Renal and Urinary System

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Functions of Renal and Urinary System

- Regulation of blood volume and blood pressure
- Regulate plasma concentrations of ionic salts, and nitrogenous waste
- Assists with maintenance of blood pH
- Elimination of waste products in the form of urine
- Assists with detoxification of blood

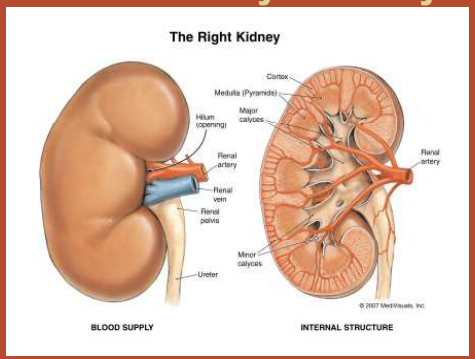
Kidneys

- Paired organs located high in the retroperitoneal cavity
  - Positioned between the 12th thoracic and 3rd lumbar vertebrae

Renal Connective Tissue

- Renal fascia- anchors the kidneys to nearby structures; dense connective tissue
- Adipose capsule- Mass of fat tissue that surrounds renal capsule
- Renal capsule- Layer of dense connective tissue that surrounds entire organ and supports the soft internal tissues

Gross Anatomy of Kidney



http://www.arizonatransplant.com/images/kidney_small_1.JPG

Renal Anatomy

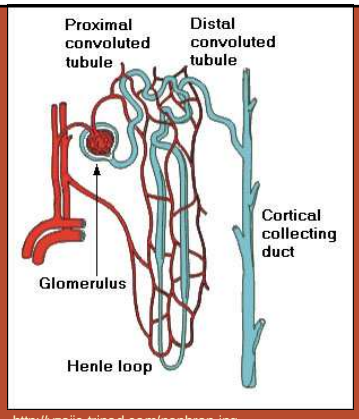
- Hilum- Indentation where blood vessels, nerves, and ureters enter and exit the kidneys
- Cortex- Superficial region of kidney
- Medulla- Deep central region of kidney
- Renal pyramids- Cone shaped structure in renal medulla
- Renal column- Extensions of cortex that separate renal pyramids

Renal Anatomy

- Renal papilla- Apex of each pyramid
- Minor calyx- cup-like structure that receives urine from duct in papilla
- Major calyx- two or more minor calices merge together
- Renal pelvis- Major calices form together; large funnel shaped chamber that empties into ureter

Nephron

- Functional unit of the kidney
- Each kidney has over 1 million nephrons
- 140 miles of filters and tubes
- Majority of nephron is in renal cortex
- There are two types of nephrons
  - Cortical nephrons (85%)
  - Juxtamedullary nephrons (15%)
    - Long loop of henle
    - Responsible for urine concentration



http://vzajic.tripod.com/nephron.jpg

Nephron

- Afferent arteriole- carries blood from renal artery into the nephron
- Bowman's capsule- A double walled capsule that surrounds the glomerulus
- Glomerulus- Multiple divisions of the afferent arteriole; approx. 50 different capillaries
  - Blood vessels in glomerulus progressively narrow as they approach efferent arteriole

Nephron

- Efferent arteriole- After the capillaries that form the glomerulus, an arteriole will leave the Bowman's capsule
  - Essential to maintain glomerular filtration in spite of fluctuations in blood pressure
  - Efferent arterioles differ depending upon the type of nephron
- Proximal convoluted tubule- Highly twisted tubular branch of the Bowman's capsule

Nephron

- Loop of Henle- Descends from the PCT into the medulla
  - Descending limb
  - Ascending limb
- Distal convoluted tubule- Tubule that extends from the ascending limb of the loop of Henle
- Collecting tubule- Merge of several distal convoluted tubules
- Renal Pelvis- Location where collecting tubule enters into

Formation of Urine

- Blood enters afferent arteriole
- Filters into glomerulus
- Drains into Bowman's capsule
  - Now it is filtrate
  - Plasma without cells and plasma proteins
- Continues through the proximal convoluted tubule
- Travels the loop of Henle
- Passes into distal convoluted tubule
  - 99% of filtrate is reabsorbed
  - 1 ml / minute

