Deacon's Challenge No. 21 Answer

A 25 year old woman was seen at an orthopaedic clinic. Since the age of 5 she had "knock knees" and had several osteotomies over the years to correct the deformities. Her height was 158 cm. Her mother and grandmother had mild knock knees. Laboratory results obtained on morning fasting samples were as follows:

Plasma phosphate	=	0.52	mmol/L
Plasma creatinine	=	89	µmol/L
Urine phosphate	=	13.5	mmol/L
Urine creatinine	=	6.52	mmol/L

She was on a reasonably constant diet, with moderate phosphate and calcium intake for several days before sample collection. Calculate:

a) The fractional excretion of phosphate (FEP).
b) The fractional tubular reabsorption of phosphate (TRP).
c) The renal tubular reabsorption of phosphate (TmP/GFR).

MRCPath, November 2001 - modified

a) The fractional excretion is the proportion of filtered phosphate (which is related to the GFR) which is excreted in the urine.

$$\text{Fractional excretion of phosphate (FEP)} = \frac{\text{phosphate clearance}}{\text{creatinine clearance}}$$

$$\text{Phosphate clearance} = \frac{U_{PO4} \times V}{P_{PO4}}$$

$$\text{Creatinine clearance} = \frac{U_{Cr} \times V}{P_{Cr}}$$

Where U_{PO4} = urine phosphate = 13.5 mmol/L
P_{PO4} = plasma phosphate = 0.52 mmol/L
U_{Cr} = urine creatinine = 6.52 mmol/L
P_{Cr} = plasma creatinine = 89 µmol/L
V = urine flow rate (mL/min)

$$FEP = \frac{U_{PO4} \times V}{P_{PO4}} \div \frac{U_{Cr} \times V}{P_{Cr}}$$

In order to divide invert the second clearance and multiply. The 'V' term then cancels:

$$FEP = \frac{U_{PO4} \times V}{P_{PO4}} \times \frac{P_{Cr}}{U_{Cr} \times V}$$

$$FEP = \frac{U_{PO4} \times P_{Cr}}{P_{PO4} \times U_{Cr}}$$

Substitute values for U_{PO4}, P_{Cr}, P_{PO4} and U_{Cr}. The same units must be used throughout. Creatinine is given in µmol/L, divide by 1000 to convert to mmol/L.

$$P_{Cr} = 89 \text{ µmol/L} = \frac{89}{1000} = 0.089 \text{ mmol/L}$$

$$FEP = \frac{13.5 \times 0.089}{0.52 \times 6.52} = \mathbf{0.35}$$

N.B: FEP is a ratio and so does not have any units.

b) The proportion of the filtered phosphate that is reabsorbed TRP must be the difference between the fraction excreted (FEP) and 1 (assuming that no phosphate is secreted by the tubules).

$$TRP = 1 - FEP$$

$$TRP = 1 - 0.35 = \mathbf{0.65}$$

c) Since TRP is the fraction of filtered phosphate that is reabsorbed, then provided a reasonable proportion is excreted in the urine i.e. the renal threshold is exceeded, mutliplication of TRP by the plasma phosphate concentration gives the maximum rate of phosphate reabsorption per litre of glomerular filtrate (TmP/GFR):

i.e. $$TmP/GFR = TRP \times P_{PO4}$$

substitute: TRP = 0.65; P_{PO4} = 0.52 mmol/L

$$TmP/GFR = 0.65 \times 0.52 = \mathbf{0.34 \text{ mmol/L glomerular filtrate}}$$

This calculation is based on the assumption that TRP < 0.86 and so the patient's values lie on the linear part of a plot of urinary phosphate excretion versus plasma phosphate.

Reference: Payne R B. Renal tubular reabsorption of phosphate (TmP/GFR): indications and interpretation. *Ann Clin Biochem* 1998; **35:** 201-206. ■

Question No. 22

A patient's arterial blood results showed a P_{O2} of 12 kPa, haemoglobin concentration of 150 g/L and an oxygen saturation of 98%. Calculate the total oxygen content of his blood in mL/L.

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