Deacon's Challenge
No 164 - Answer

A neonate weighing 850 g is admitted to the Neonatal Intensive Care Unit. Following intubation and artificial ventilation, blood gases reveal an arterial blood hydrogen ion concentration of 120 nmol/L and a pCO_2 of 6.2 kPa. Estimate the dose of sodium bicarbonate (1.25%) required to reduce the hydrogen ion concentration to 80 nmol/L. You should assume that ventilator settings remain unchanged, and ignore any effects due to changes in plasma volume and peripheral circulation. You should assume also that the total body water in neonates is 80% of body mass, due to an expansion of extracellular fluid volume compared to adults, and is evenly distributed between intra- and extracellular compartments.

FRCPath, Autumn 2013

The hydrogen ion concentration (in **nmol/L**), multiplied by the bicarbonate concentration (in **mmol/L**) and divided by the pCO_2(in **kPa**) is always constant at 180:

$$180 = \frac{[H^+][HCO_3^-]}{pCO_2}$$

To calculate the initial bicarbonate concentration substitute:

$[H^+] = 120$ nmol/L and $pCO_2 = 6.2$ kPa

so that $180 = \frac{120[HCO_3^-]}{6.2}$

$$[HCO_3^-] = \frac{180 \times 6.2}{120} = 9.3 \text{ mmol/L}$$

Similarly substitute $[H^+] = 80$ nmol/L in order to calculate the final plasma bicarbonate concentration (assume pCO_2 is still 6.2 kPa since the ventilator settings remain unchanged):

$$180 = \frac{80[HCO_3^-]}{6.2}$$

$$[HCO_3^-] = \frac{180 \times 6.2}{80} = 14.0 \text{ mmol/L}$$

Therefore administration of bicarbonate has increased the plasma bicarbonate concentration by 14.0 – 9.3 = 4.7 mmol/L

A smaller amount of bicarbonate has been consumed in reducing the $[H^+]$ from 120 to 80 nmol/L. i.e. 40 nmol/L of hydrogen ions have been neutralized by the administered bicarbonate. Therefore another 40 nmol/L = 0.00004 mmol/L are needed, which is small enough to be ignored.

Assuming administered HCO_3^- remains in the ECF and is not metabolized:

$$\text{Change in } HCO_3^- \text{ (mmol/L)} = \frac{\text{Amount of } NaHCO_3 \text{ given (mmol)}}{\text{ECF vol (L)}}$$

ECF vol (L) = Body wt (Kg) x % body water x Proportion of water in ECF

$$= 0.85 \times \frac{80}{100} \times \frac{1}{2} = 0.34 \text{ L}$$

$$4.7 = \frac{\text{Amount of } HCO_3^- \text{ needed (mmol)}}{0.34}$$

Amount of HCO_3^- needed = 4.7 x 0.34 = 1.60 mmol

Calculate concentration of sodium bicarbonate solution (1.25%) in mmol/L:

MW $NaHCO_3^-$ = 23 + 1 + 12 + (3 x 16) = 84

Therefore $[HCO_3^-] = \frac{1.25 \times 10 \times 1000}{84} = 149$ mmol/L

Volume needed (L) $= \frac{\text{Amount needed (mmol)}}{\text{Concentration (mmol/L)}} = \frac{1.60}{149} =$ **0.0107 L i.e. 10.7**

Question 165

An inherited metabolic disease is due to a gain in function of enzyme X. The erythrocyte activity of X was measured in 100 normal subjects and 100 patients with the disease. The 95% confidence limits of the two groups are:

Unaffected:	89 – 901 IU/L red cells
Diseased:	830 – 5260 IU/L red cells

The data from the unaffected group showed a normal Gaussian distribution. However, the data from the diseased group were markedly skewed but a simple logarithmic transformation produced a reasonable Gaussian distribution.

It is proposed to use the assay of X in erythrocytes as a screening test for the disease. Calculate the decision level which will result in a sensitivity of 95%. What specificity will this achieve?

Two tailed *z*-distribution:

P(%)	10	5	2	1	0.2	0.1
z	1.65	1.96	2.33	2.58	3.09	3.29

FRCPath, Spring 2014