Chapter 23

Composition and Properties of Urine
Composition and Properties of Urine

- **urinalysis** – the examination of the physical and chemical properties of urine
  - **appearance** - clear, almost colorless to deep amber - yellow color due to urochrome pigment from breakdown of hemoglobin (RBCs) – other colors from foods, drugs or diseases
    - cloudiness or blood could suggest urinary tract infection, trauma or stones
    - **pyuria** – pus in the urine
    - **hematuria** – blood in urine due to urinary tract infection, trauma, or kidney stones
  - **odor** - bacteria degrade urea to ammonia, some foods impart aroma
  - **specific gravity** - compared to distilled water
    - density of urine ranges from 1.001 -1.028
  - **osmolarity** - (blood = 300 mOsm/L)
    - ranges from 50 mOsm/L to 1,200 mOsm/L in dehydrated person
  - **pH** - range: 4.5 to 8.2, usually 6.0 (mildly acidic)
  - **chemical composition**: 95% water, 5% solutes
    - **Normal** to find
      - urea, NaCl, KCl, creatinine, uric acid, phosphates, sulfates, traces of calcium, magnesium, and sometimes bicarbonate, urochrome and a trace of bilirubin
    - **Abnormal** to find
      - glucose, free hemoglobin, albumin, ketones, bile pigments
Urine Volume

• **normal** volume for average adult - 1 to 2 L/day

• **polyuria** - output in excess of 2 L/day

• **oliguria** – output of less than 500 mL/day

• **anuria** - 0 to 100 mL/day
  – low output from kidney disease
  – Dehydration
  – circulatory shock
  – prostate enlargement

• low urine output of **less than 400 mL/day**
  – the body cannot maintain a safe
  – low concentration of waste in the plasma
Diabetes

• **diabetes** – any metabolic disorder resulting in chronic polyuria

• at least four forms of diabetes
  – **diabetes mellitus type 1, type 2, and gestational diabetes**
    • high concentration of glucose in renal tubule
    • glucose opposes the osmotic reabsorption of water
    • more water passes in urine (osmotic diuresis)
    • glycosuria – glucose in the urine

  – **diabetes insipidus**
    • **ADH hyposcretion** causing not enough water to be reabsorbed in the collecting duct
    • more water passes in urine
Diuretics

• any chemical that increases urine volume
  – some increase GFR
    • caffeine dilates the afferent arteriole
  – reduce tubular reabsorption of water
    • alcohol inhibits ADH secretion
  – act directly on nephron loop (loop diuretic)
  – inhibit Na⁺ - K⁺ - Cl⁻ symport
    • impairs countercurrent multiplier reducing the osmotic gradient in the renal medulla
    • collecting duct unable to reabsorb as much water as usual
  – Osmotic diuretics
    • Filtered but not reabsorbed
    • Solute may exceed Tubular Transport Maximum (i.e. glucose)

• commonly used to treat hypertension and congestive heart failure by reducing the body’s fluid volume and blood pressure
Renal Function Tests

- tests for diagnosing kidney disease
- evaluating their severity
- monitoring their progress
- determine renal clearance
- determine glomerular filtration rate
Renal Clearance

- the volume of blood plasma from which a particular waste is completely removed in 1 minute

- represents the net effect of three processes:

  - glomerular filtration of the waste
  - + amount added by tubular secretion
  - – amount removed by tubular reabsorption

renal clearance
Renal Clearance

• **determine renal clearance** (C) by collecting blood and urine samples, measuring the waste concentration in each, and measuring the rate of urine output:
  – U - waste concentration in urine – 6.0 mg/mL (urea example)
  – V - rate of urine output – 2 mL/min
  – P - waste concentration in plasma – 0.2 mg/mL
  – C – renal clearance in mL/min of waste cleared
  – C = UV/P = 60 mL/min (60 mL of blood plasma is completely cleared of urea per minute)

• compare C to normal GFR of 125 mL/min to see if normal rate of clearance is occurring - 48% which is normal for urea
Glomerular Filtration Rate

- kidney disease often results in lowering of GFR
  - need to measure patient’s GFR
  - can not use clearance rate of urea
    - some urea filtered by glomerulus is reabsorbed in the tubule
    - some urea is secreted into the tubule

- need a substance that is not secreted or reabsorbed at all so that all of it in the urine gets there by glomerular filtration
  - use inulin, a plant polysaccharide to determine GFR
    - neither reabsorbed or secreted by the renal tubule
    - inulin GFR = renal clearance on inulin

- clinically GFR is estimated from creatinine excretion
  - does not require injecting a substance or drawing blood to determine its blood concentration
  - in plasma and we know concentration