Deacon's Challenge No. 89 Answer

An adult male (body weight 82 Kg) produces a 24h urine collection with a total volume of 1.56 L and a creatinine concentration of 9.5 mmol/L. His plasma creatinine concentration (in a blood collected during the urine collection period) was 95 µmol/L. Estimate the half life of plasma creatinine stating any assumptions that you make.

First calculate the *elimination rate constant* of creatinine (k_d), which is the fraction of the total creatinine excreted per unit of time:

$$k_d = \frac{\text{Rate of creatinine excretion}}{\text{Total available creatinine}}$$

The rate of creatinine excretion is simply the total amount of creatinine in the urine collection divided by the collection period:

$$\text{Rate of creatinine excretion (µmol/min)} = \frac{\text{Urine creatinine (mmol/L)} \times 1{,}000 \times \text{Urine vol (L)}}{24 \times 60}$$

(multiplication by 1,000 converts mmol/L to µmol/L and multiplication by 60 converts the urine collection period from h to min).

$$\text{Rate of creatinine excretion} = \frac{9.5 \times 1{,}000 \times 1.56}{24 \times 60} = 10.3 \text{ µmol/min}$$

The total available creatinine is the plasma creatinine multiplied by its volume of distribution (V_d):

$$\text{Total available creatinine (µmol)} = \text{Plasma creatinine (µmol/L)} \times V_d \text{ (L)}$$

Assuming that creatinine is distributed throughout the ECF only, and that creatinine in the interstitial fluid is freely exchangeable with plasma and hence available for renal filtration then V_d is the ECF volume. Assuming that the body is 60% water and that one third of this is in the ECF, then:

$$\text{ECF vol} = \frac{\text{Body wt (Kg)} \times 60\%}{3} = \frac{82 \times 60}{100 \times 3} = 16.4 \text{ L}$$

$$\text{Total available creatinine} = 95 \times 16.4 = 1558 \text{ µmol}$$

$$\text{So that } k_d = \frac{10.3}{1558} = 0.00661 \text{ min}^{-1}$$

k_d is related to the half-life ($t_{1/2}$) by the expression: $k_d = \frac{0.693}{t_{1/2}}$

Therefore: $t_{1/2} = \frac{0.693}{k_d} = \frac{0.693}{0.00661} =$ **105 min**

This problem can also be solved by employing the relationship between clearance (Cl), k_d and V_d frequently used in pharmacokinetics:

$$k_d = \frac{Cl}{V_d}$$

Question 90

A plasma sample has a total CO_2 content (TCO_2) of 28 mmol/L. If the pH is 7.4, estimate the pCO_2 (in kPa). (The pKa for this buffer system is 6.1, the millimolar solubility coefficient of CO_2 (in kPa) is 0.225).

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