days (n=67)



Analysing ABG Reports

- Clinical features
- Results of other investigations e.g. electrolytes etc
- ABG result necessary for confirmation of diagnosis
- Biochemical opinion may be given even with meagre information

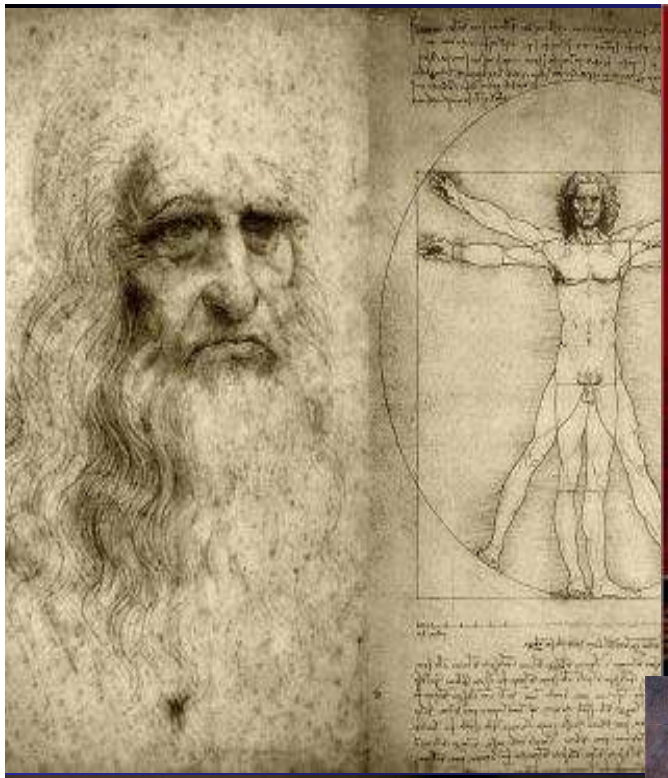
Treatment Principles of Acid-Base Disturbances

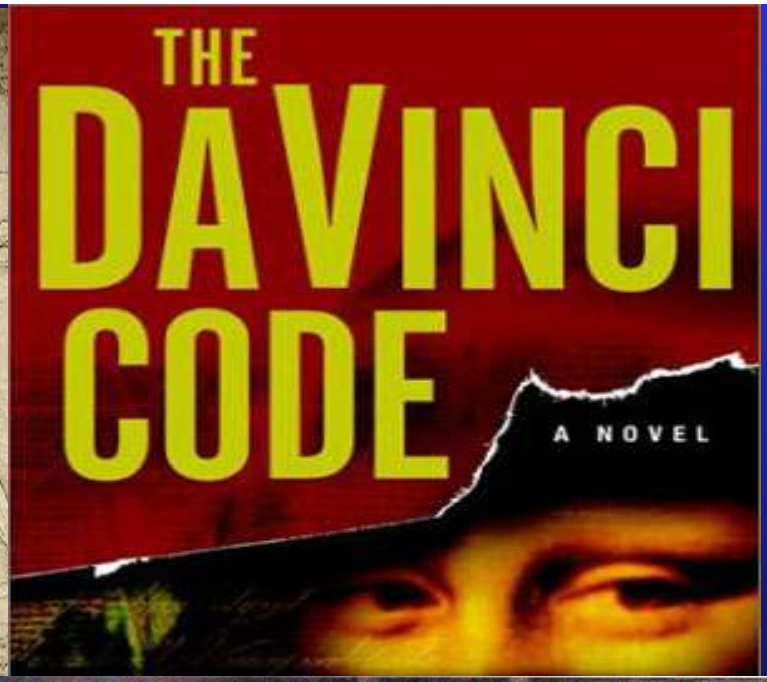
The 3-Cs

Correct analysis
(always be alert to the presence of mixed disturbances)

Correct disturbance
(buy time, don't over do)

Correct disease
(a **MUST** if possible)

