Biology 236 Human Anatomy and Physiology II
Spring 2002 Wurdak/Fahey/Campos

Renal function in humans: control of urine formation

Introduction

This cycle's lab involves the measurement of human urinary system responses to salt, water, and acid/base intake. We'll experiment on ourselves, recording urine production and properties over time after the ingestion of various solutions or foods.

Two major functions of the human kidney are to closely regulate fluid and salt content of the body, keeping plasma osmolarity near 300 mosm/L, and to ensure proper ionic concentrations of extracellular fluids. The urinary system helps the body maintain adequate hydration and avoid both dehydration and water intoxication. The reabsorption of water and electrolytes by the kidney is regulated by hormones, particularly anti-diuretic hormone (ADH) from the posterior pituitary and aldosterone, a mineralocorticoid hormone produced by the adrenal cortex.

ADH enters the blood when specialized neurons in the hypothalamus (osmoreceptors) are stimulated by an increase in the osmotic pressure of the blood (especially Na^+ concentration) as might occur in dehydration. In the kidney, ADH increases the reabsorption of water by acting on the distal tubules and collecting ducts to increase water permeability. The net result of this mechanism is a reduction in the urine volume and an increase in the concentration of salts in the urine. ADH is released continually except when inhibited by a decrease in blood osmolarity. In the absence of ADH release (for example in diabetes insipidus), large volumes of very dilute urine are lost daily.

The release of aldosterone by the adrenal cortex is stimulated indirectly (via the renin-angiotensin pathway) by a decrease in blood volume and thus blood pressure, a decrease in plasma $[Na^+]$, or an increase in plasma $[K^+]$. Aldosterone increases Na^+ reabsorption, increases water reabsorption indirectly, and aids in the maintenance of adequate blood volumes and constant plasma Na^+/K^+ ratio.

The kidneys are also involved in regulating blood pH. Bicarbonate ion (HCO_3^-) is transported across the kidney tubule epithelial wall when extra buffering capacity is needed in the blood, and when excess acid is present H^+ ions are actively secreted to acidify the urine.

Experimental procedure:

Before lab:

Don't drink a lot of coffee or carbonated beverages just before lab. If you eat before lab, please skip heavily salted foods and don't drink a whole lot with your meal. Remember the time of your last urination.

1. The first procedure is collection of a control sample. In the bathroom empty your bladder into a clean, dry sample container. Measure the total volume of urine with a graduated cylinder. You need not return to lab with the whole sample, but note the total volume. Return to the laboratory with a 25-50 ml sample. Label this sample CONTROL.

2. Note the time, and begin one of the treatments below. Drink your assigned water or salt load steadily but don't gulp it down. Try to complete drinking/eating within 5 minutes. The salt and bicarbonate solutions are somewhat disagreeable and may cause cramping or nausea. Stop drinking if this occurs.

Treatment	Volume	Number of people
Distilled water	1000 mL	3-4
0.9% NaCl	1000 mL	2-3
2% NaCl	250 mL	2-3
Diet Pepsi/Pepsi	500 mL	2-3
0.5% $NaHCO_3$	500 mL	2-3
5 g NaCl in Cheetos plus 250 mL water		2-3
Strong black coffee	500 mL	1-2

3. After 30 min, collect a second urine sample and measure the total volume voided using a graduated cylinder. Return to the lab with the 25-50 ml sample required for the analyses below. Label your sample 30 min. **Continue sample collection at 30 min intervals for 2.5 h.**

4. Between collections measure pH and osmolarity of your samples.

Measure urine pH using the pH meter as instructed. Rinse electrodes before and after use.

Measure urine osmolarity using vapor osmometers. Osmolarity is the molar concentration of osmotically active particles present in a solution. The osmometer measures total solute concentration using the vapor pressure principle. Urine osmolarities may range from <100 mosm/L to 1400 mosm/L in humans.

Once you've got both these analyses done, discard the urine sample in the toilet.

5. Record all your data on the attached data sheet. Compute the rate of urine volume production (mL/min) by dividing the volume of each sample by the time elapsed since the last urination. Turn in your sheet to your instructor after finishing measurements from your last collection.

6. When you’re finished, please help us to clean up the lab. Urine samples should be discarded in the toilet. Wash thoroughly and rinse all graduate cylinders, plasticware and beakers. Wash your hands before leaving.

Analysis:

Compute average urine volume production rates, pH values, and urine osmolarity for each treatment group. If this is done for you, concentrate on identifying trends in the data. How did pH change in those people who drank a solution containing a weak base (HCO_3-) or a weak acid (H_2CO_3 in carbonated pop)? How did urine volume change in the water drinkers? In the isotonic saline drinkers? How about in the coffee drinkers? And how did urine concentration change in the salt drinkers or the Cheetos eaters? Explain these trends on the basis of your knowledge of renal function and hormonal control of water and salt balance.

NOTES: Absorption of water from the stomach and intestine begins at once and is nearly complete within 35 min. Hypertonic solutions are absorbed more slowly. One liter of H_2O lowers the blood osmolarity by about 2%. One-half the circulating ADH is destroyed by the kidney and liver every 10 min; the ADH system is therefore, we may assume, fairly quick-responding. Neither water nor salt solutions appreciably change the glomerular filtration rate. [from Witherspoon, J.D. 1970. The functions of life. Addison Wesley Publ., Reading MA.]

RENAL LAB

SUBJECT: ____

EXPERIMENTAL GROUP: ____________________________________

Elapsed Time (min)	Urine Volume (mL)	Urine Production Rate (mL/min)	Urine Osmolarity (mOsm/L)	Urine pH