Body Fluids: The Ins & Outs

COURSE DESCRIPTION

This course focuses on the most common body fluids analyzed in the laboratory. Healthcare professionals should have a basic understanding of the collection, storage, and analysis of body fluids as they may be called upon to assist with specimen collection and handling. This course describes the following body fluids: urine, and cerebrospinal, synovial, pleural, pericardial, and peritoneal fluids.

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OBJECTIVES

Upon completion of this continuing education course, the professional should be able to:

1. List and describe body fluids that may be analyzed for diagnostic purposes in the laboratory.
2. Define and differentiate the terms transudate and exudate.
3. Define the term serous and apply it to body fluids.
4. Discuss the formation of urine.
5. Outline the procedures for collection of urine samples.
6. Discuss the testing of urine to include physical, chemical, and microscopic properties.
7. List body fluids commonly analyzed in the laboratory.
8. Discuss macroscopic, chemical, and microscopic testing of body fluids.
9. Apply specific body fluid frequently analyzed as part of a diagnostic evaluation for specific clinical conditions.

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INTRODUCTION

This course focuses on the most common body fluids analyzed in the laboratory. Healthcare professionals should have a basic understanding of the collection, storage, and analysis of body fluids as they may be called upon to assist with specimen collection and handling. This course describes the following body fluids: urine, and cerebrospinal, synovial, pleural, pericardial, and peritoneal fluids.

URINE

Since the recorded history of medical practices, urine has been analyzed in an effort to determine the physiological status of the body. Early practitioners are reported to have analyzed urine by visualizing, smelling, and even tasting it. While the thought of tasting urine is at the very least unappealing, it provided important diagnostic information in times when medical diagnostics were much more primitive. These primitive testing practices were used to help the physician diagnose liver disease, kidney disease, and diabetes to name a few. Obviously medicine has advances since the days of tasting urine, but the testing of urine remains an important diagnostic tool for general medicine as well as many medical specialties.

The following sections discuss the formation of urine, and its application to laboratory testing results and clinical conditions. Information on specimen collection and labeling is included. Finally, a brief overview of physical, chemical, and microscopic testing of urine is provided.

URINE COMPOSITION AND FORMATION

Urine is a complex mixture that consists of 96% water and 4% dissolved substances. The dissolved substances come from food eaten and waste products of metabolism. Sodium chloride and urea, the end product of protein metabolism, make up the majority of the dissolved substances. Other dissolved substances include uric acid, creatinine, potassium, ammonium, phosphate, and various amino acids, proteins, enzymes, and more. Urine can also contain formed elements such as red blood cells, white blood cells, epithelial cells, casts, and crystals.

Urine is formed by elaborate processes in the kidney where blood is filtrated, desirable substances reabsorbed back into the circulation, and unwanted substances excreted into the urine. Urine is formed in the nephron, the working unit of the kidney. Each kidney has about 1.2 million nephrons. The components of the nephron are Bowman’s capsule (glomerular capsule), glomerulus, renal tubules (consists of the proximal convoluted tubule, Loop of Henle, and distal convoluted tubule), and the collecting duct.
• Glomerulus: The glomerulus is made up of blood vessels and all of the blood in the body goes through these blood vessels. The purpose of the glomerulus is to filter the blood. When the glomerulus filters blood, an ultrafiltrate of plasma is produced. In a healthy kidney, the red blood cells, white blood cells, platelets, and proteins are not filtered and are returned to the circulating blood.

• Renal tubules - proximal convoluted tubules: The ultrafiltrate moves through the renal tubules and the proximal convoluted tubule portion of the renal tubules reabsorb water, urea, chloride, potassium, glucose, uric acid, and other substances back into the body.

• Renal tubules - Loop of Henle and distal convoluted tubule: The ultrafiltrate moves from the proximal convoluted tubules into the Loop of Henle and the distal convoluted tubule where unwanted substances are excreted. The unwanted substances are mostly weak acids and bases, but can include toxins, drugs, and excess substances from the diet.

• Collection ducts: The distal tubules lead to the collection ducts which extend into the medulla of the kidney. Collection ducts have two functions: transport urine to the ureters and determine the final volume and concentration of urine. Under the influence of antidiuretic hormone (ADH), the collecting ducts absorb or release water based on the concentration of sodium in the urine.

**SPECIMEN COLLECTION AND STORAGE**

It is important to be aware of the types of specimens and the correct collection technique for each of these specimen types. Collection of urine samples is easy for the clinical staff because, with some exceptions, urine is a specimen that can be
recollected, if necessary. There are two considerations for urine specimens: specimen type and collection method.

Regardless of the type or collection method, the ideal urine sample should be adequately concentrated so that analytes and significant formed elements will be present in sufficient quantity to be detectable. Factors to be considered for the urine to be a clinically optimal specimen are the patient’s state of hydration and the amount of time that the urine was retained in the bladder.

**Specimen Type**

The type of specimen is dependent on the tests that will be performed and the request of the healthcare provider. There are three basic types of specimens - first morning, random, and timed.

1. **First Morning Specimen**: This sample is implied by the name. The patient voids prior to going to bed and then immediately upon rising from sleep collects a urine sample. This type of urine sample is most useful for the following.
   - Elements that require concentration or incubation, e.g. nitrites and protein
   - Confirmation of postural or orthostatic proteinuria
   - Cytological studies due to the increased number of epithelial cells
   - Examination of cellular morphology as the concentrated acidic morning urine supports the stability of some of the formed elements

Disadvantages of this type of urine include the following.
   - High concentrations of salts in the early morning urines may precipitate on standing and interfere with other morphologic studies.
   - Specimen requires preservation if not analyzed within two (2) hours.
   - It is inconvenient for the patient due to the necessity to pick up a container prior to the collection day.