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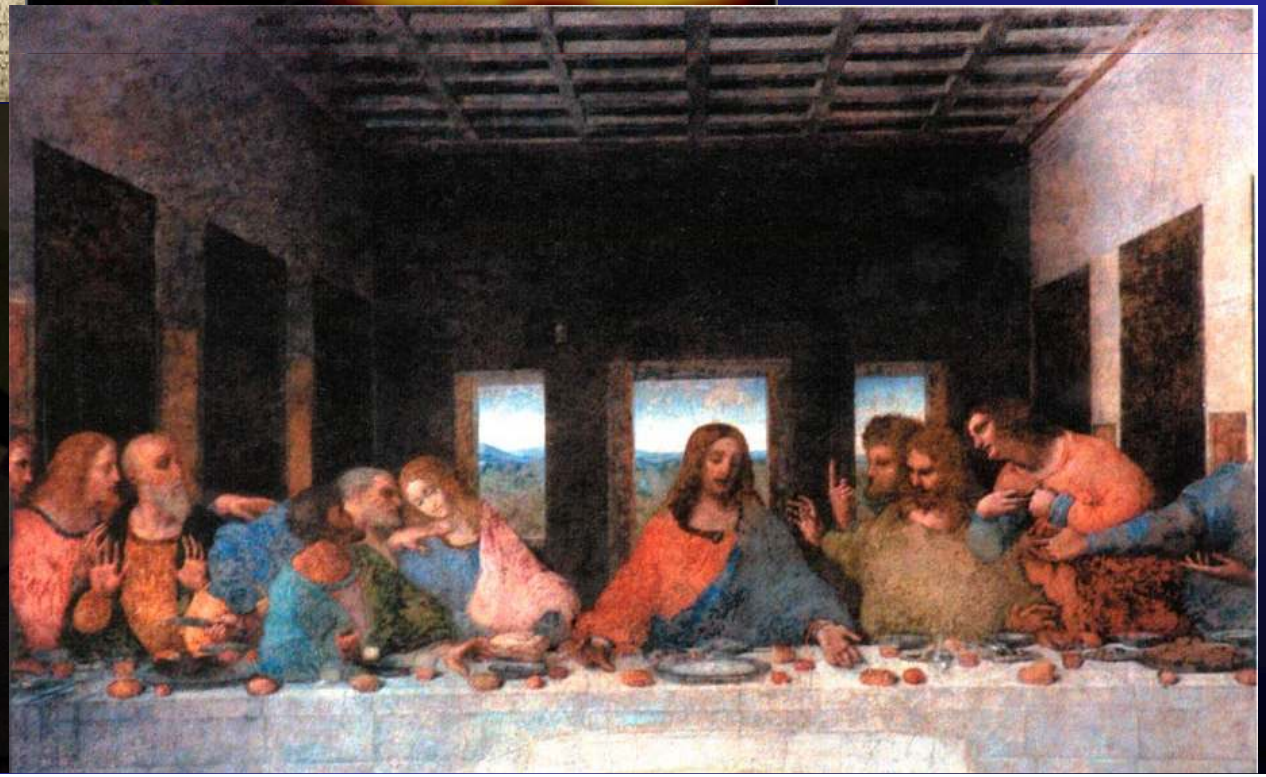


Decoding an ABG Report

Look at pH

- **Low pH**-----Acidosis
- **High pH**----Alkalosis
- **Normal pH**--- A normal pH does not rule out existence of an acid base disorder (see below)

If pH is abnormal Examine PCO2 and HCO3 relationship

- If PCO2 and HCO3 change in the same direction, it is a **single disorder.**

Example:.

- *in Metabolic Acidosis (i.e. decreased HCO3), PCO2 should decrease. If it is decreased, consider Metabolic Acidosis with Respiratory Compensation (Single Disorder)*

If pH is abnormal Examine PCO2 and HCO3 relationship (Cont)

- If PCO2 and HCO3 change in the opposite direction, it is a **double disorder**
  Example:
- *in Metabolic Acidosis (i.e. decreased HCO3), PCO2 should decrease. If it is increased, consider Metabolic Acidosis with Respiratory Acidosis (Double Disorder)*

Examine pH and HCO3 relationship (For single disorders)

If pH and HCO3change in the same direction primary abnormality is metabolic

- *Examples:*
  - *in metabolic acidosis both pH and HCO3 decrease*
  - *in metabolic alkalosis both pH and HCO3 increase*

Examine pH and HCO3 relationship (For single disorders) (Cont)

