Deacon's Challenge

No 138 - Answer

The following results were obtained on a neonate weighing 1.06 kg:

pH = 7.143
Pco_2 = 5.02 kPa

The consultant gives the child a 6 mL bolus of sodium hydrogen carbonate 4.2%. The child is ventilated and no changes are made to the ventilator settings. Calculate the anticipated change in pH.

Assume that body water in infancy is 80% of body mass, evenly distributed between intra- and extra-cellular compartments.

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First calculate the original HCO_3^- from the basal pH and Pco_2 using the Henderson-Hasselbalch equation:

$$pH = pKa + \log_{10} \frac{[HCO_3^-]}{\alpha Pco_2}$$

$$7.143 = 6.1 + \log_{10} \frac{[HCO_3^-]}{0.225 \times 5.02}$$

$$7.143 - 6.1 = 1.043 = \log_{10} \frac{[HCO_3^-]}{1.1295}$$

Taking antilogs:

$$\text{antilog}_{10}\ 1.043 = 11.04 = \frac{[HCO_3^-]}{1.1295}$$

$$[HCO_3^-] = 11.04 \times 1.1295 = 12.47 \text{ mmol/L}$$

Next calculate the rise in plasma bicarbonate attributed to the administered $NaHCO_3$:

$$\text{MW } NaHCO_3 = 23 + 1 + 12 + (3 \times 16) = 84$$

$$4.2\%\ NaHCO_3 = 4.2 \text{ g/100 mL} = 42 \text{ g/L} = \frac{42 \times 1000}{84} = 500 \text{ mmol/L}$$

Therefore 6 mL 4.2% $NaHCO_3$ contains $\frac{500 \times 6}{1000}$ = 3 mmol $NaHCO_3$

Assuming administered HCO_3^- remains in the ECF and is not metabolised;

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

$$\text{ECF vol (L)} = \text{Body wt (kg)} \times \%\text{ body water} \times \text{Proportion of water in ECF}$$

$$= 1.06 \times \frac{80}{100} \times \frac{1}{2} = 0.424 \text{ L}$$

Therefore increase in plasma HCO_3^- = $\frac{3}{0.424}$ = 7.08 mmol/L

Next calculate the final HCO_3^- concentration (assuming that keeping the ventilator settings constant is able to maintain the same Pco_2):

$$\text{Final } [HCO_3^-] = \text{Initial } [HCO_3^-] + \text{Increase in } [HCO_3^-]$$

$$= 12.47 + 7.08 = 19.55 \text{ mmol/L}$$

Next calculate the final pH using the Henderson-Hasselbalch equation using the given Pco_2 and this final $[HCO_3^-]$:

$$pH = 6.1 + \log_{10} \frac{19.55}{0.225 \times 5.02} = 6.1 + \log_{10} 17.31 = 6.1 + 1.238 = 7.338$$

Finally subtract the initial pH to give the change in pH:

Change in pH = Final pH - Initial pH = 7.338 - 7.143 = + **0.195**

Question 139

A patient is given a loading dose of 250 μg of a new drug (MW = 781). After 12 hours, his serum drug concentration is estimated at 1.0 nmol/L. After a further 12 hours, the concentration is re-measured and is estimated at 0.8 nmol/L. Assuming the elimination of this drug follows first-order kinetics, calculate the volume of distribution and the rate constant of elimination.

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