2. **Random Specimen**: This specimen type is collected at any time with no prior patient preparation. It is useful for random screening and is also sufficient for detection of most clinical conditions.

3. **Timed specimen**: Some substances in the urine are not excreted equally throughout a 24-hour cycle. Therefore, to get an accurate measurement of the substance, it is necessary to get a collection of all urine passed over a period of time collection, i.e., a timed collection. Some analytes that may require a timed collection include hormones, proteins, creatinine clearance tests, and the determination of glomerular filtration rate. There are two types of timed collections.
   - Predetermined length of time. Examples include 2, 12 or 24 hours
   - Collected during a specified time of day. Example 8 - 10 am
General Guidelines for Timed Specimens

1. Accurate timing is essential.
2. Strict adherence to the directions for collection is required.
3. General collection rules
   a. Empty bladder before beginning collection. Discard this urine.
   b. Collect all urine from the beginning of the timed period through the end time.
   c. Include the final urine in the timed collection.
   d. Include a preservative if required for the specific test requested.
   e. The container should be kept refrigerated during the collection process.
4. Provide written instructions. These should be specific and should be reviewed with the patient.
5. Provide a labeled container. Containers are generally brown to protect the specimen from light.

General Guidelines for Processing of Timed Specimens

If you are called upon to handle a timed specimen (e.g. 24-hour urine), some general guidelines are outlined below.

2. Store the specimen as per directions prior to processing.
3. Accurately measure the volume. Record the volume per protocol.
4. If it is necessary to aliquot the sample, mix the entire sample, and pour off sufficient quantity into a properly labeled container.
5. Retain the remaining urine for a sufficient time to allow for analysis of the aliquoted sample. This provides additional specimen, if required for additional or replacement testing.

Collection Techniques

1. Routine Void: This collection method requires no patient preparation or special collection conditions. Voiding into an appropriately labeled container is typically all that is required for this type of collection. A sterile specimen is not required but the container must be clean and dry.

2. Midstream ‘Clean Catch’: This type of sample helps to eliminate contamination of the urine with vaginal or fecal secretions. This type of collection is required for obtaining sterile specimens for culture and sensitivity.
   a. A sterile urine container must be used for a midstream ‘clean catch’ specimen.
   b. Prior to collection, the patient must thoroughly cleanse either the glans penis or the urethral meatus. Most sterile urine containers come with disposable disinfectant towelettes to use to cleanse in and around the urethral opening.
   c. The patient first passes some urine into the toilet and stops urinating.
   d. The patient then voids urine into the collection container until it is one-quarter to one-half full.
   e. The patient then voids the remaining urine into the toilet.
f. The patient is instructed not to touch the internal portions of the container or allow the container to come into contact with the area surrounding the urethral opening.
g. If the patient is a child, elderly, or handicapped, he/she may require assistance with specimen collection.

3. Catheterized Specimen: A catheter is a thin flexible tube that is inserted into the urethral opening and up the urethra into the bladder. The catheter can be temporary where urine is allowed to flow into a specimen collection container and is then removed, or it can be indwelling for a period of time with urine collected into a plastic collection bag.

4. Suprapubic Aspiration: This collection method uses a syringe and needle to puncture through the skin into the bladder. Urine is collected into a sterile syringe and either transferred into an appropriate container and submitted for analysis, or submitted for analysis in the syringe. This procedure is most often performed on neonates, paraplegics, and the elderly when a sterile urine specimen is required for testing.

5. Pediatric Collection: Pediatric collections are challenging for the obvious reason of lack of bladder control, compliance with instructions, and contamination with diapers. There are, however, pediatric collection bags that have adhesive to firmly attach the bag to the child’s skin. For a male, the bag is placed over the penis and secured to the area around the penis with adhesive. For a female, the bag is secured around the vaginal area. The adhesive holds the bag in place until a specimen is collected. The bag is then removed. The sample is submitted for analysis in the bag, which has a sterile interior.

**Storage of Urine Specimens**

Storage of urine specimens is important for maintaining the integrity of the substances to be analyzed. Providing appropriate containers is the first important step for maintaining a quality urine specimen for analysis. Most containers have the following characteristics.

1. Clear or translucent
2. Disposable
3. Plastic
4. Sufficient opening (e.g. 3.0 cm to 6.0 cm)
5. Adequate volume capacity (e.g. 50 – 150 mL)
6. Cover to prevent spillage; if transport is necessary, the cover should be sealable and leak proof.
7. Sterile interior, if required for testing
8. NOTE: 12- to 24-hour collection containers are usually brown in color to protect the contents from the effects of light
The cup shown above has an opening for withdrawing a sample of the urine into another container. The transfer of urine is made by using a two-ended ‘straw’. The straight end of the straw is inserted into the urine. The opposite end has a sharp end that punctures the lid of an evacuated tube. The urine fills the tube. The tube is then used to transport the urine to the testing location. There are three special tubes used for urine collection.

1. No additive tube: recommended for drug screening, pregnancy testing, and routine urinalysis testing that will be performed within 60 minutes; tube has yellow top

2. Urinalysis tube with preservative: preservative is chlorhexidine, ethyl paraben, and sodium propionate; recommended for routine urinalysis testing that will not be performed within 60 minutes; tube has yellow and cherry red top

3. Culture and sensitivity tube; contains sodium formate, sodium borate, and boric acid; tube has a gray top

Recommendations state that a healthcare professional must label the urine collection container immediately after collection. Labeling guidelines are listed below:

1. Label the container not the lid.
2. Label should contain two patient identifiers
3. Use a waterproof label with adhesive that is waterproof. These labels must be able to adhere during refrigeration.

