Acid/Base Disorders

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Overview

- Definitions
- Pathophysiology
- Diagnosis
- Differential Diagnosis
- Treatment Options
- Test Cases
- Conclusion/Questions

Acidosis

- An Acid producing process not necessarily producing an acidic PH. The Ph can be normal (7.35-7.45) or high (>7.45) i.e. lactic acidosis, ketoacidosis
- May be due to increase Acid production or to Base loss
- Can result from either a respiratory or metabolic process

Alkalosis

- A Base producing process not necessarily causing an alkaline PH. PH can be normal (7.35-7.45) or low (<7.35)
- May be due to increase in base production or increased acid loss
- Can result from either a respiratory or metabolic process

Acidemia = An acidic blood PH in hence an increased [H+] ion concentration

Alkalemia = A basic blood PH hence a decreased [H+] ion concentration

How do you make the distinction to figure out what is going on? Acidosis, Alkalosis, Metabolic or Respiratory or a mixed Acid-Base Disorder?

- Electrolytes (SMA-7)
- ABG

[HCO3-]?

- Low HCO3 suggests Acidosis
- High HCO3 suggests Alkalosis

ANION GAP?

- A.G.=[Na+] – [Cl- +   HCO3-]
- A.G. represents unaccountable anions
- H+ Lactate-   (organic acid)
- H+ Ketoacids-   "
- H+ Salicylate-   "
- If A.G. is elevated it suggests that there are unexplained/unaccountable anions circulating about.
- Normal A.G.= 10-12 (unaccounted for anions)
- If A.G. is elevated than we have more anions than expected. Where are they coming from?

A.G. >10-12 = DX is A.G. Metabolic Acidosis

Usually Organic Acidosis

A.G. Metabolic Acidosis DDX

- Methanol
- Uremia
- DKA, Drugs
- Paraldehyde
- Infection
- Lactic acidosis
- Ethylene Glycol, Ethanol
- Salicylates, Starvation

Normal A.G.+Low [HCO3]+Acidemic PH

Conclusion

No presence anion gap metabolic acidosis but a nonanion gap metabolic acidosis is present. Therefore a normal A.G. may mean patient is truly normal but does not rule out an acidosis.

Nonanion Gap Metabolic Acidosis

- Hypoaldosteronism
- Acetozolamide (carbonic anhydrase inh.)
- Renal Tubular Acidosis
- Diarrhea, Drainage(fistula, drain)
- Ureterosigmoidostomy
- Potassium sparing diuretics Spironolactone

Step 1 [HCO3] (Normal = 24)

Low, Normal or High?

Step 2 Calculate A.G.

Elevated or Normal

Step 3 ABG PH

Acidemic or Alkalemic?

Normal PH

Henderson Hasselbach

- H20+CO2⇔ H2CO3⇔H+HCO3

  Increases or Decreases in extreme components cause a shift in the equilibrium relationship.

$H20 + CO2 \Leftrightarrow H2CO3 \Leftrightarrow H + HCO3$

1)An indication for obtaining an ABG may only be a low HCO3 with or without an associated anion gap since an acidosis is suspected. The above equation will be shifted to the left favoring the depletion of HCO3- in order to neutralize the excess acid H+.

2) [HCO3] can be depleted by hyperventilation, How?

Ex. Low PCO2 and Alkalemia=?

Ex. Low [HCO3] and normal PCO2=?

Ex. High PCO2 an Acidemic PH=?

Conclusion Blood Gases determine Respiratory or Metabolic etiology.

$H20+CO2 \Leftrightarrow H2CO3 \Leftrightarrow H+HCO3$

- Step 4 PCO2
- Step 5 Calculate Winters Formula

Winters Formula

- Predicted PCO2 = 1.5 X [HCO3] +8 +/- 2
- Determines in an acidosis if the pulmonary system is working properly.
- Result should approximate measured PCO2
- Use measured [HCO3] not calculated [HCO3]
- If predicted PCO2 and measured PCO2 don’t agree than something else (independent) is going on in the pulmonary system i.e. overcompensation.

