

Urinary System

Introduction

1. Chemistry of body - of our sea within
2. Excretory organs:

<u>Organ</u>	<u>Essential</u>	<u>Incidental</u>
Skin	heat	H ₂ O, CO ₂ , salts, urea
Digestive system	solids, secretions	H ₂ O, CO ₂ , salts, heat
Lungs	CO ₂	H ₂ O, heat
Kidneys	H ₂ O, salts, nitrogen products, neutralization of acids, etc.	CO ₂ , heat

Urinary System

Kidney (Gross Structure)

1. Hollow - urine filled
2. Pyramids (red)
3. Cortex - urine produced (blue)

Microscopic Structure

1. Nephron - (~1 million per kidney) cortex structure except loop of Henle
2. Blood supply - important to understanding kidney
 - a. Renal artery -> stellate arteries -> afferent arteriole -> glomerulus -> efferent arteriole -> peritubular capillaries -> stellate veins -> renal vein
 - b. Influenced by hormones and nervous system

Urine Formation

1. **Urine** - fluid that is mostly water (95%), urea (2%), and assorted ions
2. Product of kidneys that empties into collecting tubule
 - a. Glomerular filtration
 - b. Tubular reabsorption
 - c. Tubular secretion
 - d. Tubular excretion
3. Glomerular filtration
 - a. Role of afferent arteriole versus efferent arteriole blood pressure
 - b. Endothelium (simple squamous) has "holes" in the lining of capillaries in glomerulus small enough for water, sugar, amino acids, urea, and ions to pass through, but not larger molecules
 - c. Endothelium is a ultrafilter - no cells or plasma proteins pass through

Blood

1000 ml blood enters both kidneys per minute

60 liters blood per hour

720 liters blood per day

Glomerular Filtrate into Bowman's Capsule

120 ml filtrate per minute

7.2 liters/hour

170-180 liters/day

Urine

1 ml per minute

60 ml/hour

1.5 liters/day

4. Tubular reabsorption
 - a. Water, glucose, amino acids, salts, urea and wastes go through glomerulus
 - b. Active transport (energy = enzymes) glucose, bicarbonate, sodium, water, amino acids
 - c. Passive transport
 - i. Osmosis - water due to high colloidal osmotic pressure of blood and low blood pressure in peritubular capillaries
 - ii. Electrical gradients - sodium actively absorbed, chlorine follows, ions follow
 - iii. Urea - some goes back into blood by diffusion
5. Tubular secretion
 - a. Acid and base regulation accomplished in distal tubule
 - b. H⁺ regulation of tissues, cells, blood from carbonic acid (H₂CO₂)
 - c. Sodium, NCO₃ - buffer, important in keeping normal plasma pH
 - d. Urine is usually acidic (avg. pH 6, range of 5.5-7.5)
 - e. As urine acidity goes up - ammonia is formed by tubule cells by deamination of amino acids
 - f. Conserves NH₄Cl instead of NaCl; Na saved
 - g. Keeps pH from becoming too acidic
 - h. Rids body of excess amino acids
 - i. If H⁺ needed to be conserved then K⁺ substituted for Na⁺
6. Tubular excretion
 - a. Active transport from blood to tubular system
 - b. Creatinine
 - c. Dyes - phenol sulphonthaline (PSP test) injected, removed in certain time, used to test kidney function
 - d. Drugs - penicillin

Blood Supply to Kidney - Regulation

1. Nerves: vasomotor control effects vasoconstrictors/vasodilators in vessels
2. Hormonal control:

- a. Juxtaglomerular apparatus (JGA) of afferent arterioles secrete renin
 - b. Renin -> combines with plasma protein of blood to form **Angiotensinogen** -> **Angiotensin I** -> **Angiotensin II**
 - c. Effect of angiotensin II
 - i. Raise blood pressure by causing constriction of arterioles throughout body
 - ii. Stimulates adrenal cortex to produce aldosterone which works on renal tubules - promotes reabsorption of sodium, causes water to diffuse and increase volume
3. ADH
- a. Water reabsorption regulated by ADH (**antidiuretic hormone**)
 - b. Regulation and production controlled by hypothalamus
 - c. Hypothalamus osmoreceptors - sensitive to osmotic pressure of plasma (salts)
 - d. Stored in posterior pituitary
4. Aldosterone
- a. Regulates Na⁺, K⁺ concentration in body
 - b. High levels = sodium retained, potassium excreted
 - c. Low levels = potassium retained, sodium lost in excessive amounts along with water