Unpreserved urine should immediately be sent to the laboratory and it analyzed as quickly as possible. If it is going to be more than two hours before testing, the specimen should be protected from light and stored in the refrigerator. Changes that can occur in unrefrigerated, unpreserved urine include the following.

1. Bacteria can grow which affects the urine’s odor, pH, nitrite, and glucose as well as the accuracy of the bacterial culture results.
2. Disintegration of formed elements (e.g. items seen in the microscopic evaluation of urine sediment).
3. Changes in quantities of certain analytes; some may increase and some may decrease, resulting in unreliable test results.
Preservatives used for testing will decrease the likelihood that chemical changes will occur and produce an inaccurate result. No single preservative is effective for all analytes. The preservative chosen will be dependent on the type of collection, tests performed, and the length of time delay.

Prompt refrigeration is sufficient for many analytes. Urine for microbiological analysis should be promptly refrigerated to prevent the overgrowth of bacteria. This allows the sample to remain suitable for storage for up to 24 hours.

In summary, proper specimen collection and storage is important in achieving accurate and useful testing results for urine specimens.

**URINE TESTING**

Urine testing is comprised of three parts: physical, chemical, and microscopic. While specific test methods and results are beyond the scope of this course, it is important for healthcare professionals to have a general understanding of the components of a complete urinalysis. A brief overview of each type of testing will follow.

**Physical Testing**

The physical examination of the urine is comprised of four major components. These are summarized as follows.

1. **Color:** The color of normal urine is a shade of yellow. The intensity of the yellow color will vary with state of hydration, diet, intake of vitamins and supplements, etc. Common causes of abnormal urine color follow.

   **Common Causes of Abnormal Urine Coloration**

<table>
<thead>
<tr>
<th>Color</th>
<th>Pathologic Causes</th>
<th>Food and Drug Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown</td>
<td>bile pigments, myoglobin</td>
<td>fava beans, levodopa, metronidazole (Flagyl), nitrofurantoin (Furadantin), some antimalarial agents</td>
</tr>
<tr>
<td>Brownish-black</td>
<td>bile pigments, myoglobin, melanin, methemoglobin</td>
<td>cascara, levodopa, methyl dopa (Aldomet), senna</td>
</tr>
<tr>
<td>Green or blue</td>
<td>urinary tract infection caused by Pseudomonas bacteria, biliverdin</td>
<td>amitriptyline (Elavil), indigo carmine, IV cimetidine (Tagamet), IV promethazine (Phenergan), methylene blue, triamterene (Dyrenium)</td>
</tr>
<tr>
<td>Orange</td>
<td>bile pigments</td>
<td>phenothiazines, phenazopyridine (Pyridium)</td>
</tr>
<tr>
<td>Red</td>
<td>hematuria, hemoglobinuria, myoglobinuria, porphyria</td>
<td>beets, blackberries, rhubarb, Phenolphthalein, rifampin (Rifadin)</td>
</tr>
<tr>
<td>Yellow</td>
<td>concentrated urine</td>
<td>carrots, vitamins, cascara</td>
</tr>
</tbody>
</table>

2. **Clarity:** Clarity is the visual appearance of the urine. It is assessed in combination with color, and it describes the transparency of the urine. Normal urine is clear or slightly cloudy. Cloudiness in urine can be caused by mucus, sperm, prostatic fluid, skin cells, urine crystals, red blood cells, white blood cells, and bacteria. Cloudiness due to red blood cells, white blood cells, and bacteria are a cause of concern.

   Terms used to describe urine clarity include clear, hazy, slightly cloudy, cloudy, and turbid. Terms for urine clarity are based on the ability to view newsprint as if it were placed *behind* the urine container.
- Clear: Newsprint can be easily read
- Hazy/slightly cloudy: Newsprint can be read but the urine is not completely clear
- Cloudy: The newsprint is blurred or obscured
- Turbid: The newsprint is completely obscured and cannot be read

3. Other physical characteristics: While urine color and clarity are always included on a urinalysis report form, two other characteristics, foam and odor, are reported only when seen.

- Foam: Moderate to large amounts of protein will cause stable white foam to be produced. This foam will remain intact for a period of time. The presence of yellow foam may indicate the presence of a substance called bilirubin.
- Odor: Freshly collected urine from a healthy individual has a characteristic faintly aromatic odor. The presence of a strong ammonia smell may indicate a bacterial infection, or simply that the urine has been allowed to sit at room temperature for too long. The ingestion of certain foods as well as metabolic disorders will create a distinctive odor. The urine from a patient with uncontrolled diabetes may have a fruity or acetone odor.

4. Specific Gravity: A standard method for measurement of urine concentration is specific gravity. The greater the density of the urine (the more solutes present) the higher the specific gravity. Specific gravity is determined by comparing the density of the urine to the density of an equal volume of pure water. The specific gravity of water is 1.000. The reference range values for specific gravity are 1.005 to 1.035.

Most laboratories use one of the following methods to determine the specific gravity of urine.

- Refractometry: An instrument called a refractometer compares the refractive index of light that passes through the urine solution to that of water. As the light beam is refracted by the solutes the angle changes as does the velocity.
- Chemical test strips: This method employs a color change that occurs when the solutes in the urine react with the polyelectrolyte in the pad and consequently change the pH.
Chemical Testing

Chemical testing on urine is most often performed using a commercial reagent strip often called a dipstick. These strips are designed to perform chemical analysis of the urine. The analytes usually present on a chemical test strip are:

- pH
- Protein
- Glucose
- Ketones
- Blood
- Bilirubin
- Urobilinogen
- Nitrite
- Leukocyte esterase
- Specific gravity

Some manufacturers make strips with just a few of the above analytes, such as ketones and glucose, or blood and protein.

