**BACKGROUND**

Urinalysis is a non-invasive screening method for many types of diseases. In this introduction to urinalysis, you will learn how urine is formed, what urine is composed of, the different types of specimens collected, and changes that can occur to the specimen (and test results) due to improper handling.

**ASSIGNMENT**

1. Read the 'Introduction to Urinalysis' notes, using the objectives to focus your study. Refer to chapter 3 and specific sections in chapter 2 and 4 in the required textbook for clarification as needed.
   a. Brunzel: page 37-45
   b. Brunzel: page 54, table 4-2
   c. Brunzel: page 27-28 (Monitoring Analytical Components of Quality Assurance)

2. Complete the 'Introduction to Urinalysis Worksheet' as you complete the reading assignment.

2. Complete the study questions found on page 45-46 (#1-10, 12-13) and page 33-34 (#1, 5, and 10) of the textbook.
OBJECTIVES

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

1. List at least three clinical reasons for examining urine.

2. State the three major chemical solutes of urine.

3. Name a test that may be performed on a questionable sample to determine if it is urine or another body fluid.

4. Describe the following collection techniques for urine specimens, including the advantages and disadvantages of each:
   a. First morning void
   b. Random
   c. Midstream “clean catch”
   d. Catheterized
   e. Suprapubic aspiration
   f. Timed collections
   g. Pediatric collections

5. Identify at least one diagnostic use for each collection technique listed in Objective #4.

6. Explain the importance of the following guidelines used for specimen collection and processing of urine samples:
   a. Storage
   b. Labeling
   c. Handling
   d. Accurate timing and complete collection for timed specimens

7. Describe the collection protocol used for a 24-hour (timed) urine collection.

8. Predict the potential changes that may take place in an unpreserved urine specimen that remains at room temperature for longer than two hours, explaining the mechanism for each change.

9. Discuss the advantages and disadvantages of refrigeration as a method of preserving urine.

10. Discuss the proper use of chemical additives as a method of preserving urine.

11. Discuss the advantages and disadvantages of refrigeration as a method of preserving urine.

12. Explain the use of quality control in the urinalysis laboratory.

13. Correlate physical, chemical and microscopic urinalysis results to determine the acceptability of a urinalysis report.

14. Select appropriate actions based on the results obtained on a urinalysis report.
EXAMINATION OF URINE

A. Clinical reasons (rationale) for the examination of urine are to:
   1. Aid in diagnosis of disease
   2. Screen for asymptomatic, congenital or hereditary disease
   3. Monitor disease progression
   4. Monitor therapy effectiveness or complications

B. Clinical utility of urinalysis (why study urine?):
   1. Easy specimen to collect (noninvasive)
   2. Inexpensive and essential screening tool
   3. Provides information regarding the health status of the kidneys
   4. Provides information regarding systemic diseases that may or may not affect the kidney
   5. Urine contents reflect metabolic function

FORMATION AND COMPOSITION OF URINE

FORMATION OF URINE

A. Urine is continuously formed by the kidneys; Involves 3 complex processes:
   1. Glomerular filtration of small molecular weight substances from the blood
   2. Tubular reabsorption of essential substances such as water, glucose, and electrolytes into the blood
   3. Tubular secretion of toxic substances (toxins, drugs) and waste products (urea, uric acid, creatinine) into the urine

COMPOSITION OF URINE (textbook, refer to table 4-2, page 54)

A. WATER is the largest component (> 96 %) of urine
   1. Amount is dependent on the hydration state (status) of the patient.
   2. If the patient is well hydrated, the urine will be dilute (contains more water) and if the patient is dehydrated, the urine will be concentrated (contains less water)

B. The main chemical solutes of urine are:
   1. Urea
   2. Sodium
   3. Chloride

C. Other chemical components of urine include:
   1. Potassium (small amounts)
   2. Creatinine (large amounts)
   3. Uric acid
   4. Phosphate (PO4) and sulfate (SO4)
D. Sometimes a specimen is submitted to the laboratory and the technologist may question if the sample is really urine or another type of body fluid (such as amniotic fluid or blood). Two tests that may be done to determine if the sample is urine are creatinine or urea.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Creatinine:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amniotic Fluid</td>
<td>~ 1 - 2 mg/dl</td>
</tr>
<tr>
<td>Urine</td>
<td>100 – 1000 mg/dl</td>
</tr>
<tr>
<td>Plasma</td>
<td>Urea: 5-20 mg/dl</td>
</tr>
<tr>
<td>Urine</td>
<td>Urea: 2400 mg/dl</td>
</tr>
</tbody>
</table>

