Chapter 7

Question 7.4

The question asks us to calculate the ultrafiltration coefficient for the glomeruli (K_f) using the mean values provided.

SNGFR equals the product of ultrafiltration coefficient (K_f) and the effective filtration pressure (P_{UF}) of a glomerulus, which is expressed by the following equation:

$$\text{SNGFR} = K_f \times P_{UF} \qquad \text{Equation 1}$$

Rearranging Equation 1 and incorporating the units, in brackets, gives the following relationship:

$$K_f\ (\text{nL min}^{-1}\ \text{kPa}^{-1}) = \frac{\text{SNGFR (nL min}^{-1})}{P_{UF}\ (\text{kPa})} \qquad \text{Equation 2}$$

The question gives values for the pressures that allow calculation of P_{UF} from the relationship

$$P_{UF} = P_{GC} - P_{BC} - P_{COP}\ (\text{kPa}) \qquad \text{Equation 3}$$

in which:

P_{GC} = Blood pressure in the glomerular capillaries = 6.7 kPa
P_{BC} = Hydrostatic pressure in Bowman's capsule = 1.6 kPa
P_{COP} = Colloid osmotic pressure difference between renal arterial blood plasma and the fluid in Bowman's capsule = 3.3 kPa

Substituting the values provided into Equation 2:

$$K_f\ (\text{nL min}^{-1}\ \text{kPa}^{-1}) = \frac{20\ (\text{nL min}^{-1})}{6.7 - 1.6 - 3.3\ (\text{kPa})}$$

$$= \mathbf{11.11\ \ nL\ min^{-1}\ kPa^{-1}}$$

Question 7.7

(i) Glomerular filtration rate (mL min^{-1})

Glomerular filtration rate (GFR) is the product of urine flow rate and the ratio of urine to plasma concentration of inulin, as we discuss in Section 7.1.3, Box 7.2, and is expressed by the following equation:

$$\text{GFR (mL min}^{-1}) = \text{Urine flow rate (mL min}^{-1}) \times \frac{\text{Urine concentration of inulin (mg L}^{-1})}{\text{Plasma concentration of inulin (mg L}^{-1})}$$

(Equation 1)

The question gives the following values:
Urine concentration of inulin = 20 mg L^{-1}
Plasma concentration of inulin = 1.5 mg L^{-1}

Over a 15 hour period 10.17 mL of urine was excreted.

Hence, urine flow rate (mL min^{-1}) $= \frac{10.17}{15} \times \frac{1}{60}$

$= 0.0113$ mL min^{-1}

Using the calculated value for urine flow rate and the information provided in the question for inulin concentrations, we can calculate GFR (mL min^{-1}) from Equation 1:

$$\text{GFR} = 0.0113\ (\text{mL min}^{-1}) \times \frac{20\ (\text{mg L}^{-1})}{1.5\ (\text{mg L}^{-1})}$$

GFR = 0.151 mL min^{-1}

(ii) Urine/plasma concentration of inulin

Using the provided values for inulin concentrations in urine and in plasma:

$$\text{Urine/plasma concentration of inulin} = \frac{20\ (\text{mg L}^{-1})}{1.5\ (\text{mg L}^{-1})} = 13.33$$

To compare this value to that of various mammals and their relative abilities to produce hyperosmotic urine look at Table 6.3 and Section 7.2.3.

(iii) Sodium clearance

The renal clearance of any substance is the *volume* of plasma that is completely emptied (cleared) of the substance per unit time, to account for the amount excreted per unit time.

$$\text{Sodium clearance (mL min}^{-1}) = \frac{\text{Rate of excretion of Na}^{+}}{\text{Plasma concentration of Na}^{+}}$$

$$= \frac{\text{Urine flow rate} \times \text{Urine Na}^{+}\text{concentration}}{\text{Plasma concentration of Na}^{+}}$$

Using values obtained for urine flow rate (ml min^{-1}) in calculation (i) and the provided values for Na^{+} concentrations (mmol L^{-1}) in plasma and urine (whose units cancel out), we obtain:

Sodium clearance (mL min^{-1}) = $\dfrac{0.0113\ (\text{mL min}^{-1}) \times 9.7\ (\text{mmol L}^{-1})}{145\ (\text{mmol L}^{-1})}$

= 0.0007559 mL min^{-1}

= 0.045 mL h^{-1}

Question 7.9

Relative medullary thickness has no units. It is traditionally calculated (as in the original use by Sperber) by the division of medullary thickness (in mm) by kidney size based on dimensions (in cm) expressed as (kidney length × width × depth)$^{0.33}$, as shown by the following equation:

Relative medullary thickness

$$= \frac{\text{Medullary thickness } (\text{mm})}{[\text{Kidney length } (\text{cm}) \times \text{width } (\text{cm}) \times \text{depth } (\text{cm})]^{0.33}}$$

$$= \frac{19}{(12 \times 6 \times 3)^{0.33}}$$

$$= \frac{19}{(216)^{0.33}}$$

$$= \frac{19}{\sqrt[3]{216}}$$

$$= \frac{19}{6}$$

Relative medullary thickness = **3.16**