The reagent strip is a plastic strip with test pads containing chemicals. When the urine wets the chemical pad, a chemical reaction is initiated. As a result of the chemical reaction, a color is developed. The color that develops can be used to determine if an analyte is present, and may also provide information on the quantity of the analyte present. For example, the test pad for glucose is an aqua color. If no glucose is present in the urine, the test pad remains an aqua color. If glucose is present, a green to tan to brown color develops. If a green color develops, this indicates the quantity of glucose as 250 mg/dL.

Each reagent strip pad must be read at a specific time after the dipstick has been dipped into the urine sample. The color change can be either read manually (by the naked eye) or mechanically (instrument). The intensity of the color change is graded for each test. Most result scales are from negative to 4+. pH is read on the standard pH scale (5.0 – 8.0) and specific gravity is read from 1.005 to 1.035. Some manufacturers used a scale of small, moderate, or large.

### Clinical Significance of Reagent Strip Results

<table>
<thead>
<tr>
<th>Abnormal Result</th>
<th>Associated Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>&gt;8.0 indicates an old specimen</td>
</tr>
<tr>
<td>Protein</td>
<td>Kidney disease, inflammatory disease, prolonged exercise</td>
</tr>
<tr>
<td>Glucose</td>
<td>Diabetes</td>
</tr>
<tr>
<td>Ketones</td>
<td>Diabetes, starvation, vomiting</td>
</tr>
<tr>
<td>Blood</td>
<td>Kidney disease, inflammatory disease, burns, upper/lower urinary tract infections, kidney stones</td>
</tr>
<tr>
<td>Bilirubin</td>
<td>Liver disease, obstructive jaundice</td>
</tr>
<tr>
<td>Urobilinogen</td>
<td>Liver disease, obstructive jaundice</td>
</tr>
<tr>
<td>Nitrite</td>
<td>Bacteria, i.e. urinary tract infection</td>
</tr>
<tr>
<td>Leukocyte esterase</td>
<td>White blood cells, i.e. urinary tract infection</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>&lt;1.010 is associated with the inability of the kidney to concentrate the urine; &gt;1.025 (with negative glucose and protein results) generally indicates the presence of radiographic contrast media</td>
</tr>
</tbody>
</table>

The following paragraphs contain some important general information on the use of chemical strips and the testing of urine in the laboratory.
Urine Dipstick Testing

The physical procedure for dipping the chemical strip into the urine and achieving a reliable, accurate result is simple but requires some attention to detail. The user of the test strip must follow some basic guidelines. These basic steps are:

1. Mix the urine and remove the container lid.
2. Remove one strip from the container. Do not remove the strip in advance.
3. Replace the lid on the canister that contains the strips.
4. Dip the strip into the urine and remove promptly.
5. Remove excess urine from the strip by running the edge of the strip along the rim of the container or briefly touching the edge of the strip on absorbent paper.
6. If interpreting the results visually (manually), time the readings as per manufacturer’s requirements, and read each test at the appointed time.
7. If interpreting visually (manually), hold the strip next to the color chart for comparison of the test pads at the appropriate time interval.
8. If using an instrument to read the reactions, follow the manufacturer’s instructions.

Quality Control

As with other laboratory testing, the use of multiple levels of quality control is essential for assurance of accurate laboratory testing. The use of these controls ensures that the chemical strips are working within appropriate range and that the testing personnel are correctly performing the testing. New containers of chemical strips must have quality control performed upon opening. The schedule of quality control testing is determined by CLIA, state, local, and accrediting agencies. The laboratory administration will determine the frequency for quality control testing in your laboratory.

1. Test two levels of controls. For urinalysis, one control will be negative (no analytes present) and the other will be positive (a certain quantity of each analyte is present).
2. Check expiration dates of both the controls and the chemical strips.
3. Follow the manufacturer and institutional instructions for performing the test.
4. Compare results of chemical strip testing to values in the package insert.
5. Document all control testing in the manner specifically outlined for the institution.
6. Do not test patient samples if controls are unacceptable.

**Care and Storage**

Chemical reagent strips should be stored as per manufacturer recommendations. These recommendations are outlined in the package insert provided with the product. General guidelines for storage of chemical reagent strips include:

1. Store the strips in the original container, tightly sealed.
2. Keep the desiccant in the container.
3. Protect from excess heat, cold, or moisture while contained within the original container.
4. Examine strips for signs of deterioration including:
   a. Discoloration of test pads
   b. Warped or bent appearance to the strip
   c. Evidence of moisture on the strips or pads
   d. Dye running or leakage from one pad to another
5. Discard containers that contain any strips that show any sign of deterioration or contamination, such as a color change.
6. Retest controls if patient results are suspicious or do not correlate with clinical condition.

**MICROSCOPIC TESTING**

The third and final type of testing performed as part of a complete urinalysis is microscopic testing. This testing is usually 'reflex' testing based on the results of the chemical testing. Each laboratory establishes the parameters employed to determine if it is appropriate to perform a microscopic examination of the urine. Some of the chemical parameters that reflex to a microscopic test include the following.

1. Positive leukocyte esterase: indicates presence of white blood cells
2. Positive blood: indicates the presence of hemoglobin or red blood cells
3. Protein present in more than trace amounts
4. Positive nitrites: indicate the presence of bacteria

Microscopic testing is performed to confirm the presence of the analytes determined to be present based on the reagent strip reactions. Chemical and microscopic reactions must be correlated with each other as falsely positive and falsely negative reactions can occur.

