

Urinalysis and Body Fluids 09

Unit 1 E
Physiology of the Urinary System

Physiology of the Urinary System

- Functions of the kidney
 - Elimination of excess water
 - Elimination of waste products of metabolism. such as Urea & Creatinine
 - Elimination of foreign substances (such as drugs that have been detoxified by the liver)
 - Retention of substances necessary for normal body function (glucose, electrolytes, minerals, amino acids, etc)

Physiology of the Urinary System

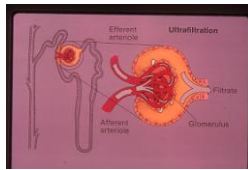
- Functions of the kidney, continued
- Regulation of electrolyte balance and osmotic pressure of body fluids (BP)
- Maintenance of body acid / base balance
- Hormone production
 - Erythropoietin - RBC stimulus
 - Renin - long term regulation and maintenance of blood pressure.

Physiology of the Urinary System

- Physiology of the Urinary System
- Kidney accomplishes these tasks by:
 - Filtering
 - Reabsorbing
 - Secreting
 - Concentrating
- To accomplish these tasks, needed are:
 - Renal blood flow
 - Glomerular filtration
 - Tubular reabsorption
 - Tubular secretion

Urine Formation - Filtration

- Glomerular filtration
 - @ 120 ml/minute of renal plasma is filtered through the glomeruli
 - (Glomerular filtration rate / GFR - chemistry test)
 - Blood enters glomerular capillary system
 - Very high pressure created by arterioles
 - Special capillaries allowing filtration
 - Selected components of the blood plasma to pass through the semi-permeable membrane into the capsular space of Bowman's capsule

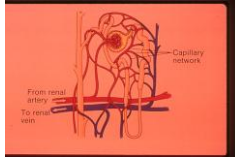


Urine Formation - Filtration

- Glomerular filtration continued
 - Ultrafiltrate
 - *Composition similar to blood plasma
 - Contains substances up to @ 70,000 daltons.
 - Water, glucose, amino acids, urea, creatinine, ammonia, electrolytes - Na, Cl, etc.
 - NOT blood cells, fats, & proteins.
- Recap
 - GFR - glomerular filtration rate - @ 120 mL/min, varies with age and sex, used to monitor kidney disease progression
 - Ultrafiltrate -
 - substances < 70,000 daltons
 - No blood cells, fats, higher mol wt. proteins, etc.

Urine Formation

- Physiology of the Urinary System
 - Kidney accomplishes these tasks by:
 - Filtering
 - Reabsorbing
 - Secreting
 - Concentrating



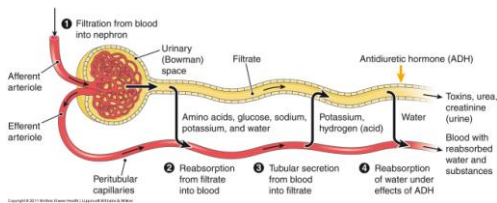
- Anatomy review
 - Modified blood leaving through efferent arteriole pass through vessels (peritubular capillaries) that participate in reabsorption process.
 - These vessels eventually become the renal vein.

Urine Formation -Reabsorption

- Selected substances removed during ultrafiltration are returned to circulation.
 - Those things (small enough to filter) that the body cannot afford to lose.
 - Proximal tubules reabsorb water, sodium chloride, bicarbonate, potassium, calcium, amino acids, phosphate, protein, glucose, and other substances.
- Varying proportions are reabsorbed
 - proteins and glucose almost completely reabsorbed
 - sodium chloride is only partly reabsorbed
 - no reabsorption of creatinine

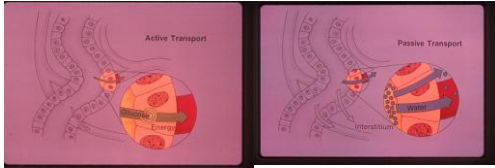
Urine Formation -Reabsorption

- Tubular processing of the glomerular ultrafiltrate



Urine Formation -Reabsorption

- Both active and passive transport processes are used.



Urine Formation -Reabsorption

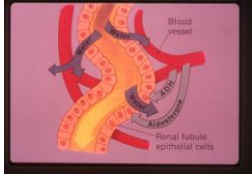
- Renal tubular function
 - Failure to reabsorb unwanted substances
 - Urea
 - Creatinine
 - phosphates, sulfates, uric acid
 - Such substances not actively transported, but some may be passively returned.