Formation of Urine

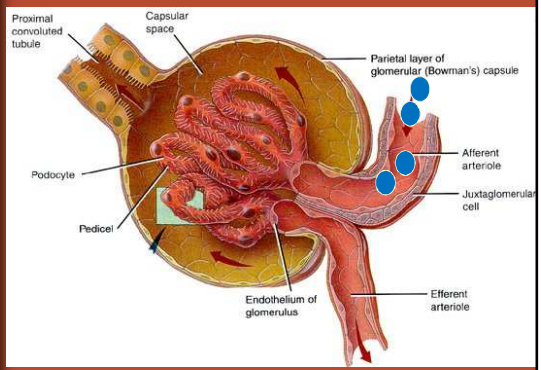
- Urine drains into renal pelvis
- Urine goes into ureter
- Stores in the bladder
- Urethra
- Urinary meatus
- Toilet! Flush!

Urine formation in nephron

- Nephrons form urine by three processes
  - Glomerular filtration
  - Tubular reabsorption
  - Tubular cell secretion

Glomerular Filtration

- Pressure in glomerulus increases to 60 mmHg to 90 mmHg
  - Normal capillary pressure is 25 mmHg
  - Occurs because of narrowing of capillaries in glomerulus
- Forces plasma to leave the capillary and enter Bowman's capsule; filtrate
- Filtrate consists of water, glucose, amino acids, salts, and urea
- Doesn't contain large proteins and cells



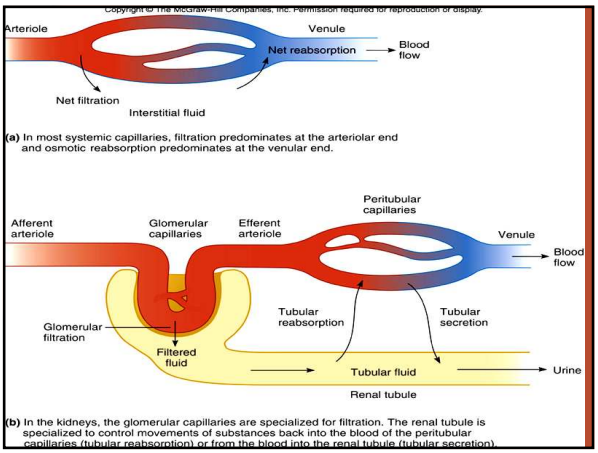
http://coe.fgcu.edu/faculty/greenep/kidney/glomer3.jpg

Glomerular Filtration

- 99% of the filtrate that enters Bowman's capsule is reabsorbed in the loop of Henle
- Filters 125 ml/min = GFR
- 180 liters per day is filtered in the glomerulus
- What would happen is reabsorption did not occur?

Control of GFR

- If the glomeruli blood pressure is too low, filtration and urine formation cease.
- **Primarily three mechanisms are responsible for keeping the GFR constant**
  - **Increased sympathetic impulses decrease GFR by causing afferent arterioles to constrict**
  - **Renin-angiotensin- aldosterone system**
  - **Autoregulation**