If pH and HCO3 change in the opposite direction primary abnormality is respiratory

- *Examples:*
  - *in respiratory acidosis pH decreases and HCO3 increases*
  - *in respiratory alkalosis pH increases and HCO3 decreases*

If pH is normal Examine PCO2 and HCO3 relationship again

If PCO2 and HCO3 **grossly** change in the same direction, it is also a **double disorder**

Examples:

- *in Metabolic Acidosis (i.e. decreased HCO3), PCO2 should decrease to a certain extent. If it is decreased too much, consider Metabolic Acidosis with Respiratory Alkalosis (Double Disorder)*

- *in Respiratory Acidosis (i.e. increased PCO2), HCO3 should increase to a certain extent. If it is increased too much, consider Respiratory Acidosis with Metabolic Alkalosis (Double Disorder)*

If pH, PCO_2 and HCO_3 all are normal

Normal Acid Base Status !!

(----but please be careful of values on the extreme of reference ranges, which may be due to a fully compensated disorder like Chronic Respiratory Alkalosis or mild double disorders)

ANION GAP

- It is a measure of anions other than HCO_3 and Chloride
- Biochemical Basis:

  Always:

  CATIONS = ANIONS

ANION GAP (Biochemical Basis)

- Major Cat-ions:
  - Na = 140 mmol/L
  - K = 4 mmol/L
  - Ca = 4.5 mmol/L
  - Mg = 1.5 mmol/L

TOTAL CATIONS = 150 mmol/L

ANION GAP (Biochemical Basis)

- Major Anoins:
  - Cl = 100 mmol/L
  - HCO_3 = 27 mmol/L
  - proteins = 15 mmol/L
  - PO_3 = 2 mmol/L
  - SO_3 = 1 mmol/L
  - Organic Acids = 5 mmol/L

TOTAL ANIONS = 150 mmol/L

Anion Gap:

- Calculated as following:

  $(Na + K) - (Cl + HCO) = 18$ mmol/L

  Range : 7 – 18 mmol/L
- It is only a lab derived index
- There can *Never* be an anion gap in any condition because electroneutrality is always maintained in the plasma

High Anion Gap
(Hyperkalaemic Metabolic Acidosis)

- Increased unmeasured Anions
  - Ketoacidosis
  - Lactic Acidosis
  - Renal Failure
  - Poisoning
    - Methanol
    - Ethanol
    - Salicylates
    - others

Normal Anion Gap
(Hypokalaemic Metabolic Acidosis)

- Diarrhoea:
  - Loss of HCO_3
  - Loss of K
- Renal Tubular Acidosis
- Acetazolamide therapy
- Uretro-illeal shunt

DELTA RATIO

The delta ratio is used for the determination of a mixed acid base disorder in an elevated anion gap metabolic acidosis

$$\frac{\text{Measured anion gap} - \text{Normal anion gap}}{\text{Normal } [HCO_3^-] - \text{Measured } [HCO_3^-]}$$

or

$$\frac{(\text{anion gap} - 12)}{(24 - [HCO_3^-])}$$

Delta Ratio Assessment Guideline

< 0.4	Hyperchloraemic normal anion gap acidosis
0.4 - 0.8	• Renal failure • Combined high AG & normal AG acidosis
1 to 2	•Uncomplicated high-AG acidosis •Lactic acidosis: 1.6 (average value)
>2	A pre-existing elevated HCO3 level due to: –a concurrent metabolic alkalosis, or –a pre-existing compensated respiratory acidosis

Predicted HCO3

Predicted [HCO3] = 24 -[Anion Gap-12]

- If patient's [HCO3] > Predicted [HCO3]
  - Metabolic acidosis + Metabolic Alkalosis
  - Compensatory response to resp acidosis

If patient's [HCO3] =Predicted [HCO3]

