Renal Disorders

Renal Functions
- Cleanse ECF
- Maintain acid-base balance
- Excretion of metabolic wastes
- Maintenance of blood volume (pressure)

A&P of the Kidney
- Nephron is the basic functional unit of the kidney

Nephron
- Glomerulus
- Proximal Convoluted tubule
- Loop of Henle
- Distal convoluted tubule
- Collecting duct

Kidney Processes
- Filtration –
  - Occurs in glomerulus
  - passive, nonselective
- Reabsorption
  - active transport, water follows solute
- Active tubular secretion
  - Proximal convoluted tubule
  - Acid pumps
  - Base pumps

Reabsorption
- Proximal Convoluted Tubule
  - 65% of Na and Cl
  - Virtually all bicarb and K
- Loop of Henle
  - 20% of Na and Cl
  - Descending – permeable to water
  - Ascending – not permeable to water
- Distal
  - 10% of Na and Cl
Reabsorption

- Late distal Convoluted Tubule and Collecting duct
- Sodium-potassium exchange – aldosterone
  - Actually causes more pumps to be made
- Final concentration of urine – ADH
  - Controls water permeability of collecting duct

Diuretics

- Most work by inhibiting reabsorption of NaCl
  - Earlier in the tubule they work, the stronger
  - Fun with Math
  - 180 liters of filtrate produced daily
  - 1% blockade of NaCl \( \Rightarrow 1.8 \) liters urine
  - 3% blockade of NaCl \( \Rightarrow 5.4 \) liters urine
  - 12 pounds in one day

Diagnostic and Laboratory

- Blood Urea Nitrogen (BUN): 10 – 20
- Creatinine: 0.7 – 1.2
- Creatinine Clearance
- Variety of Urinalysis tests
  - pH
  - Specific gravity
  - Presence of Proteins, Blood, Urobilinogen, Leukocytes, Bacteria, Glucose, Ketones
  - Microscopic examination

Adverse Impact

- Hypovolemia
- Acid-base imbalance
- Electrolyte imbalance
- Mitigating
  - Use short acting
  - Timing

Diuretics

- High Ceiling (Loop) diuretics
- Thiazide diuretics
- Potassium-sparing
  - Aldosterone antagonists
  - Non-aldosterone antagonists
- Osmotic Diuretics
- Carbonic anhydrase inhibitors (not used for diuresis; used for IOP)

Loop Diuretics

- Act in ascending loop of Henle
- Strongest
- Drugs
  - Furosemide (Lasix)
  - Bumetanide (Bumex)
  - Torsemide (Demadex)
  - Ethacrynic acid (Edecrin)
**Furosemide (Lasix)**
- **Pharmacokinetics**
  - PO onset 60 minutes, duration 8 hours
  - IV onset 5 minutes, duration 2 hours
  - Hepatic metabolism, renal excretion
- **Therapeutic uses**
  - Pulmonary edema
  - CHF
  - Edema
  - Hypertension
  - Work even with severe renal impairment

**Adverse effects**
- Hyponatremia, Hypochloremia, Dehydration
- Hypotension
  - Monitor BP at home
  - Get up slowly
- Hypokalemia
- Ototoxicity
- Hyperglycemia – caution in DM
- Elevated uric acid
- Lipids, Calcium, Magnesium

**Drug Interactions**
- Digoxin
- Ototoxic drugs
- Potassium sparing diuretics
- HTN drugs
- NSAIDS

**Thiazide Diuretics**
- Hydrochlorothiazide (HCTZ)
- Action – blocks NaCl in early DCT
  - Do not work when GFR < 15-20 mL/min
- **Pharmacokinetics**
  - PO, Onset 2 hours, peaks 2 – 6 hours
  - Excreted unchanged in kidneys
- **Uses**
  - HTN
  - Edema

**Adverse effects**
- Hyponatremia, Hypochloremia, Dehydration
- Hypotension
  - Monitor BP at home
  - Get up slowly
- Hypokalemia
- Hyperglycemia – caution in DM
- Elevated uric acid
- Lipids, Calcium, Magnesium

