BACKGROUND

It is said the analysis of urine was actually the beginning of laboratory medicine. References to the study of urine can be found in the drawings of cavemen and Egyptian hieroglyphics. Historically urine was evaluated by its color, clarity, odor and taste. Today, color and clarity (and odor) are still assessed but chemical reactions have taken the place of the ‘taste test’. Results obtained from the physical examination of urine are helpful to the clinician in determining the presence of disease.

ASSIGNMENT

1. Read the ‘Physical Examination of Urine’ notes, using the objectives to focus your study. Refer to chapter 6 in the required textbook for clarification as needed
   a. page 95-105 (omit Osmolality section)
   b. page 110 (specific gravity term: isosthenuria)
   c. page 116-117 (specific gravity section)

2. Complete the Physical Examination of Urine Study Questions

3. View the following videos in Blackboard:
   a. Color (1:36)
   b. Clarity (1:42)
   c. Refractometer: Specific Gravity (5:19)
OBJECTIVES

Upon completion of unit, the Clinical Laboratory Science student will:

1. Describe the physical examination of normal and abnormal urine, including:
   a. Color
   b. Clarity
   c. Odor
   d. Specific gravity

2. Discuss the origin of the following pigments and their effect on urine color:
   a. Urochrome
   b. Bilirubin
   c. Urobilin
   d. Uroerythrin

3. Correlate any abnormal findings for the characteristics discussed in Objective #1 to possible pathologic conditions or interfering substances.

4. Discuss the significance of the specific gravity measurement.

5. Discuss the following terms, including possible disease states associated with that term:
   a. Isosthenuria
   b. Hyposthenuric
   c. Hypersthenuric

6. Describe the principle of measurement of specific gravity using a refractometer.

7. Evaluate the effect of radiographic dye on specific gravity measurements by refractometry.

8. Evaluate the effect that increased amounts of protein and bilirubin can have on the appearance of urine foam.
STANDARDIZED RECOMMENDATIONS

A. The following protocol is used when evaluating the physical characteristics of urine
   1. Use a well-mixed urine
   2. View through a CLEAR container: plastic or glass
   3. View against a white background
   4. Evaluate a consistent depth or volume of specimen
   5. Maintain room lighting at a consistently adequate level

B. All laboratorians should follow this protocol when examining urine so that urine is evaluated consistently and urine color is reported consistently; encourages attention to detail and the use of established/standardized terminology

COLOR

A. Urine is normally a shade of yellow. Color variations (colorless, amber, orange, red, green, blue, brown, black) can be due to:
   1. Presence of disease
   2. Excessive physical activity
   3. Metabolic abnormality
   4. Stress
   5. Ingested food or drug

B. The main pigment responsible for normal urine color is called urochrome. Urochrome is a product of endogenous metabolism; it is a lipid-soluble pigment found in the plasma and excreted into the urine

C. Because production and excretion of this pigment is constant, the intensity of urine color can be a crude indicator of the concentration of the urine and the body’s level of hydration.

D. Two additional urinary constituents also contribute to urine color:
   1. Urobilin: orange-brown pigment color
   2. Uroerythrin: pink pigment color

E. It is recommended all laboratory personnel use the same terminology when describing urine color. This is to reduce ambiguity in color interpretation and improve consistency in the reporting of urine colors

F. Abnormal color and possible causes:
   1. Bright yellow: most often due to multivitamins
   2. Amber, dark amber: presence of bilirubin, urobilin
   3. Orange: medications most common cause (urinary analgesic), bilirubin
   4. Red/pink: intact red blood cells, hemolyzed red blood cells (hemoglobin), Myoglobin (muscle protein), porphyrins (heme precursors), beets
   5. Brown/black: methemoglobin, hemoglobin, myoglobin, homogentisic acid, melanin
   6. Green/blue: renal function dyes, methylene blue, chlorophyll (breath mints), pseudomonas infection
CLARITY

A. Refers to the transparency of urine

B. It is recommended all laboratory personnel use the same terminology when describing urine clarity. This assures consistency in reporting and eliminates ambiguity

C. Freshly voided ‘clean catch’ normal healthy urine appears clear. Many urines submitted to the laboratory for analysis appear hazy