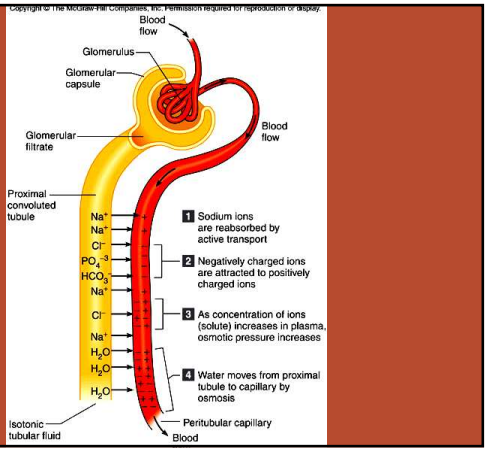


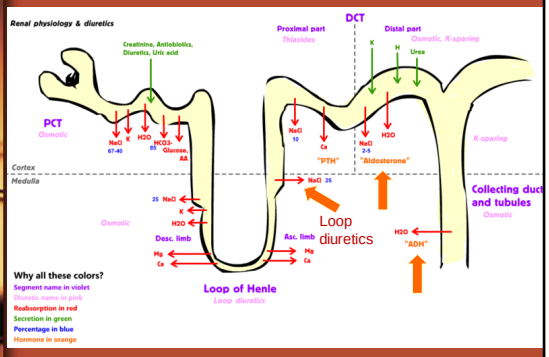
Reabsorption

- Not every thing that enters filtrate should be excreted
  - Water
  - Glucose
  - Amino acids
  - Vitamins
  - Bicarbonate
  - Some salts
- Begins in the proximal convoluted tubule
  - 80% of water in filtrate is reabsorbed in PCT

Reabsorption

- Solute reabsorption is the driving force of water reabsorption
  - Water follows salts/ solutes!
  - Can be driven by passive, or active processes
  - Creates a thresh hold value
    - Only a certain amount can be reabsored because of carrier protein saturation
    - If filtrate level exceeds thresh hold value => spill over occurs
- Optional reabsorption occurs in DCT
  - Under control of ADH hormones
- Large osmotic gradient is created in medulla





http://en.wikipedia.org/wiki/Image:Renal_Diuretics.gif

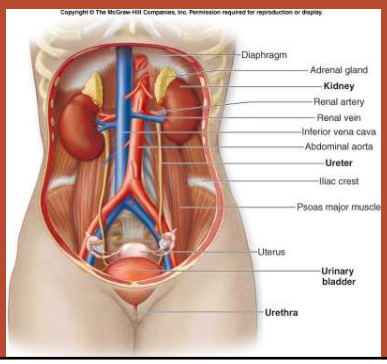
Secretion

- Opposite of reabsorption
- Active secretion of substances into tubule from peritubular capillaries
  - Ammonia
  - Creatinine
  - Hydrogen ions
  - Potassium ions
  - Medications
  - Acid base maintenace occurs here

Urinary Output

- Average 1500 ml /day
- Volume varies with person, diet, medications, and activity level
- Other factors that affect UO are solute level
- Consider diabetic patient with hyperglycemia

Urinary System



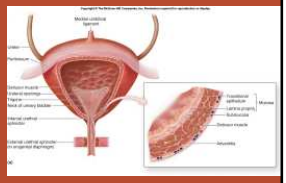
Ureters

http://i27.photobucket.com/albums/c190/lovesthesunset/anatomy%20and%20physiology/urethralabeled.jpg

- Extend from renal pelvis to the bladder
- Contain a transitional epithelium
- Smooth muscle to encourage peristalsis

Bladder

- Detrusor muscle is main muscle of bladder
- Detrusor muscle is under involuntary control
- Able to store approx. 500 ml
- Detrusor contraction forces urine into urethra
- Urethra opens into urinary meatus
- External urethral sphincter is under control of voluntary nervous system



http://academic.kellogg.cc.mi.us/herbrandsenc/bio201_McKinley/f27-9a_urinary_bladder_c.jpg

Control of Urinary Secretion

- Chemical control
  - ADH – Increases size of cell membrane pores in DCT cell membranes and collecting tubule cell membranes
  - Under control of osmoreceptors in hypothalmus
  - Aldosterone promotes excretion of potassium and hydrogen ions and reabsorption of sodium, chloride, and water

Control of Urinary Secretion

- Chemical control
  - Renin is released by cells in response to drop in blood pressure
- Nervous System control
  - CNS control of blood vessel diameter
    - Controls afferent and efferent arterioles
    - Dependent upon blood pressure

Renal Failure

- Can be acute or chronic
- Can be caused by an inflammation of the glomerulus
- Can be caused by an infectious process
- Can be obstructive in origin

Dialysis

- Treatment used for kidney failure
- Passes blood through a semi-permeable membrane to rid blood of harmful products
- Can be accomplished by directly passing blood through thin membranes surrounded with dialysate
  - Accomplished by laws of diffusion
- Can be accomplished by injecting dialysate into peritoneal space