**HCTZ dosing**
- Smaller is better these days
- Starting dose 6.25 or 12.5 mg
- Max dose 50 mg/day
- Prefer max of 25 mg/day
- Dirt cheap
- Frequently combined with other antihypertensive medications
Potassium Sparing

- Spironolactone (Aldactone)
  - Aldosterone antagonist
    - HTN and Edema
    - Portal Hypertension/Ascites
    - CHF
- Adverse effects
  - Hyperkalemia
  - Endocrine effects
- Interactions
  - Other Diuretics, Potassium raising drugs

Osmotic Diuretics

- Mannitol
  - 6 carbon sugar
  - Not metabolized
  - Not reabsorbed
  - Increases osmolality of filtrate
- Uses
  - Renal failure prophylaxis
  - ICP
  - IOP

Measures of Renal Function

- BUN
- Creatinine
- Electrolytes: esp. Na, K, Cl
- Estimated GFR: 85 – 135 (insuff <60)
- Creatinine Clearance
- Urine volume
- Urinalysis

Urinalysis

- Color
- Odor
- Protein (uria)
- Glucose (uria)
- Ketones (uria)
- Urobilinogen
- Sp. Grav
- Osmolality
- pH
- RBCs (hematuria)
- WBCs (leuckocyte)
- Casts
- Culture*

Renal and Urinary D/Os

- Infectious (UTI)
  - Cystitis, Pyelonephritis, Urethritis, Prostatitis, Epydidimitis, PID
- Kidney
  - Glomerulonephritis
  - Nephrotic syndrome
- Calculi
- Renal Failures: ATN, Acute, Chronic
Infectious Diseases

- Lower Tract
  - DOC: TMP/SMX
  - Fluoroquinolone
- Upper Tract
  - Pyelonephritis
    - Inflammation of parenchyma
  - Interstitial cystitis
    - "Fake UTI"

Glomerulonephritis

- Immune damage
  - extent of damage
  - etiology
  - extent of changes
- Mechanism
  - Type II
  - Type III

Rhabdomyolysis

- Increased muscle destruction
  - Proteinemia
  - Proteins clog glomerulus
  - May lead to Renal Failure

Renal Failures

- ARF (50% mortality with treatment)
  - Prerenal: blood flow
  - Intrarenal
  - Postrenal: ureteral blockage
- CRI/CRF
  - GFR < 60 l/min
  - ESRD < 15 l/min
    - Dialysis
    - Kidney Transplant
**ARF: General**
- ↑ Fluid, BUN, Creat, electrolytes
- ↓ Urine output (<400ml/day)
- azotemia: uremic frost
- Acidosis
- Anemia, Agranulocytosis
- Stages: Initiation → Oliguric (1-7 days) → Diuretic → Recovery
- Dialysis if necessary

**ARF**
- Prerenal
  - Decreased blood flow
    - Renal artery stenosis
    - Hypovolemia, Shock, Heart failure
  - Drugs: e.g. Norepinephrine
- Tx
  - Underlying disease
  - Drugs: Dopamine, mannitol

**ARF**
- Intrarenal
  - Acute Tubular Necrosis (ATN)
  - Ischemia, toxins, pigments** (contrast)
- Postrenal
  - Kidney stones or strictures
  - Cancer
  - Hydronephrosis
  - Remove blockage

**Chronic Kidney Disease**
- Major risk factors
  - Diabetes 45%
  - Hypertension 27%
- Prevention
  - Control above diseases
  - ACE Inhibitor/ARB

**Manifestations**
- Early
  - ↓ Creatinine Clearance
  - ↑ BUN/Creatinine
  - Proteinuria
- Later
  - Fluid retention --> edema, oliguria
  - Anemia --> reduced erythropoietin
  - Acidosis
  - ↑ Electrolytes and other waste products