D. Provides a rapid quality check of microscopic results: A cloudy urine should have a significant number of microscopic components present

E. Describe the appearance of urine using the following clarity terms:
   1. **Clear** = no visible particulate matter present
   2. **Hazy** = some visual particulate matter is present; newsprint is not obscured
   3. **Cloudy** = visible particulate matter is present; newsprint is obscured or blurred
   4. **Turbid** = newsprint cannot be viewed through urine OR particulate falls out of solution

F. Specimen collection and handling errors that can cause urine to appear hazy or cloudy:
   1. Contamination from squamous epithelial cells or mucus (due to lack of proper site/area cleansing prior to collection of a clean catch urine; or patient did not follow the clean catch procedure)

   2. Improper handling of the urine specimen after collection can cause bacterial overgrowth (urine not analyzed within 2 hours of collection and/or not refrigerated)

G. Substances contributing to the clarity of urine can be pathologic or nonpathologic
   1. Non-pathologic substances contributing to turbidity:
      a. Normal solute crystals (urates, phosphates, calcium oxalate)
         1) Amorphous urates: pink precipitate in acidic urine
         2) Amorphous phosphates: white precipitate in alkaline urine
      b. Spermatozoa and prostate fluid – contaminants
c. Radiographic contrast media (dye) - iatrogenic  
d. Mucus, mucin, squamous epithelial cells  
e. Contaminants such as talc, lotion, powders, creams, etc.  
f. The presence of fecal material and/or many squamous epithelial cells in the urine sample indicates  
   1) Improper collection technique (contaminant)  
   2) Presence of fistula between bladder and colon (pathologic)  

2. Pathologic substances in urine indicate a:  
a. Deterioration of the barrier normally separating the urinary tract from the blood  
b. Disease process  
c. Metabolic dysfunction  

3. These substances, when present in urine, indicate a pathologic condition:  
a. RBC – indicate damage  
b. WBC – inflammation  
c. Abnormal crystals and calculi  
d. Bacteria (in fresh urine)  
e. Yeast and trichomonads (vaginal contaminants)  
f. Renal epithelial cells  

H. Clear urine does not indicate normal urine. Glucose, protein, lysed red blood cells are a few examples of substances that can be present in abnormal amounts in a clear urine. The clarity and microscopic evaluation should correlate.  

FOAM  

A. Presence is not reported but used by the technologist as preliminary evidence for the presence of bilirubin and abnormal amounts of protein  
   1. White foam that persists upon agitation - protein  
   2. Amber urine with dark yellow foam upon agitation – bilirubin  
   3. All other urine may form a small amount of foam upon agitation, but it quickly dissipates and will be clear to white.  

ODOR  

A. Not reported  

B. Normal urine: ‘aromatic’ odor due to organic and inorganic byproducts of metabolism  

C. Abnormal urine - the following abnormal odors may be caused by:  
   1. Foul/ammonia: old urine, urine improperly stored  
   2. Pungent/fetid: urinary tract infection  
   3. Sweet/fruity: ketone production (caused by diabetes mellitus, starvation, dieting, malnutrition, strenuous exercise, vomiting, diarrhea  
   4. Mousy/barny: amino acid disorder = phenylketonuria (PKU)  
   5. Maple syrup: amino acid disorder = maple syrup urine disease (MSUD)  
   6. Rotting fish: Trimethylaminuria  
   7. Rancid: Tyrosinemia  
   8. Bleach: adulteration of the specimen or container contamination  
   9. Ingestion of foods: asparagus, garlic, onions
D. The importance of odor is in determining that urines with strong odors are fresh specimens that have been stored properly.

TASTE
A. Circa 1674, urine was tasted to detect urinary sugars. Fortunately, this is no longer the case!

CONCENTRATION
A. Concentration refers to the amount of solutes present in a volume of water and is most often expressed as Specific Gravity as part of routine urinalysis. Specific Gravity (SG) is a measurement of density.
   1. Osmolality is a more accurate measurement of urine density based on the colligative property. Colligative properties of a solution depend only on the number of solute particles present. Particle size and ionic charge have no effect. This is not a routine test for urinalysis.

