Urine Physical Properties

- Excellent web site on physical properties:
  - http://www.texascollaborative.org/spencer_urinalysis/dl_sub1.htm
- Physical properties
  - simple observations
    - Color and clarity / transparency or turbidity
    - Odor, specific gravity & Volume
  - clues to subsequent findings
    - Example: red & cloudy = possible blood
- Some abnormal physical properties dictate special or additional tests needed
  - Example: amber color & yellow foam = may need to do Ictotest to verify presence of bilirubin

Urine Physical Property - Volume

- Volume
  - Not usually recorded in routine UA
  - Dependent of body's state of hydration
  - Influenced by fluid intake, loss through non-renal sources (sweat, vomiting, etc.) ADH hormone, etc.
  - Example: diabetics have very large quantities of urine, yet are often dehydrated.
  - Volume required for 'timed specimens' and quantitative tests
Urine Physical Property - Volume

• Volume
  NV = 600-1600 (ave. 1200-1500 mL/24 hr)
  2-3 times more produced during day than night

• Terms
  • Polyuria – consistent elimination of abnormally large amounts of urine (> 2000 mL/24 hr.)
    Many possible reasons
    • Diabetes mellitus
    • Diabetes insipidis (suppressed ADH)
  • Diuresis – any increase, even temporary
  • Oliguria – decrease in volume (< 500 mL/24 hr.)
    Many possible reasons
    • Dehydration
    • Severe burns

Terms cont.
• Anuria – absence of urine formation. Usually due to serious damage to kidneys or the blood flow.
• Nocturia – excretion of urine at night.
• Most urine (2-3 x) produced during day.
• Nocturia may or may not be pathology related.

• QNS – quantity not sufficient for testing.

Urine Physical Properties

• Color & Clarity
  Varies with concentration, physical activity, ingested substances, & drugs
  Pathological reasons also affect urine color and transparency
Normal urine color variations

- **Color**
  - Normal colors: colorless, straw, light yellow, yellow, dark yellow and ~ amber
  - Specimens that are truly amber should be considered suspicious of containing bilirubin / bile

Urine Physical Properties - Color

- **Cause - pigment byproducts of metabolism**
  - Urochrome - yellow pigment (predominant)
    - Normally produced at constant rate, and in normal patients can be good indicator of level of patient hydration.
  - Uroerythrin - red pigment
    - Causes pink-ish color to amorphous crystals (urates) that frequently form in refrigerated specimens.
  - Urobilin - orange-red/brown pigment
    - Oxidation product of urobilinogen

Urine Physical Properties - Color

- **Abnormal urine colors**
  - May or may not indicate disease
  - May cause problems with readings of dipstick (may need to use 'back up' tests to obtain test results).
  - Most abnormal colors have variety of possible reasons.** Review your textbook.**
  - Amber - possible bile / bilirubin, often associated with hepatitis
Urine Physical Properties - Color

- Pale to colorless – urine often very dilute
- Brown – many possibilities: bile/bilirubin, old blood
- Orange-red – increased urobilin, or possibly medication (pyridium - frequently prescribed for UTI)
- Clear red – hemoglobin (lysed RBCs) or myoglobin (muscle hemoglobin)
- Cloudy red – intact red cells
  - Pinkish red, beets
- Port wine – porphyrins
  - Classic color from a group of related compounds
  - Dipstick for blood is negative
  - Detect with Watson-Schwartz screening test or positive fluorescence under ultraviolet light
  - Cola color – usually old hemoglobin or myoglobin

Urine Physical Properties - Color

- Abnormal urine colors  Pink, Red, Brown & Black
- Blood
  - Fresh blood in small amount (acid pH) = pinkish
  - Abundant blood, fresh = red urine
  - Blood in any amount alkaline ph = shade of brown
  - Old blood = shades of brown

Urine Physical Properties - Color

- Abnormal colors - Pink, Red, Brown, & Black
- Myoglobin – from breakdown of skeletal muscle tissue
- Low molecular weight – filters easily
- Fresh urine red – brown
- Not found in Patient’s plasma
Urine Physical Properties - Color

- Black -
  - Melanin – oxidation product of colorless melanogen
    - Melanogen released from malignant melanoma.
    - Urine will have normal color when voided.
    - As specimen is exposed to air, melanogen oxidizes to melanin & it turns dark from top down.

- Homogentisic acid (alkapton bodies)
  - Metabolite of amino acid, phenylalanine,
  - Turns dark as pH becomes alkaline

Urine Physical Properties - Color

- Bizarre urine colors
  - Blues – Greens
    - Can be due to drugs and chemicals
    - Bacteria - Pseudomonas can cause greenish color

Urine Physical Properties

- Urine transparency
  - Also called clarity

- Clear - normal - fresh urine that is cloudy usually indicates a problem

- Classifications: clear, slightly hazy, hazy, cloudy, very cloudy, turbid
Urine Physical Properties - Clarity

- Causes - the causes of a non clear urine should be accounted for in the microscopic
  - Amorphous (no shape) crystalline material
    - Amorphous urates - acid urine - pink precipitation
    - Amorphous phosphates - alk urine - white precipitation
  - Mucin - or mucous threads

- Pus (WBCs) and bacteria
  - Cells - such as epithelial cells
  - Other substances - artifacts; threads from clothing, powder etc.

