GenBio2
Spring 2008

Clearance Problems

Try to answer the questions with the following data and what you know about clearance and related functions in the kidney.

$[glucose]_{urine} = 0$ mg * mL^{-1}	$[glucose]_{plasma} = 100$ mg * mL^{-1}
$[PAH]_{urine} = 2.0$ mM	$[PAH]_{plasma} = 0.002$ mM
$[inulin]_{urine} = 1.8$ mM	$[inulin]_{plasma} = 0.018$ mM
Rate of urine production = 1 ml/min	

(a) What is the value of the GFR in ml * min^{-1}?

(b) What is the concentration of glucose in the glomerular filtrate?

(c))What is the numerical value of the filtration fraction?

(d) How many mL of filtrate are produced per minute?

(e) How much water is reabsorbed per minute?

(f) Where is the vast majority of the water reabsorbed?

(g) How many milligrams of glucose are reabsorbed per minute?

(h) By what factor are PAH and Inulin concentrated in the urine as compared to plasma? Where does this occur?

ANSWERS: (a) GFR based on clearance of inulin = (1.8 mM*1mL* min^{-1})/ 0.018 mM = 100 ml min^{-1}
(b) the same as in the plasma since it is freely filterable – 100 mg mL^{-1}
(c) FF = GFR/RPF, so we need the RPF which we can estimate as the clearance of PAH = (2 mM *1mL* min^{-1})/0.002 mM = 1000 mL $^{min-1}$ so FF = 100 mL min^{-1} /1000 mL min^{-1} = 0.1
(d) This would equal the GFR – why? Because if the GFR is the amount of plasma swept clean of freely filterable only substances per minute then that must be the amount of water (also freely filterable) that is removed from the plasma
(e) The difference between the GFR and the urine production rate – here 100 mL min^{-1} (the GFR) – 1 mL min^{-1} (rate of urine production) = 99 mL water reabsorbed per minute
(f) the PCT
(g) The amount of glucose that passes across the filter from plasma to filtrate must equal: its concentration in the plasma (since it is the same in the filtrate – remember, it is freely filterable)
times the GFR (the amount of fluid passing through the filter)
Thus 100 mg glucose dL^{-1} * 100 mL min^{-1} * 1 dL / 100 mL = **100 mg glucose min^{-1}**

However, the clearance of glucose is zero in this case (C_{glu}= 0 mg dL^{-1} * 1 mL min^{-1} / 100 mg glucose dL^{-1} = 0).

Thus all of this is reabsorbed i.e, 100 mg min^{-1}

(h) The concentration is simply the ratio of the concentration in the urine to that of the plasma. Thus, for inulin the ratio is 100 (1.8/0.018) and for PAH the ratio is 1000 (2 / 0.002). In inulin the concentration increase over the plasma is entirely a result of the fact that the volume of filtrate was reduced to $1/100^{th}$ of what we started with (see d). The higher concentration of PAH was due to the fact that we not only filtered PAH but also added more by secretion in PCT.
Most of this concentrating occurred in the PCT. Even though the overall osmolarity in the PCT is isotonic with the body, this is achieved by reabsorbing many substances (e.g., glucose, amino acids, ions etc) as the volume is reduced. The "finishing touches" can be put on in the collecting duct if vasopressin is high – here the concentrations of both inulin and PAH would rise further and at the same time the osmolarity would increase as no further solutes are removed whilst water is removed.