If a microscopic examination is warranted, then an aliquot (portion) of the urine will be used to perform this testing.

**Standardized vs. Non-Standardized Systems**

There are standardized systems for performing microscopic analysis of urine. Each system comes with multiple pieces: conical tube, pipette, and a slide with a pre-determined volume for analysis. The purpose of these systems is to assure a standard volume of urine is examined. The standard volume is then centrifuged and a specific
quantity of sediment is examined microscopically with any formed elements counted. By using a standardized system, the test results are comparable from one patient to another, from one day to another. The amount of variation is controlled, providing more accurate and reliable laboratory test results.

Many facilities do not use standardized systems but rather use a slide, add a drop of urine sediment, and a coverslip is placed over a drop of urine sediment. This is a non-standardized system. The test results from a non-standardized system may not always provide accurate and reliable patient test results.

**Specimen Volume**

In order to perform a microscopic examination of urine, the urine sample is concentrated by centrifugation. To produce a sufficient quantity of sediment for analysis, 12 mL is the recommended amount of urine to be centrifuged for adult patients. However, a range of 5-12 mL is generally acceptable for centrifugation. Most facilities have a minimum volume that can be centrifuged, and the volume varies from facility to facility. Most often, specimens of volumes < 5 mL are microscopically examined without centrifugation.

**Concentration of Urine**

Urine for microscopic examination is concentrated by using a centrifuge. Well-mixed urine is poured into a conical tube with graduated markings. The markings allow for measurement of the volume of urine centrifuged. The conical tip of the tube is to facilitate the concentration of the sediment.

A cover is placed on the conical tube and the tube is placed into the centrifuge. The time and speed of centrifugation is 5 minutes at 400 to 450 rcf (relative centrifugal force). These criteria allow for optimal concentration without disruption of the formed elements. The centrifuge brake should not be used to slow down the centrifuge head when the timer turns off.

At the completion of centrifugation, the liquid portion of the urine is decanted (removed) leaving 1 – 2 mL of urine in the tube. The remaining fluid is used to resuspend the concentrated urine. The urine sediment is examined following the individual laboratory’s procedure. Most procedures call for putting one drop of urine sediment on a slide and placing a coverslip over the drop.

**Microscopic Evaluation**

Once the sediment is applied to the slide, the material is examined microscopically. Following are general guidelines.

1. Stain may be used to enhance visualization of the sediment. The use of stain enhances the refractive index of the formed elements.
2. A decreased light setting on the microscope will also enhance the appearance of formed elements when using bright field microscopy.
3. The elements are identified on low (X 10 objective) and/or high power (X 40 objective).
4. The procedure for the laboratory should be followed for observing and counting the elements.
5. Use of alternate types of microscopy may be employed to provide better enhancement of the formed elements.

Specific Microscopic Elements

There are varieties of formed elements that may be seen in urine sediment. These are briefly described below. The following website has photographs of formed elements found in urine sediment, if the reader wants to view them.


1. Cellular elements

   a. Red blood cells (erythrocytes): A few red blood cells are found in healthy individuals. Larger numbers are possibly indicative of a disease state, such as glomerulonephritis or urinary tract infection, or can indicate the urine specimen is contaminated with menstrual blood.

      Red blood cells may be difficult to observe in urine sediment. In unstained urine, they appear as yellowish-red biconcave disks with a smooth appearance. They do not have a nucleus or granules. They are about 7 microns in diameter.

   b. White blood cells (leukocytes): Urine sediment from healthy individuals may contain a small number of leukocytes. When observed on high power, white blood cells are 10 to 14 microns in diameter. Most have granules and all have a nucleus. The presence of more than a couple of white blood cells generally indicates an infection in the urinary tract or kidney. White blood cells are also present if the urine specimen has been contaminated with vaginal secretions or discharge.

   c. Epithelial cells: There are three types of epithelial cells that may be found in a microscopic examination of the urine.

      - The most common type is squamous epithelial cells. They most often originate from the urethra or vagina. When more than a few are seen in urine, these cells may indicate an incorrectly collected or contaminated sample. These cells are very large flat shaped and have distinct edges. They have a nucleus about the size of a white blood cell and granules in the cytoplasm.

      - A second type of epithelial cells found in urine is transitional epithelial cells. These cells are seen in normal urine in small numbers. Increased numbers may be seen in urinary tract infections and pathologic conditions. These are smaller than squamous cells and have variable morphology to include round or elongated.

      - The third type of cell is renal tubular epithelial cells. These cells are
more round, smaller and more pathological than either of the other two types. They come from the renal tubules in the kidney and are indicative of serious kidney disease.

2. Casts: Casts are protein that has precipitated in the renal tubules. In the process of precipitating the protein may entrap cells or other material in the protein matrix. The materials that are present in the cast assist with determination of pathology. There are many types of casts. With the exception of a rare hyaline cast, casts are always clinically significant and should be regarded as an important finding in urine sediment. Types of casts that may be seen in urine sediment include:

- Hyaline cast
- White blood cell cast
- Red blood cell cast
- Granular cast (fine or coarse)
- Waxy cast
- Fatty cast

3. Crystals: Urine can contain many dissolved substances that can solidify and become crystals. There are many types of crystals that can be seen in urine sediment. Some crystals are clinically significant of disease states, but others simply indicate the urine was stored too long before analysis. Examples of crystals seen in urine include the following.

