

## ***PROBLEMS FOR RENAL SECTIONS***

### ***SECTION 1***

#### **Case 1.**

A 63 kg diabetic patient with no kidneys forgets to take her insulin and develops a blood glucose of 1200 mg%. Assume that because of the lack of insulin glucose is unable to enter any of the patient's cells.

*Reminders: molecular weight of glucose is 180 grams/mole; mg% is mg per 100 ml.*

- a. What would happen to the plasma [Na] concentration after the glucose concentration increased from a normal value of 100 mg% to 1200 mg%.
- b. What would happen to the relationship between intracellular and extracellular water. (Quantify the answer).
- c. The patient is treated with two liters of 0.9% NaCl. *This solution is isotonic.* What will happen to the extracellular volume? The intracellular volume?
- d. The patient is treated with insulin suddenly dropping the glucose to 100 mg%. Describe the changes in the relationship between extracellular and intracellular water.

#### **Case 2.**

A forty-something, 90 kg, out of shape investment banker runs in a marathon for charity in 90° F heat. Even before he reaches the finish line he collapses and is brought to the CPMC emergency room. On admission to the ER he is found to have a low blood pressure.

- a. His plasma [Na<sup>+</sup>] is measured and found to be 154 meq/liter. Assuming that his normal [Na<sup>+</sup>] was 140 meq/liter, how much water did he lose during the race?
- b. How much water was lost from the intracellular space, how much from the extracellular space?
- c. The house-staff was worried about his kidney function, because he produced only 400 ml of urine during the first 12 hours in the hospital. To assess the kidney function they measured his urine [creatinine] and found it to be 150 mg/100 ml. His plasma [creatinine] was 1.2 mg/100 ml. What is his creatinine clearance, and is this a normal value?
- d. The patient is sent to radiology to have a new kidney scan, one that measures the renal plasma flow. It is found to be 75 liters/6 hours. What is his filtration fraction?

### Case 3.

A patient is sent to open heart surgery for an aortic valve replacement. After returning to the recovery room the valve starts to leak and the blood pressure starts to fall. After the house-staff starts to infuse norepinephrine to increase the blood pressure, they notice that the patient's renal function starts to deteriorate.

- a. What are the mechanisms by which norepinephrine might lower the glomerular filtration rate? Be sure to focus on renal plasma flow and  $P_{GC}$ .
- b. The house-staff is concerned by his lowered glomerular filtration rate. They elect to try a new treatment, the infusion of atrial natriuretic peptide (ANP). What might be the mechanism by which this would increase GFR?
- c. Instead of administering the ANP, the house-staff accidentally administers a new angiotensin II receptor blocker. What would be the effects on the glomerular filtration rate of administering this drug while the patient is receiving the norepinephrine infusion?
- d. The patient is given an intravenous infusion of a cationic molecule protamine, as part of a protocol. The astute medical student on the service reminds the house-staff that the glomerular basement membrane is negatively charged, and, as a result, retards the passage of albumin across the glomerular capillary into Bowman's space. The student predicts that protamine will increase the filtration of albumin. What could you measure before and after the protamine to prove that this is the case?

### Case 4.

A hard-working student goes to the gym to play squash and after a two hour work-out finds that he has lost 2 kilograms.

- a. Why (and how) did he lose the 2 kilograms?
- b. What happened to his plasma  $[Na]$  and why?
- c. What changes will occur, in both his behavior and renal function, which enable him to regain the weight? What are the hormonal and cellular mechanisms by which his behavior and renal function change?
- d. What is his serum  $[Na]$  when he has finally regained the weight and why?

### Case 5.

The identical twins Dylan and Benjy, both in perfect health, go to Tom's pizza parlor for lunch and pack away four slices each. They consume a total of 9 grams of NaCl and drink one liter of water. The next day Dylan finds that he has gained one kilo whereas Benjy has not gained any weight. Why was Benjy able to excrete the sodium and water load and Dylan not?

### Case 6.

A patient on an average and constant dietary sodium content is given large doses of aldosterone for many weeks. After an initial weight gain of 1-2 kilograms, the patient does not gain any more weight. Why doesn't the patient keep on gaining weight?

#### *Be sure to understand and know:*

Permeability characteristic of glomerular capillary

Calculating the glomerular filtration rate

Calculating the renal plasma flow

The concept of clearance (at least for creatinine)

Hormonal effects on the glomerular circulation

Flow-dependence of GFR

Afferent sensors of volume

Response to increasing or decreasing sodium intake and the establishment of a new steady state Interaction between proximal and distal tubular function, and their properties

Response to sodium deficit and surfeit

Mechanisms of increased sodium reabsorption during volume depletion by increased AII: increased proximal reabsorption ( $\pi$ , direct effect); aldosterone

Mechanism of increased sodium excretion during volume expansion (ANP and reverse of above)

## **SECTION 2**

### Case 1.

An aspiring astronaut, who is vaguely aware of some "renal problem" goes to the army base for a physical and a battery of tests. He is asked to fast for 12 hours overnight and collect all of his urine in the morning. During the final 8 hour period his urine volume is 1200 ml, and his urine osmolality is 200 mosm/l. Based on these observations he is given an bus ticket to return home.