**TYPES OF URINE SPECIMENS**

*First Morning Void*

A. This specimen is the most concentrated and is frequently the specimen of choice for most studies

B. Procedure: patient voids before going to bed, and immediately upon rising collects urine sample

C. First morning voided urine is retained in bladder approximately 8 hours

D. This is considered the ideal screening specimen for substances that require
   1. A concentrated urine specimen
   2. Urine that has been incubated in the bladder
   3. This urine is also used to confirm postural or orthostatic proteinuria

E. Formed elements (i.e. WBC, RBC and casts) are more stable in this type of collection because the urine is:
   1. Concentrated *(not hypotonic)*
   2. Slightly acidic (maintains cellular elements)

F. Disadvantages:
   1. Not the most convenient to obtain, because the patient must pick up a container and instructions at least 1 day prior to collection
   2. Specimen must be preserved if not analyzed within 2 hours of collection

*Random*

A. **Most common specimen collected**

B. Easiest and most convenient specimen type: can be collected at any time

C. No patient preparation is required for this collection

D. This specimen will be affected by fluid intake (state of hydration) and exercise; therefore, may not accurately reflect the patient’s condition at the time of collection

E. Random collection is good for routine screening to detect abnormalities that may indicate the presence of disease
TIMED COLLECTIONS

A. Eliminates the need to determine when excretion of a particular substance is optimal; also allows comparison of excretion pattern of a particular substance (ex: creatinine) from day to day

B. **Quantitative** urine assays require a timed urine collection to mitigate the effects of the following:
   1. Diurnal or circadian variation in excretion of many substances
   2. Variation in function throughout the day
   3. Effect of exercise
   4. Effect of hydration status
   5. Effect of body metabolism on excretion rates

C. Timed collections can be divided into two types: urine collected
   1. For a pre-determined length of time: 12 hours or 24 hours
   2. At a specific time of day: between 2 and 4pm

D. A 2-hour post prandial (2 hr PP) sample is collected 2 hours after any meal

E. Collection Protocol for 24 hour urine
   1. Accurate timing and proper collection are essential.
   2. Discuss collection procedure with patient and provide with well written instructions
   3. On day 1, at start time (example at 0800): patient empties bladder into toilet
   4. Patient collects all urine samples for the next 24 hours in the container provided.
   5. During collection, the urine container should be preserved, such as refrigeration
   6. On day 2, at the end time (example at 0800): patient empties bladder and includes this urine in the collection container
   7. After transport to the laboratory, the entire specimen is well mixed, the total volume of urine is measured and recorded, and an aliquot of urine is saved for analysis. This aliquot should be large enough to run the tests ordered and extra for additional testing that may be ordered

F. Common errors associated with quantitative urine testing:
   1. Not all of the specimens were saved: loss of specimen (a voided specimen was discarded down the toilet instead of being included in the collection container)
   2. The first void was included in the collection container instead of discarded
   3. Total volume of urine was not measured accurately
   4. Transcription error in recording data (volume, dates of collection)
   5. Specimen was not properly preserved during collection period

SPECIMEN COLLECTION TECHNIQUES

**RANDOM (ROUTINE)**

A. Most common specimen collected; special patient preparation not required

B. Patient does not need assistance (except for patient age? patient condition?), but does require clear instructions

C. Used for routine urinalysis
**Midstream Clean Catch**

A. This type of collection is used when:
   1. Bacterial culture is needed (microbiology lab)
   2. There is a possibility of contamination from vaginal discharge

B. Proper collection is essential for accurate results.
   1. Inform patient of collection criteria verbally and in written form
   2. Thoroughly cleanse and rinse the glans penis of the male or the urethral meatus of the female using appropriate cleansing agent
   3. Patient should first pass some urine into the toilet, stop, and then urinate the ‘midportion of urine’ into the specimen container. Any remaining urine is discarded into the toilet
   4. The interior of the container should not come in contact with the patient’s hands or perineal area

C. The midstream collection technique allows collection of a specimen that most represents the contents of the bladder, ureters and kidneys

D. This type of specimen considered an excellent specimen for routine urinalysis and culture because when properly collected this technique eliminates sources of contamination

**Catheterized Specimen**

A. Requires medical personnel assistance

B. Sterile technique

C. Collection protocol: sterile catheter inserted through urethra into bladder allowing urine to flow directly from the bladder into the collection bag

D. Bacterial cultures are often performed on these types of urine because catheterized patients often contract urinary tract infections (UTI)

E. When additional tests are ordered, the culture is performed first to prevent possible contamination of the specimen (ex: when dipping the reagent strip into the urine for chemical analysis)

**Suprapubic Aspiration**

A. Requires medical personnel assistance

B. Sterile specimen

C. Collection protocol: the abdominal wall and distended bladder is punctured using a needle and syringe. The urine in the bladder is aspirated into the syringe

D. This type of collection is used for infants when specimen contamination is unavoidable using other collection techniques and bacterial cultures, especially anaerobic microbes
**PEDiatric Collections**

A. Used because newborns and some pediatric patients cannot urinate voluntarily

B. Sterile collection bag with hypoallergenic skin adhesive

C. Collection protocol: Clean and dry the perineal area before placing the specimen collection bag onto the skin (bag has adhesive). The bag is placed over the penis in the male and around the vagina (excluding the rectum) in the female, and the adhesive is firmly attached to the perineum.