- Calcium oxalate
- Uric acid
- Amorphous urates
- Amorphous phosphates
- Tyrosine
- Bilirubin
- Calcium carbonate
- Cystine
- Cholesterol
- Calcium phosphate
- Triple phosphate
4. Other elements seen in urine: Many other substances may be seen in urine. Some of these have clinical significance while others are from contamination during specimen collection. Some of these substances follow.

- Bacteria – contamination or upper/lower kidney tract infection
- Mucus – contamination or if there is a large amount it may mean there is an irritation, inflammation, or infection in the urinary tract
- Fibers – contamination
- Yeast – contamination or indicative of a urinary tract infection
- Fat – may indicate a server kidney disease
- Spermatozoa – not clinically significant
- Parasites – Pinworm eggs may be seen and indicate skin contamination from specimen collection. *Trichomonas vaginalis* may be seen and its presence indicates vaginal contamination of the urine during specimen collection.

Detailed discussion on microscopic elements is beyond the scope of this course. However, it is important for healthcare professionals to understand the terminology and have a general understanding of the components of a complete urinalysis as well as be knowledgeable with regard to the complexity of analysis performed during this testing.

**Correlation of Reagent Strip/Microscopic Urine Results**

On the surface, a complete urinalysis seems to be a simple procedure from start to finish. However, numerous preanalytical and analytical errors are possible. Specimen collection, processing, and analysis must be carefully performed following instructions based on the manufacturer’s information.

One final check that is useful to assure accurate and reliable test results is to compare reagent strip reactions to microscopic findings. There are many causes of false negative and false positive reagent strip reactions. If there is no correlation between a specific reagent strip reaction and a microscopic finding, repeat testing should be performed to evaluate the discrepancy before releasing test results. Following are some common correlations.
<table>
<thead>
<tr>
<th>Positive Reaction with Reagent Strip</th>
<th>What to Look for Microscopically</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood</td>
<td>Red blood cells, red blood cell casts</td>
</tr>
<tr>
<td>Leukocyte esterase</td>
<td>White blood cells, bacteria, white blood cell casts</td>
</tr>
<tr>
<td>Nitrite</td>
<td>White blood cells, bacteria</td>
</tr>
<tr>
<td>Protein</td>
<td>Red blood cells, casts</td>
</tr>
</tbody>
</table>

**BODY FLUIDS**

Analysis of other body fluids is performed to identify and diagnose certain disease states. This section of the CE course will discuss the following.

- The origin of specific body fluids
- Definition and application of appropriate terminology
- Appearance of a body fluid
- Testing for specific body fluids
- Specimen containers and storage for body fluid samples

This general knowledge will provide a basis for appropriate specimen processing and application of this information to clinical conditions.

**INTRODUCTION**

Body cavities that surround various organs are known as the *serous* body cavities. The organs and their specific cavities are listed on the table below.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Cavity/Fluid Name</th>
<th>Specimen Collection Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>Pericardial</td>
<td>Pericardiocentesis</td>
</tr>
<tr>
<td>Lungs</td>
<td>Pleural</td>
<td>Thoracentesis</td>
</tr>
<tr>
<td>Abdominal</td>
<td>Peritoneal</td>
<td>Paracentesis</td>
</tr>
</tbody>
</table>

A membrane known as a serous membrane also surrounds each of the cavities. There are two membranes in each cavity. These are called parietal membranes and they line the cavity wall and the visceral membrane that covers the organs within the cavity.

There is fluid that lies between the membranes in each of the cavities. This fluid is assigned the name ‘serous’ due to the serum-like nature of the fluid. The serous fluid is an ultrafiltrate of plasma. This serous fluid serves as a lubricant between the membranes of the body walls and the organs. These fluids are known as pericardial fluid, pleural fluid, and peritoneal fluid (refer to the chart above). The formation and absorption of these fluids is dynamic. Alteration in the absorption/removal system will result in an accumulation of fluid in the body cavity. Many disease states cause the accumulation of fluids. The process for collecting samples of a fluid has a specific name that corresponds to the specific cavity.

The accumulation of a serous fluid is called an *effusion*. An effusion results from the disruption of the balance of fluid formation and absorption/removal. This fluid accumulation may also be the result of infection or inflammatory processes. Effusions are further classified into *transudates* and *exudates*. Correct classification of effusions assists with the formation of a diagnosis. The two terms are defined as follows.
• Transudate: This type of effusion caused by increased pressure in the veins and capillaries that force fluid through the vessel walls into the body cavities, e.g. congestive heart failure. A transudate is essentially normal fluid that has accumulated in great quantity.

• Exudate: This type of effusion caused by increased permeability of blood vessels due to disease processes, e.g. infections and malignancies. As with a transudate, excess fluid accumulates in the body cavities. However, the fluid of an exudate is full of cells and large molecules such as protein.

Any further differentiation of transudates and exudates is beyond the scope of this unit.

Some body fluids are non-serous fluids. For example, cerebral spinal fluid is not an ultrafiltrate nor is it a serous fluid, and while synovial fluid is an ultrafiltrate it is not a serous fluid. More detail on specific fluids will be provided in a later section.

SPECIMEN CONTAINERS

The containers used for collection of samples for analysis vary by the tests request. A brief summary of tubes are listed below. Be aware that the tube type may vary by institution.

<table>
<thead>
<tr>
<th>Test</th>
<th>Collection Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell count &amp; differential</td>
<td>EDTA or sodium heparin</td>
</tr>
<tr>
<td>Cytology</td>
<td>Sodium heparin or EDTA</td>
</tr>
<tr>
<td>Glucose</td>
<td>Tube with no additive</td>
</tr>
<tr>
<td>Protein, lactic dehydrogenase, amylase, other chemistry tests</td>
<td>Tube with no additive</td>
</tr>
<tr>
<td>Gram stain, culture &amp; sensitivity</td>
<td>Sodium heparin</td>
</tr>
</tbody>
</table>

BASIC TESTING PROCEDURES

Specimens should be immediately transported to the laboratory for immediate processing.

