ANSWER KEY

Integrative Sciences: Biological Systems B
Body Fluid/Electrolytes and Kidney Systems

<u>Problem Set Review</u>

Monday, November 28, 2011 at 9 am

Lecturer: Lisa M Harrison-Bernard, PhD

I. <u>Body Fluid Problems</u> - Shifts of water between compartments

What happens to the following 5 parameters:

ECF volume?
ICF volume?
ECF osmolarity?
Plasma protein concentration (PPC)?
Blood pressure?

A. Infusion of isotonic NaCl (isosmotic volume expansion)

B. Diarrhea - loss of isotonic fluid (isosmotic volume contraction)

C. Excessive NaCl intake - addition of NaCl (hyperosmotic volume expansion)

D. Sweating in a desert - loss of water (hyperosmotic volume contraction)

E. Syndrome of inappropriate antidiuretic hormone (SIADH) - gain of water (hypoosmotic volume expansion)

F. Adrenocortical insufficiency - loss of NaCl (hypoosmotic volume contraction)

	ECF Volume (L)	ICF Volume (L)	ECF Osmolarity (mOsm)	PPC (g%)	Blood Pressure (mmHg)
A	⇑	⇔	⇔	⇓	⇑
B	⇓	⇔	⇔	⇑	⇓
C	⇑	⇓	⇑	⇓	⇑
D	⇓	⇓	⇑	⇑	⇓
E	⇑	⇑	⇓	⇓	⇑
F	⇓	⇑	⇓	⇑	⇓

II. Starling Forces

1. At the afferent arteriolar end of a glomerular capillary, P_{GC} is 45 mmHg, P_{BS} is 10 mmHg, and π_{GC} is 27 mmHg.

What are the value and direction of the net ultrafiltration pressure?

$P_{UF} = (P_{GC} – P_{BS}) – (\pi_{GC} - \pi_{BS})$
P_{UF} = (45 - 10 mmHg) – (27) = 8 mmHg favors filtration of fluid out of the glomerular capillary

III. Renal Clearance, Renal Blood Flow, Glomerular Filtration Rate

2. To measure GFR:

Infuse inulin intravenously until P_{IN} is stable. Measure urine volume produced in a known period of time (urine flow). Measure P_{IN} and U_{IN}.

Given the following:
P_{IN} = 0.5 mg/ml
U_{IN} = 60 mg/ml
Urine flow = 1.0 ml/min

Calculate GFR?

$GFR = C_{IN} = (U_{IN})(UV) \div P_{IN}$
GFR = (60 mg/ml) (1 ml/min) ÷ (0.5 mg/ml) = 120 ml/min

3. To estimate Renal Plasma Flow (RPF):

Infuse PAH. Obtain a timed, complete urine collection and a blood sample. Measure P_{PAH}, U_{PAH}, and urine flow.

Given the following:
P_{PAH} = 0.05 mg/ml
U_{PAH} = 29.5 mg/ml
Urine flow = 1.0 ml/min

Calculate C_{PAH}?

$RPF = C_{PAH} = (U_{PAH})(UV) \div P_{PAH}$
C_{PAH} = (29.5 mg/ml) (1.0 ml/min) ÷ (0.05 mg/ml) = 590 ml/min ~ RPF

4. Calculation of Renal Blood Flow (RBF): RBF = RPF ÷ (1–HCT)

Given the following:
Hematocrit = 0.45
RPF calculated in problem #3

What is RBF = ?

RBF = 590 ml/min ÷ (1 - 0.45) = 1,072 ml/min

5. Calculation of Filtration Fraction (FF): Fraction (%) of renal plasma flow that is filtered (moves across the glomerular capillary walls into the Bowman's space) as blood traverses the kidney. FF = GFR ÷ RPF

Given the GFR and RPF calculated in problems #2 and #3
What is FF = ?

FF = 120 ml/min ÷ 590 ml/min = 0.20 = 20%

6. Fractional Excretion (FE_Q) is the fraction (%) of filtered substance (Q) that is excreted in the final urine. FE_Q = Amount excreted/min ÷ Amount filtered/min = $U_QV \div (P_Q \times GFR) = Clearance_Q \div GFR$

Given the following:
$Clearance_{Na}$ = 0.9 ml plasma/min
GFR from problem #2

What is FE_{Na} = ?

$FE_{Na} = C_{Na} \div GFR$ = (0.9 ml/min) ÷ (120 ml/min) = 0.0075 = 0.75%

7. Fractional Reabsorption (FR) is the fraction (%) of filtered substance that is reabsorbed by the tubules. $FR_Q = 1 – FE_Q$

Given the FE_{Na} calculated in problem #6
What is FR_{Na} = ?

$FR_{Na} = 1 - FE_{Na}$
$FR_{Na} = 1 – 0.0075 = 0.9925 = 99.25\%$

8. Creatinine is a substance that is excreted primarily by filtration and is produced by the body at a fairly constant rate. Thus, it can be used to estimate glomerular filtration rate (GFR).

Given the following data:
24 hour urine volume = 1.2 liters
U_{Cr} = 144 mg/100 ml
P_{Cr} = 2 mg/100 ml

8A. Calculate the GFR.

GFR = C_{Cr} = $(U_{Cr})(UV) \div P_{Cr}$
GFR = C_{Cr} = (144 mg/100 ml) (1,200 ml/1,440 min) ÷ (2.0 mg/100 ml) = 60 ml/min

8B. Is this value below normal, normal, or above normal?
Below normal

9. In many experimental studies, inulin is used to measure GFR because it is easily measured and only filtered. Also, PAH is used to estimate the plasma flow because the kidney extracts it from plasma very efficiently.

Given the following data:

urine flow = 3 ml/min
P_{IN} = 0.22 mg/ml
U_{IN} = 9.5 mg/ml
P_{PAH} = 0.08 mg/ml
U_{PAH} = 20 mg/ml

9A. Calculate the GFR and PAH clearances.

GFR = C_{IN} = $(U_{IN})(UV) \div P_{IN}$
GFR = (9.5 mg/ml) (3 ml/min) ÷ (0.22 mg/ml) = 130 ml/min

RPF = C_{PAH} = $(U_{PAH})(UV) \div P_{PAH}$
C_{PAH} = (20 mg/ml) (3.0 ml/min) ÷ (0.08 mg/ml) = 750 ml/min ~ RPF

9B. Calculate the filtration fraction.

FF = GFR ÷ RPF = 130 ml/min ÷ 750 ml/min = 0.17 = 17%

9C. If the hematocrit is 0.40, what is the total renal blood flow?

RBF = RPF ÷ (1–HCT)
RBF = 750 ml/min ÷ (1–0.4) = 750 ml/min ÷ 0.6 = 1,250 ml/min