Urine Formation - Secretion

- Secretion of unwanted substances
 - drugs, & some waste products
- Acid - base balance through the
 - reabsorption of filtered bicarbonate ion
 - secretion of H^+ ions attached to bicarbonate
 - secretion of H^+ ions attached to phosphate
 - secretion of H^+ ions attached ammonia

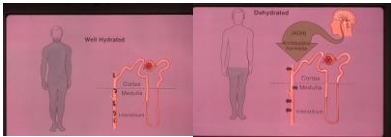
Urine Formation - Concentration

- Endocrine influence - hormones affecting excretion/reabsorption of electrolytes and water.



Urine Formation - endocrine influence

- Antidiuretic hormone (ADH) (also known as vasopressin)
- secreted by the posterior pituitary gland.
- Controlled by body hydration, ADH regulates absorption of water in the distal portion of the nephron
- By making the walls of the distal and collecting tubules permeable to water.

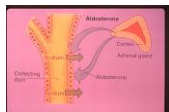


Urine Formation - endocrine influence

- Antidiuretic hormone (ADH)
- insufficient ADH results in **diabetes insipidus**
 - Effects
 - Excess urine production , increased urine volume
 - Decreased plasma volume
 - Excess results in SIADH
 - Results in
 - high plasma volume,
 - low serum osmolarity
 - high urine osmolarity
 - low plasma sodium
 - higher than normal urine sodium.

Urine Formation - Concentration

- Endocrine influence
 - Aldosterone
 - From adrenal cortex
 - Acts on distal and collecting tubules
 - Promotes active reabsorption of sodium from the glomerular filtrate (and concurrent secretion of potassium).
 - Increases water retention
 - Raises blood pressure



Renal Functions

- Hormones produced by the Kidney
 - Erythropoietin / EPO
 - Also called hematopoietin / hemopoietin
 - Produced and released by peritubular capillary endothelial cells in the kidney
 - Stimulates bone marrow to produce and release RBCs

Renal Functions

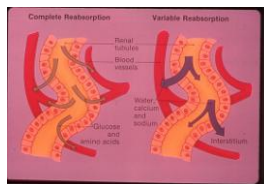
- Hormones produced by the Kidney
 - Renin
 - Enzyme-like acting substance
 - Released from the juxtaglomerular cells
 - Released in response to decreased blood pressure.
 - Acts on plasma substrate (angiotensinogen) changing it to Angiotensin I. When it passes through the lungs it is then changed into the active form, Angiotensin II.
 - causes dilation of afferent arterioles and vasoconstriction of efferent arterioles
 - promotes reabsorption of sodium in the proximal tubules
 - promotes secretion of the sodium retaining hormone, aldosterone.
 - (all of which cause increase in BP)

Renal Functions

- Electrolyte balance
- Sodium & Potassium
 - Renin-angiotensin-aldosterone system (reabsorption of sodium and secretion of potassium)
- Calcium reabsorbed in proximal tubule under influence of parathyroid hormone (PTH)
- Magnesium regulation parallels calcium
- Phosphorus reabsorption in proximal tubule is suppressed by PTH.

Renal Functions

- Renal threshold /Threshold substances
- When plasma concentration of a substance is so high that it can no longer be reabsorbed. The substance will then be detectable in the urine.



Renal Functions

- Renal threshold /Threshold substances
- Glucose - high threshold substance
 - appears in the urine when plasma concentration exceeds about 160 to 180 mg/dl.
- Other threshold substances:
 - amino acids
 - ascorbic acid
 - creatine
 - potassium
 - sodium chloride

Renal Functions

- Acid - Base balance
 - Hydrogen ions are produced as waste from metabolism and are generally secreted.
 - Lungs eliminate *volatile respiratory acids*
 - Kidneys responsible for *non-volatile metabolic acids*
 - Keto acids (from ketones)
 - Sulfuric & Uric acid
 - Hydrogen ions
 - Kidneys also capable of removing base substances (bicarbonate), if needed
 - Goal is to maintain overall body pH of 7.40 ± 0.005 (7.35 - 7.45)

Renal Functions

- Acid - Base balance
 - In metabolic acidosis (\downarrow pH) blood condition
 - H^+ ions are secreted in exchange for sodium and bicarbonate ions
 - H^+ ions are attached to ammonia ions making ammonium (NH_3 & NH_4^+) which is eliminated in exchange for sodium.
 - Alkalosis (\uparrow pH)
 - Hydrogen ions conserved
 - Bicarbonate can be excreted, but not often

Exam 1

- Includes identifying anatomy from drawings....