Some basic testing procedures apply to analysis of most body fluids. These include the following.

1. Macroscopic Examination: This is a description of the appearance of the fluid. Normal serous fluids resemble serum: clear and pale yellow. Additional colors and associated significance are described below.

<table>
<thead>
<tr>
<th>Abnormal Color</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbid, white</td>
<td>Microbial infection</td>
</tr>
<tr>
<td>Bloody</td>
<td>Hemothorax, hemorrhagic effusion, traumatic tap (blood vessel hit during collection procedure)</td>
</tr>
<tr>
<td>Milky</td>
<td>Chylous (lymph fluid and fat) material from the thoracic duct, chronic inflammation</td>
</tr>
</tbody>
</table>

Clotted specimens should be noted, and analysis of these may not be possible. As
with urine, the clarity of the sample is also recorded upon receipt in the laboratory.

2. Chemical testing: Chemical testing may be performed on body fluids. The same test methods are used for body fluids as those used for blood specimens. Tests commonly performed on body fluids include the following.

- Glucose
- Protein
- Alkaline phosphatase
- Ammonia
- Amylase
- Bilirubin
- Chloride
- Lipids
- pH

3. Microscopic testing: Body fluid analysis usually includes a microscopic evaluation. The microscopic analysis includes the following.

- Cell count: Enumeration of the cells present in the fluid is performed on either concentrated or unconcentrated fluids.
  - Red blood cells: These cells are not normally found in body fluids. Their presence generally indicates a disease/disorder. However, red blood cells can be present if a blood vessel is hit with the needle during specimen collection. This is called a traumatic tap.
  - White blood cells: The presence of increased numbers of white blood cells may be associated with disease.
  - Mesothelial cells: These cells line the serous cavities. Small numbers may be present because of cells sloughing from the lining. Large numbers may indicate a disease state.
  - Malignant cells: A pathologist always identifies and confirms the presence of malignant cells. As the name indicates, the cells are present due to a tumor or other cancerous process.

- Other testing associated with cell counts on fluids include:
  - Cell count: Cell counts can be performed manually or by a hematology analyzer.
  - Cell identification (differential): A differential count is performed on a concentrated specimen that has been applied to a slide and stained. The specimen must be concentrated as it is necessary to assure all cellular elements present can be identified. The specimen is concentrated using a centrifuge or a cytopsin. The concentrated specimen is placed on a slide and
stained with a Wright or Wright-Giemsa stain. Any cells observed on the slide are identified and counted.

- Microbiological testing: A Gram stain and culture/sensitivity are performed on all body fluids. Causes of infections in body fluids include bacterial, fungal, parasitic, and viral organisms.

**SPECIFIC BODY FLUIDS**

Specific body fluids are analyzed for help with diagnoses of infection, clinical conditions, and chemical imbalances. A brief summary of specific body fluids will be outlined in this section.

**Cerebral Spinal Fluid**

Cerebral spinal fluid (CSF) is the fluid that surrounds the brain and spinal cord. The majority of CSF comes from secretions produced and secreted into the four ventricles of the brain.

The main purpose of this fluid is to protect the tissues of the central nervous system. There is a flow path between the CSF and the blood stream. This flow path allows for a process that helps to maintain an appropriate pressure at all times. This interface between the CSF and the blood is known as the blood-brain barrier. If this flow path is blocked, the fluid accumulates and creates a condition known as hydrocephalus. The intracranial pressure produced may cause brain damage and mental retardation if not relieved.

CSF is collected by the process known as a lumbar puncture, also known as a spinal tap. A needle is inserted through two of the lumbar vertebrae into the spinal column. Spinal fluid is collected into three sequentially labeled tubes, with 1 – 2 mL of fluid in each. The tubes are used for the following.

- **#1** This tube contains the first fluid collected; this fluid is used for chemistry and immunological tests. It should NOT be used for culture as it may be contaminated with bacteria from the skin. It should NOT be used for cellular examination as it may be contaminated with cells from the insertion of the needle through the skin and into the spinal column.
- **#2** Microbiological examination; fluid in this tube should not contain any bacteria from skin contamination.
- **#3** Cellular examination; fluid in this tube is the least likely to contain cells from specimen collection.

All testing should be performed as soon as possible after collection. An examination of the physical characteristics should be evaluated. CSF from a healthy individual should be clear and colorless. The presence of a yellow discoloration is known as xanthochromia. This abnormality should be noted, as it can indicate the patient has had a subarachnoid hemorrhage. The presence of large amounts of blood may be the result of a traumatic tap or hemorrhage. Centrifugation of the fluid will help with this differentiation as well as the comparison of the first and last tubes collected. Traumatic tap will show a diminishing amount of blood as the tube numbers increase.
In addition to the testing discussed in the previous section, CSF may have an extended evaluation of the protein content. Changes in the permeability blood-brain barrier are indicative of numerous disorders, such as multiple sclerosis and other neurological diseases. Therefore, extensive analysis of the protein content in the CSF will aid in diagnosis and monitoring of these clinical conditions. Once the CSF total protein is determined, laboratory professionals may perform the following tests to provide some specific diagnostic data for use.

- **Protein electrophoresis** – Details the composition and protein distribution of the proteins in the CSF.

- **Albumin and immunoglobulin G** – Albumin is not normally present in the CSF. Any albumin found in the CSF has crossed the blood-brain barrier. IgG is normally found in the CSF, however, increased amounts of IgG immunoglobulins are significant findings for certain clinical conditions.

