approach to ABG analysis [created by Paul Young 14/12/07]

1 pH: - Check arterial pH

Principle:
- The net deviation in pH will indicate whether an acidosis or an alkalosis is present

Guidelines:
- IF an acidaemia is present THEN an acidosis must be present
- IF an alkalaemia is present THEN an alkalosis must be present
- IF pH is normal pH THEN Either (no acid-base disorder is present) or (Compensating disorders are present ie a mixed disorder with an acidosis and an alkalosis)

2. assess the pattern

Principle:
- Each of the simple disorders produces predictable changes in [HCO3] & pCO2.

Guidelines:
- IF Both [HCO3] & pCO2 are low THEN Suggests presence of either a Metabolic Acidosis or a Respiratory Alkalosis (but a mixed disorder cannot be excluded)
- IF Both [HCO3] & pCO2 are high THEN Suggests presence of either a Metabolic Alkalosis or a Respiratory Acidosis (but a mixed disorder cannot be excluded)
- IF [HCO3] & pCO2 move in opposite directions THEN a mixed disorder MUST be present

3. look for associated clues

Principle:
- Certain disorders are associated with predictable changes in other biochemistry results

Guidelines:
(i) High anion gap
- Always strongly suggests a metabolic acidosis.
(ii) Hyperglycaemia
- If ketones also present in urine -> diabetic ketoacidosis
(iii) Hypokalaemia and/or hypochloraemia
- Suggests metabolic alkalosis
(iv) Hyperchloraemia
- Common with normal anion gap acidosis
(v) Elevated creatinine and urea
- Suggests uraemic acidosis or hypovolaemia (prerenal renal failure)
- With an elevated creatinine consider ketoacidosis: ketones interfere in the laboratory method (Jaffe reaction) used for creatinine measurement & give a falsely elevated result; typically urea will be normal.
(vi) Elevated glucose
- Consider ketoacidosis or hyperosmolar non-ketotic syndrome
(vii) Urine dipstick tests for glucose and ketones
- Glucose detected if hyperglycaemia; ketones detected if ketoacidosis

4. assess the compensatory response

Rule 1 : The 1 for 10 Rule for Acute Respiratory Acidosis
- The [HCO3] will increase by 1 mmol/l for every 10 mmHg elevation in pCO2 above 40 mmHg.

Expected [HCO3] = 24 + { (Actual pCO2 - 40) / 10 }

- The increase in CO2 shifts the equilibrium between CO2 and HCO3 to result in an acute increase in HCO3. This is a simple physicochemical event and occurs almost immediately.

Rule 2 : The 4 for 10 Rule for Chronic Respiratory Acidosis
- The [HCO3] will increase by 4 mmol/l for every 10 mmHg elevation in pCO2 above 40mmHg.

Expected [HCO3] = 24 + 4 { (Actual pCO2 - 40) / 10}

- With chronic acidosis, the kidneys respond by retaining HCO3, that is, renal compensation occurs. This takes a few days to reach its maximal value.

Rule 3 : The 2 for 10 Rule for Acute Respiratory Alkalosis
- The [HCO3] will decrease by 2 mmol/l for every 10 mmHg decrease in pCO2 below 40 mmHg.

Expected [HCO3] = 24 - 2 { (40 - Actual pCO2) / 10 }

- In practice, this acute physicochemical change rarely results in a [HCO3] of less than about 18 mmol/s. (After all there is a limit to how low pCO2 can fall as negative values are not possible!) So a [HCO3] of less than 18 mmol/l indicates a coexisting metabolic acidosis.

Rule 4 : The 5 for 10 Rule for a Chronic Respiratory Alkalosis
- The [HCO3] will decrease by 5 mmol/l for every 10 mmHg decrease in pCO2 below 40 mmHg.

Expected [HCO3] = 24 - 5 { (40 - Actual pCO2) / 10 } (range: +/- 2)

- It takes 2 to 3 days to reach maximal renal compensation
- The limit of compensation is a [HCO3] of about 12 to 15 mmol/l

Rule 5 : The One & a Half plus 8 Rule - for a Metabolic Acidosis

- The expected pCO2 (in mmHg) is calculated from the following formula:

Expected pCO2 = 1.5 x [HCO3] + 8 (range: +/- 2)

- Maximal compensation may take 12-24 hours to reach
- The limit of compensation is a pCO2 of about 10 mmHg
- Hypoxia can increase the amount of peripheral chemoreceptor stimulation

Rule 6 : The Point Seven plus Twenty Rule - for a Metabolic Alkalosis
- The expected pCO2(in mmHg) is calculated from the following formula:

Expected pCO2 = 0.7 [HCO3] + 20 (range: +/- 5)

- The variation in pCO2 predicted by this equation is relatively large.

5. check additional indices for metabolic acidoses

anion gap
- An elevated Anion Gap always strongly suggests a Metabolic Acidosis.
- the 'normal anion gap depends on the serum phosphate and the serum albumin.
anion gap = 0.2 x [albumin] (g/L) + 1.5 x [phosphate] (mmol/L)
- If AG is 20-30 then high chance (67%) of metabolic acidosis
- If AG is > 30 then a metabolic acidosis is definitely present
causes of raised anion gap are MUDPILES
causes of a normal anion gap are USED CRAP
causes of a low anion gap are:
(i) decreased unmeasured anions (albumin, dilution)
(ii) increased unmeasured cation (multiple myeloma, hypercalcaemia, hypermagnesaemia, acute lithium overdose, polymixin B)
(iii) non random analytical errors (increased sodium, increased viscosity, iodide ingestion, increased lipids)

Delta Ratio
< 0.4 - Hyperchloraemic normal anion gap acidosis
0.4 to 0.8 - Combined high AG and normal AG acidosis
1 - Common in DKA due to urinary ketone loss
1 to 2 - Typical pattern in high anion gap metabolic acidosis
> 2 Check for either a co-existing Metabolic Alkalosis (which would elevate [HCO3]) or a co-existing Chronic Respiratory Acidosis (which results in compensatory elevation of [HCO3])