- a. What would his urine volume have been had he been able to form a maximally concentrated urine?
- b. What might be "wrong" with his kidney that accounts for his inability to form a concentrated urine?
- c. Why did the space program reject him?

### Case 2.

During the annual Medical Student Blood Bank Drive student A inadvertently removes 2 liters of blood from student B. Upon rising, student B falls into the arms of student A who says "drink these two quarts of water." Student B says "that's ridiculous, I'll simply excrete that free water in one hour and still remain volume depleted."

- a. What happened to total body water, intracellular and extracellular water after giving up blood?
- b. If student B drank the water, what would be the result and why?
- c. Is there a better form of therapy?

### Case 3.

Two students go on different diets which generate 100 meq of  $H^+$  in one student and 50 meq of  $OH^-$  in the other. What would you expect the are the qualitative differences in their "net acid excretion" to be?

### Case 4.

A young healthy person loses a kidney in a car accident. We find that his net acid excretion one month later is "normal" and the same as from before the accident. What changes occurred in the remaining kidney which allowed him to maintain net acid balance?

### Case 5.

A patient is admitted to the hospital with AIDS and must receive a new antibiotic to cure an opportunistic fungal infection. The drug is an experimental one which has not been fully tested but is known from in vitro studies to inhibit the  $H^+$ -ATPase pump in the distal segments of the kidney tubule. The patient is eventually given the drug.

- a. What might be the effect of the drug on the urine pH?
- b. What would be the effect on the urine  $HCO_3^-$  content of the urine?
- c. Would the drug causes acidosis?
- d. If it does, why doesn't the proximal tubules immense capacity for  $HCO_3^-$  generation make up for the decline in  $HCO_3^-$  generation by the distal tubule?

**Case 6.**

A patient with glaucoma is given a carbonic anhydrase inhibitor which inhibits bicarbonate production exclusively in the proximal tubule.

- a. What would be the effects of the drugs on the bicarbonate content of the urine? What would happen to urine pH?
- b. What would be the effect of this drug on the patient's pH?

**Case 7.**

A first year student, anxious about the upcoming end of the year renal exam starts to hyperventilate. His  $\text{PCO}_2$  falls from 40 mm Hg to 25 mm Hg, and blood pH increases from 7.40 to 7.61 (normal range 7.38 - 7.42). His plasma  $[\text{HCO}_3^-]$  is initially 24 meq/l. He continues to hyperventilate and one week later his blood pH is 7.46,  $\text{PCO}_2 = 25$  mM, and  $[\text{HCO}_3^-]$  was 17 meq/l.

- a. What are the mechanisms by which his blood pH returned to near normal?
- b. Why doesn't the pH return to 7.40.

**Case 8.**

Give the diagnosis.

	pH	pCO <sub>2</sub>	[HCO <sub>3</sub> <sup>-</sup> ]	Diagnosis
a.	7.40	44	26	?
b.	7.70	20	24	?
c.	7.52	47	37	?
d.	7.21	25	10	?
e.	7.31	55	27	?
f.	7.34	60	31	?
g.	7.28	60	27	?
extra-credit!	7.40	40	21	???

**Case 9.**

A patient comes to the emergency room vomiting profusely. The plasma [K] is measured and found to be 3.2 meq/liter. The plasma bicarbonate is found to be 32 meq/liter. The intern on the case immediately reaches for the potassium from the cabinet. Should this patient be given potassium?

**Case 10.**

A patient develops an aldosterone secreting tumor which raises his aldosterone level to 100 arbitrary units (AU). A second patient, a jogger, also develops a high aldosterone level of 100 AU, because he is habitually volume depleted. The first patient, with the tumor, has a plasma [K] of 2.4 meq/liter, while the jogger has a plasma [K] of 3.8 meq/liter.

- a. Explain how these two patients with identical aldosterone levels could have different serum [K]?
- b. The two patients are instructed to take a loop diuretic, a drug that inhibits sodium transport in the thick ascending limb. What would happen to the K excretion and the serum K in both of these patients?

***Be sure to understand and know:***

Action of ADH

Response to water deficit and surfeit: Thirst and ADH response to water deficit (and increased osmolality)

Excretion of free water during surfeit

For the masochists: the countercurrent multiplier

Potassium: secretion, what drives it, permeability, aldosterone, flow dependence

All six of the major acid-base disturbances: metabolic acidosis and alkalosis, acute and chronic respiratory acidosis and alkalosis.