  - Simple Metabolic acidosis

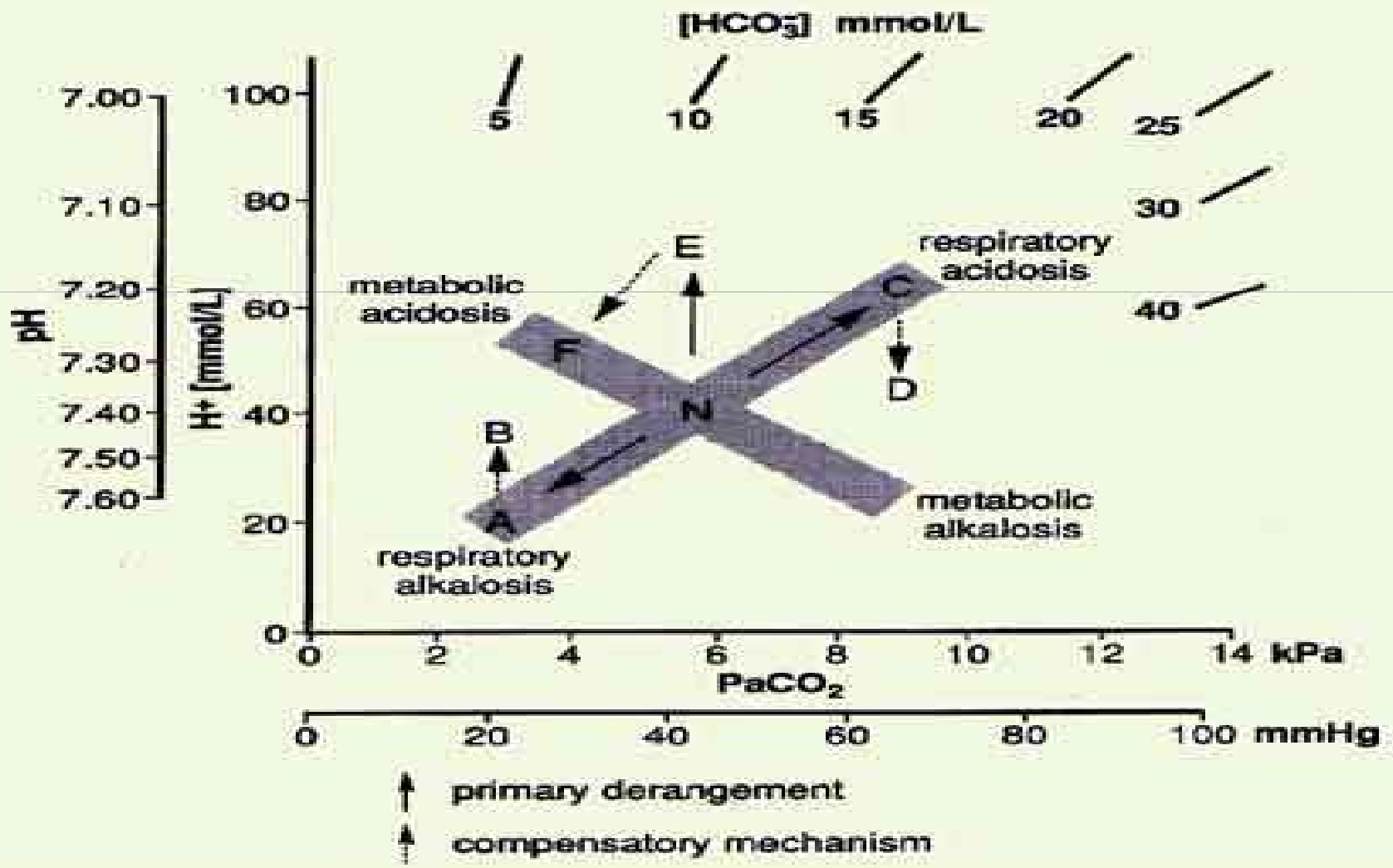
- If patient's [HCO3] < Predicted [HCO3]
  - Compensatory response to resp alkalosis

Other Interpretation Assistants

- Flenley's Graph
- Electronic Calculators (*Skyscape for desktop, ipads etc).*
- Equations (or Formulas) – usually required for interpreting more subtle changes in ABGs.

Flenley's graph

By plotting the result of the pH, HCO3 and Paco2 on the graph, a mixed ABG disturbance is present if the point falls outside the arms of the CROSS.



Learning Points

- **ABG samples should be sent to the lab immediately and ask for results instantly**

- **Mixed disturbances are very common in critically ill patients because of multiple pathologies**

- **Always be on the lookout for Mixed Disturbance**

Acknowledgement

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