Example

- If [HCO3] = 20
- Using W.F. Predicted PCO2 = 38 +/- 2
- If Meas. PCO2 >> Pred. PCO2
- Conclusion: Primary respiratory disorder in this case respiratory acidosis
- If Meas. PCO2<< Pred. PCO2
- Conclusion: Primary respiratory disorder in this case respiratory alkalosis (overcompensation)

!!! You cannot fully compensate for either an acidosis or alkalosis to a normal PH or to a above or below normal PH respectively.

- If you have an acidosis and a normal or above normal PH than this is not compensation but a coexisting superimposed primary alkalosis!!!
- If you have an alkalosis and a normal or below normal PH than this is not compensation but a coexisting superimposed primary acidosis!!!

Compensatory Mechanisms

- Kidneys reabsorb or excrete [HCO3]
- Kidneys trap H+ with ammonia in the tubules promoting excretion various other pumps facilitate H+ balance
- Lungs hyperventilate
- H20+CO2⇔ H2CO3⇔H+HCO3

Metabolic Alkalosis

- Suspected if [HCO3] is increased
- Usually iatrogenic
- Vomiting, N.G. tube, Gastric fistula
- Volume Contraction (diuretics, dehydration) How?
- Severe Potassium Depletion
- Bicarbonate Administration

Delta Delta(Predicted[HCO3])

H20+CO2⇔ H2CO3⇔H+HCO3

X	24
(X+10)	14

Adding H+ from some other acid lowers bicarbonate by equal molar amounts in a 1:1 ratio.

Example using Predicted [HCO3]

- A.G. = 22 (10 extra unaccountable anions above normal)
- Delta Delta = 24 – [A.G. – 12]
- Predicted [HCO3] = 24 – [22 – 12] = 14
- $H_2O + CO_2 \Leftrightarrow H_2CO_3 \Leftrightarrow H + HCO_3$

	H	HCO_3
before	X	24
after	(X+10)	14

$H20+CO2 \Leftrightarrow H2CO3 \Leftrightarrow H+HCO3$

If measured [HCO3] = Predicted [HCO3] then pure metabolic acidosis or alkalosis exists alone.

$H20+CO2 \Leftrightarrow H2CO3 \Leftrightarrow H+HCO3$

- If meas. [HCO3] > pred. [HCO3] then there is more [HCO3] than expected and a coexisting superimposed metabolic alkalosis exists or excess CO2 secondary to hypoventilation and hence a respiratory acidosis exists. Check PCO2.

- If meas. [HCO3] < pred. [HCO3] then there is a less [HCO3] than expected and a coexisting superimposed metabolic acidosis exists or if PCO2 is low than a superimposed respiratory alkalosis exists.

Summary

- Step 1 [HCO3]
- Step 2 A.G.
- Step 3 PH
- Step 4 PCO2
- Step 5 Winters Formula PCO2 comparing measured and predicted
- Step 6 Predicted [HCO3]
- Step 7 Diagnosis

Example #1

18 year old male flu like symptoms abdominal pain, N/V, clinically dehydrated, tachypneic.

Na = 140 PH = 7.36

Cl = 100 PCO2 = 30

HCO3 = 20

Glucose = 500

BUN = 30

Cr = 1.1

Diagnosis

1) A.G. Metabolic acidosis
   DKA, Lactic Acidosis
2) Respiratory Alkalosis
   Hyperventilatio-
overcompensation
3) Metabolic alkalosis
vomiting, volume contraction

Example 2

48 year old diabetic with N/V for 1 month.

Na = 144 PH = 7.42

Cl = 90 PCO2 = 40

HCO3 = 22

Glucose = 140

BUN = 68

Cr = 12

Diagnosis

Anion gap metabolic acidosis with adequate respiratory compensation sec. Renal Failure

Metabolic alkalosis
vomiting

24 year old female bulimic depressed patient found unresponsive.

Na = 140 PH = 7.28

Cl = 98 PCO2 = 46

HCO3 = 18

Glucose = 90

BUN = 28

Cr = 0.9

Diagnosis

1) A.G. Metabolic acidosis secondary to ASA intoxication
2) Respiratory acidosis sec. to respiratory failure
3) Metabolic alkalosis secondary to purging

Treatment

- ABC’s, O_2, IV
- Continued support of respiratory status
- Hydration?
- **Treat underlying cause**
- Bicarbonate administration?