D. Once the bag is in place, the patient is checked every 15 minutes to see if adequate specimen has been collected. The specimen/bag should be removed as soon as possible after collection to avoid contamination (surrounding skin areas)

E. Use of disposable or cloth diapers is discouraged due to possible bacterial and fiber contamination

F. Because of the many sources for contamination, urine for culture may need to be obtained using a catheter or suprapubic aspiration.

**SPECIMEN STORAGE, LABELING AND HANDLING GUIDELINES**

**General Considerations**

1. Collect specimen in a clean, dry, clear and plastic container. Use a sterile container if bacterial culture is to be done; best if container is disposable

2. When a specimen must be stored for greater than 2 hours prior to testing, a sterile container should be used due to the potential changes that can occur in unpreserved urine (bacterial proliferation)

3. Often, collection containers (especially for timed collections) are made of a brown, opaque plastic to protect the specimen from ultraviolet light and white light: bilirubin and urobilinogen are light sensitive

4. It is NOT good practice to label only the specimen container lid. Lids are removed to access the specimen for testing, and can potentially be placed onto a different specimen causing a specimen mix-up error. If only the lid is labeled, once the lid is removed, technically the specimen is not labeled anymore.

5. Containers should be properly labeled following collection. The following information is required on the label:
   a. Patient’s full name (last name, first name, middle initial)
   b. A unique identification number (MRN or DOB)
   c. Date of collection (month, day, year)
   d. Time of collection (military time)
   e. Optional: test ordered; ordering physician; preservative if used; patient location
6. Specimens should be analyzed within 1-2 hours of collection. If analysis is delayed, precautions must be taken to preserve the integrity of the specimen

**Preservation of Urine Specimens**

1. Easiest and most ideal = refrigeration (4-6°C)
   a. Advantages: Prevents bacterial proliferation; Specimen suitable for culture up to 24 hrs
   b. Disadvantages: Refrigeration can cause crystal precipitation

2. Preservatives and fixatives might be used to inhibit bacterial growth and preserve the urine sediment; however, do not use these if there is any chance they will interfere with chemical testing. The specimen should be kept on ice or refrigerated regardless

3. Handling/processing protocol for timed urine collections when the sample reaches the laboratory:
   a. Mix the entire urine collection well to ensure homogeneity of the specimen
   b. Determine the total volume
   c. Remove an appropriate aliquot for testing

4. At no point during a timed collection should urine be removed or discarded from the collection container, even if the volume of that urine is recorded and accounted for. Because of diurnal variations the concentration of the analyte in any removed aliquot cannot be determined and corrected for; thus the collection would be invalid

**Changes in Unpreserved Urine**

The results of a routine urinalysis can be **seriously affected** by improper handling or preservation

**Physical Changes**

A. **Color**: can change due to oxidation or reduction of substances in urine (conversion of bilirubin to biliverdin changes amber to green color; urine may turn black upon standing if homogentisic acid present)

B. **Clarity** becomes more hazy, cloudy due to bacterial proliferation, precipitation of solutes, crystals

C. **Odor** becomes more ammonia-like, foul (bacterial proliferation)

**Chemical Changes**

A. **pH**: most often becomes more alkaline upon prolonged standing, due to bacterial enzymes converting urea to ammonia; loss of CO2 (CO2 is an acidic metabolic byproduct and is volatile)

B. **Glucose** falsely decreased due to cellular/bacterial use of glucose

C. **Ketones** falsely decreased due to volatilization of acetone

D. **Bilirubin** falsely decreased due to exposure to light
E. **Urobilinogen** falsely decreased due to exposure to light

F. **Nitrite** most often falsely increased due to bacterial conversion of nitrates to nitrites (over 4 hours of time)

**MICROSCOPIC CHANGES**

A. **Red blood cells, white blood cells, casts**: falsely decreased due to disintegration of these elements, especially in dilute alkaline urine

B. **Bacteria** falsely increased due to bacterial proliferation

**QUALITY CONTROL (QC)**

A. QC testing is performed to assess and monitor analytical error (ensures accuracy and technical performance of the method)

B. QC testing serve to alert the laboratorian of changes in the method's performance that will directly affect the quality of test results, including patient test results

C. QC material is purchased from commercial source, but can be prepared by lab

D. QC material should be similar to patient samples in their physical and chemical characteristics: they should have the same matrix (urine base)

E. Limitations of quality control: running QC cannot...
   a. Pinpoint the source of the problem
   b. Solve the problem
   c. Detect a specimen mix-up error