SPECIFIC GRAVITY
A. Definition: the ratio of urine density to the density of an equal volume of pure water under specific conditions
B. Affected by the number and molecular size of solutes in solution. The greater the urine density, the higher the specific gravity.
C. Significance of SG: reflects concentrating ability of kidney by measuring dissolved solids in urine
   1. High specific gravity: Indicates a more dense or concentrated urine
      a. Also may indicate low urinary volume (output)
      b. The max specific gravity urine can attain is approximately 1.040 (hyperosmotic renal medulla)
   2. Low specific gravity: Indicates a less dense or dilute urine
      a. Also may indicate high urinary volume (output)
      b. It is physiologically impossible to attain a urine specific gravity of 1.000 (pure water). The lowest attainable is approximately 1.002
D. Urine specific gravity ranges:
   1. SG of pure water: 1.000 (physiologically impossible)
   2. 1.001-1.009: Dilute urine, increased intake, diuresis
   3. 1.010-1.025: Average intake and excretion
   4. 1.025-1.035: Concentrated urine, dehydration, fluid restriction
   5. >1.040: Physiologically not possible. Indicates presence of iatrogenic substance.
   6. SG will vary throughout the day as hydration status changes.
E. Terms used to describe SG:
   1. Isosthenuria = specific gravity measurements remain at 1.010 over time
      a. Presence of renal disease
      b. Repeated measurements at different times/different days all 1.010
1. **Hyposthenuric**: SG < 1.010 (descriptive term only)

2. **Hypersthenuric**: SG > 1.010 (descriptive term only)

**F. Specific Gravity Methods of Measurement**

1. **Urinometer**: historical method, lacks accuracy

2. **Harmonic Oscillation Densitometry**: Sound wave oscillation (frequency) is directly related to density (increased frequency = increased density). Used on the semi-automated workstation: IRIS, and rarely used today

3. **Refractometry**
   
a. Principle: Indirect measure based on the refractive index of light. When light passes from air into a solution at an angle, the direction of the light beam is refracted (bent) and its speed (velocity) decreases.

b. The ratio of light refraction between the air and the solution is called the **refractive index** (RI).

c. Three factors affect the refractive index of a solution:
   1) The wavelength of light used
   2) Temperature of solution
   3) Concentration of solution

d. **Refractometers** measure the angle at which light passes through a solution and mathematically converts this angle to specific gravity.
   1) When viewing the refractometer reading scales, there are 3 scales to ‘pick’ from: urine specific gravity, serum or plasma protein T/C or refraction. Make sure you read the ‘Urine Specific Gravity T/C’ scale.
   2) Refer to (**Figure 6-5, page 101**). Using this schematic, the specific gravity reading for a urine sample is **1.030**.

e. Temperature of urine does not affect refractometer measurements because the temperature of the urine is equilibrated to the temperature of the liquid in the ‘prism apparatus of the refractometer’ (when temp of urine is between 15° and 37°C).

f. **Specific gravity measurements using a refractometer measure all solutes in solution including glucose and protein (and radiographic contrast media). Remember, the presence of radiographic media will cause SG measurements that are physiologically impossible.**

g. Calibration of the instrument is checked using distilled water (1.000) and 5% NaCl (1.022 ± 0.001)

h. **Advantages of using refractometry to determine specific gravity:**
   1) Small amount of sample required (2-3 drops)
   2) Ability to automatically make temperature compensations for specimens between 15° and 37°C
i. Disadvantages: may need to correct specific gravity measurements due to the presence of high concentrations of glucose and/or protein. Most laboratories do NOT perform these corrections on a routine basis, unless requested by clinician.

1) 1 gram/dl of protein will increase SG by 0.003
2) 1 gram/dl glucose will increase SG by 0.002
3) Example: Specific gravity by refractometry = 1.035.

If the protein concentration in the urine is 2.0 g/dl, then 0.006 (2 x 0.003) will need to be subtracted from 1.035 giving a 'corrected' specific gravity result = 1.029

4. For the Reagent Strip Method, refer to the Chemical Examination of Urine Lecture Notes