Urine Physical Properties - Odor

- Odor - not normally reported out
  - Normal - aromatic
  - Ammonia - from bacterial breakdown of urea
    - specimen is old, allowed to sit at room temp OR
    - patient has a UTI problem
  - Metabolic
    - Sweet (diabetes) / Fruity = ketones
    - Maple syrup = Maple syrup urine disease
    - Musty / Mousy (PKU)
  - Food
    - Onion
    - Garlic
    - Asparagus - need to have the gene to smell it

Urine Physical Properties - Foam

- Foam - not reported out
  - White - possible protein
  - Yellow - may be due to bile / bilirubin
Urine Physical Properties

- **Specific gravity**
  - **Definition**: Relation of the weight of a solution to the weight of an equal volume of water at a given temperature.
  - **Used to measure**: the concentrating and diluting ability of the kidney.
  - A measure of the density of the dissolved chemicals.
  - Indicates how concentrated the specimen is
    - Increased sp gr = more concentrated
    - Decreased sp gr = dilute urine
  - Water is used as the point of reference and is assigned the value of 1.000 (sp. gr. is a ratio and has no units)

Physical Properties - Specific Gravity

- **Specific gravity measurement**
  - **Direct methods**
    - Urinometer
    - Harmonic oscillation densitometry (HOD)
  - **Indirect methods**
    - Refractometer
    - Chemical reagent strips

Physical Properties - Specific Gravity

- **Urinometer - hydrometer**
  - Not very accurate and rarely used.
  - No longer recommended by National Committee for Clinical Laboratory Standards (NCCLS)
  - A calibrated floating device is suspended in a volume of urine.
  - Float displaces the urine
    - (with its greater mass), the level to which the float sinks is measurement of the density of the urine.
Refractometer (TS / total solids meter)
- Most common instrument for measurement of specific gravity.
- Measures density of solutions by their refractive index
  - Comparing velocity of light passing through air to velocity passing through the solution.
  - More dense the solution the more altered (bent) the light will be.
- Read result on scale within the TS meter

Physical Properties - Specific Gravity

Specific Gravity - Refractometer
- Refractometer
- This measurement represents a reading of 1.014.
Physical Properties - Specific Gravity

• Refractometer (TS / total solids meter)
  - Calculation of specific gravity following a dilution.
    - Reason – occasionally specific gravity too high for reading on scale.
    - Method – make a dilution (usually x2) using distilled/deionized water. Read in TS meter.
    - Example calculation of result:
      reading = 1.032
      multiply the .032 x dilution factor (usually 2)
      report as 1.064

• Osmometer / osmolarity
  - Measured either by freezing point or by vapor pressure depression.
  - Measures total solute concentration, but depends on the number of particles in the solution, whereas specific gravity depends on the number and weight of the solutes.
  - Osmolality is a better indicator of the concentrating and diluting abilities of the kidney, because it is unaffected by the density of solutes.

• Not routinely used in UA screening
  - Usually found in chemistry department where both serum and urine are tested.
  - Measurement is a function of dissolved particles
  - Two basic types
    - Vapor pressure depression (dew point) – measures temperature that water vapor condenses to a liquid
    - Freezing point depression – * most common
  - Normal serum = 275-300 mOsm/kg
  - no set normals for urine, look at ratio between serum and urine, which should be 1:1
Harmonic Oscillation densitometry
- Not commonly used in the clinical laboratory.
- Uses sound waves to measure urine concentration.
- Urine enters a glass tube with an electromagnetic coil at one end.
- Sonic oscillation is generated when an electric current is applied to the coil. The oscillation detected is proportional to the density of the urine.
- A microprocessor corrects sample temperature.
- Result is valid up to a specific gravity of 1.080 based on change in frequency of sound waves as they are passed through the solution. The waves are altered by the density.

Physical Properties - Specific Gravity
- Urine dipstix with specific gravity - *Most common method used today.
- Measures pKa change of polyelectrolytes in relation to ionic concentration; actually measures ionic concentration that relates to urine specific gravity.
- When more ions are present, more acid groups become dissociated, releasing hydrogen ions and causing the pH to change.
- Indicator then measures the change in pH.
- When urine has an increased specific gravity, the reagent pad becomes more acidic.

Physical Properties - Specific Gravity
- Normal value
  - Overall 1.015 - 1.025 (first morning specimens usually have sp. gr. > 1.020)
  - Kidneys are capable of 1.001-1.030 (authors vary; 1.002 - 1.040)
    - Specific gravity > 1.040 by refractometer usually due to X-ray dye Renografin, or Hypaque - these specimens usually also have large amount of sediment from the precipitation of the dye.
**Physical Properties - Specific Gravity**

**Related terms**
- Isosthenuric: SG of 1.010 (the SG of the plasma ultrafiltrate)
  - Isosthenuria is a very serious clinical condition where the patient's kidneys are not able to dilute or concentrate the urine. The specific gravity remains fixed at 1.010
- Hyposthenuric: SG lower than 1.010
- Hypersthenuric: SG higher than 1.010

**Physical Properties - Specific Gravity**

**Normal random specimens range:**
- 1.003–1.035; most common 1.015–1.025
- Below 1.003 may not be urine
- Consistent low readings: further testing needed

**Physical Properties - Specific Gravity**

**Review and Clinical significance**
- Osmotic pressure - Specific gravity is a means of assessing kidneys ability to regulate osmotic pressure maintaining homeostasis of body fluids
- Kidney function assess ability of renal tubule cells to regulate concentration
  - Increased fluids should = decreased specific gravity
- State of hydration if there is no reason to believe kidneys are malfunctioning, a doctor can use specific gravity to evaluate if patient is properly hydrated.
- Review all the terms related to urine volume.