Urine

1. Normal urine
- a. General: yellow, clear, aromatic, upon storage urine may cloud due to precipitation of solutes
 - b. pH: high protein diet = acidic, vegetable diet = alkaline, avg. 6
 - c. Specific gravity: 1.008 to 1.030 reference, 1.002 to 1.040 text
 - d. Output: 1,200 to 1,500 ml, vary without being pathological
 - e. Chemical composition: 95% water
 - i. 1,500 ml/day, 60 grams of solute, 35 grams of organic material: 30 grams of urea, 1-2 grams of creatinine, 1-2 grams ammonia, 1 g uric acid, 1 g other (ketones); 25 grams of inorganic salts: 15 g NaCl, chlorides, sulfates, phosphates, sodium, potassium, magnesium, calcium.
 - ii. Urea - from amino acid deamination in liver, amine group split off
 - iii. Ammonia - formed in kidneys from amino acids
 - iv. Creatinine - from Creatine from muscle relaxation
 - v. Creatine - from children, menstruation, pregnancy, during starvation or fever, from muscle disease
 - vi. Phospho-creatine - used as an energy source and creatinine becomes a waste product
 - vii. Uric acid (purine bodies) - from nucleic acids
 - viii. Ketones - metabolism of fatty acids (ketonuria if excessive)
2. Abnormal urine
- a. Albuminuria = albumin in urine result of organic disease of kidney and permeability and injury to glomerular membrane
 - b. Glycosuria = abnormal to normal occasionally, dilute urine has great quantities of glucose
 - c. Diabetes insipidus = abnormal continuously, insipidus taste

- d. Hematuria = blood in urine, smoky or reddish color, acute inflammation of any urinary organ, tuberculosis, cancer, renal stones
- e. Pyuria = pus in urine, bladder infection, pelvic or Ureter inflammation
- f. Ketone bodies = from metabolism of fatty acids in liver, eliminated normally, increased by fasting, starvation and diabetes
- g. Casts = line kidney tubules and harden
- h. Calculi = (stones) any part of urinary tract, tubules to external orifice, excessive amounts of salts, decrease amount of water, or results from consistently abnormally acidic or basic urine

Diuresis

- 1. Increased excretion of urine
- 2. Water diuresis - ADH decreases and water removed
- 3. Osmotic diuresis - large amounts of urea, more water and sugar removed
- 4. Drugs - heart beat - pressure and blood flow to kidneys, digitalis - mercurial diuretics pull Na⁺ and with it water
- 5. Caffeine - dilation of renal vessels and more blood flow
- 6. Ethyl alcohol - inhibits ADH, more water lost

Hemodialysis

Ureters

- 1. 2, one from each kidney, 12 inches long, begin within kidneys as calyces (minor calyx, major calyx, renal pelvis)
- 2. Externally from kidney Ureter lined with mucous membrane
- 3. Have peristaltic waves to move urine along, stones cause excruciating pain

Urinary Bladder

- 1. Reservoir
- 2. Empty folds called rugae except in area at floor of bladder called trigone
- 3. Detrusor muscle - composite muscle

Urethra

- 1. Female - 1/2" long, guarded by striated muscle sphincter, voluntary control, directly in front of vaginal opening
- 2. Male: three parts
 - a. Prostatic portion - surrounded by prostate gland, gland may enlarge
 - b. Membranous portion - 1/2" long, from apex of prostate to urethral bulb
 - c. Cavernous portion - in penis, from bulb of urethra to external orifice

Micturition

- 1. Emptying of urinary bladder - receptor stimulated - 300ml
- 2. Release of voluntary control - relaxation of voluntary muscles of perineum
- 3. Detrusor muscle - rhythmic contractions
- 4. Relaxation of internal sphincter
- 5. Relaxation of external sphincter