**Synovial Fluid**

Synovial fluid is found in the spaces of the skeleton where friction can develop. These include joints, bursae, and tendon sheaths. Synovial fluid is viscous. This fluid serves the purpose of lubricating and bathing the joints, and is the sole nutrient source for the metabolically active cartilage in the joints. The cells that line these joints, synoviocytes, produce a mucopolysaccharide called hyaluronate. Analysis of synovial fluid is performed to identify the cause of joint disorders as hemorrhagic, infectious, inflammatory, or non-inflammatory.

Synovial fluid is collected by an aspiration called an arthrocentesis, where a physician inserts a needle into the affected space and removes fluid. Specimens collected are the same as described in the previous section on specimen containers. As with other fluids, synovial fluid should be analyzed as soon as possible after collection.

Normal synovial fluid will appear colorless, pale yellow, or clear. Trauma to the joint will result in blood and a resulting red or brown color of the fluid. The viscosity of the fluid is assessed while the fluid is being withdrawn. Normal fluid is viscous. The test for viscosity will result in a drop of fluid forming a string of 3 to 6 cm long.

Some joint disorders are identified by the presence of crystals in synovial fluid. To look for crystals, a drop of the synovial fluid is placed onto a clean glass slide, coverslipped, and viewed microscopically. Any crystals present should be noted with the following criteria

- Number of crystals
- Specific type(s) of crystals
- The presence of fibrin, which may cause crystals to be overlooked
- Presence of artifacts

Crystals seen in synovial fluid include the following.

- **Monosodium urate crystals**: seen in gouty arthritis
• Calcium pyrophosphate dehydrate crystals: present in pseudogout
• Cholesterol crystals: associated with chronic inflammatory conditions such as rheumatoid arthritis
• Hydroxyapatite crystals: present inside (intracellular) leukocytes; associated with conditions characterized by deposits of calcium

Synovial fluid is an important diagnostic tool. The handling and analysis should be approached with care to obtain accurate and appropriate results.

**Peritoneal, Pleural, and Pericardial Fluids**

As previously discussed, there are serous fluids that surround major organs in the body. These are the peritoneal, pleural, and pericardial fluids. As with the fluids previously discussed, these fluids are collected and transported to the laboratory for analysis to determine the presence of disease/disorder. However, removal of these fluids is also for therapeutic purposes. These fluids may accumulate in great quantities, sometimes well over 1,000 mL. The volume of the fluid puts pressure on the organs, causing problems with the organ function, e.g., difficulty breathing.

When examined macroscopically, normal fluids are clear, and yellow to dark yellow. Cloudy appearance often indicates large numbers of leukocytes, but a milky appearance has a different significance. The milky appearance indicates presence of chyle. Chyle is an emulsion of lymph and chylomicrons (fatty proteins). Chyle is most often produced by a blockage or breakdown of the lymphatic system. *Pseudochylous* effusions are seen in conditions such as rheumatoid arthritis and tuberculosis.

A few diagnoses can be made solely from analysis of pleural, pericardial, or peritoneal fluids including the following.

• Malignancy: malignant cells are identified during microscopic examination of the fluid
• Systemic lupus erythematosus (SLE): characteristic lupus cells are identified during microscopic examination of the fluid
• Infectious disease: microorganisms are seen on Gram stain testing and then cultured

**CONCLUSION**

A basic understanding of body fluids and the analysis of these fluids is important when professionally you may be working in or transporting fluids to the laboratory. This CE course has provided a basic overview of body fluids, testing associated with these fluids and an understanding of collection, storage, and diagnostic testing.

**REFERENCES**


TEST QUESTIONS
Body Fluids: Ins and Outs #1222118

Directions:
- Answer sheets: Read the instructions to assure you correctly complete the answer sheets.
  - NOTE: If the online test questions differ from the course test that follows the reading material, the CE course you are using is outdated or the question has been revised since you downloaded it. The online question is the most current and it should be answered accordingly.
- Select the response that best completes each sentence or answers each question from the information presented in the course.
- If you are having difficulty answering a question, go to www.ncctinc.com and select Forms/Documents. Then select CE Updates and Revisions to see if course content and/or a test questions have been revised. If you do not have access to the internet, call Customer Service at 800-875-4404.

1. Which of the following urine specimen types is the best for cytological studies?
   a. First morning specimen
   b. Random specimen
   c. 12 hour timed specimen
   d. 24 hour timed specimen

2. To determine a creatinine clearance, which one of the following specimens is recommended?
   a. First morning specimen
   b. Random specimen
   c. Timed specimen
   d. All specimen types can be used for this determination

3. You are providing instructions for collection of a 24-hour urine. Choose the most appropriate instruction from the following list.
   a. Start the collection time upon rising on day
   b. Start the collection after voiding for the first time on day
   c. Start the collection before retiring for the night prior to day
   d. Start the collection with the first midstream collection of the day 1
4. Which of the following would be the easiest method to collect a urine specimen for a culture and sensitivity?

   a. Catheterized specimen
   b. Clean catch
   c. Routine collection
   d. Suprapubic aspiration

5. Which of the following is a TRUE statement regarding labeling of a urine collection container?

   a. One patient identifier is sufficient for identification.
   b. The label and label adhesive should be waterproof.
   c. The label should be placed on the lid of the container.
   d. The patient should label the container before collection.

6. Which of the following can cause urine to be cloudy?

   a. drug contamination
   b. protein
   c. glucose
   d. white blood cells

7. You receive a urine specimen container with a gray top urinalysis tube. You withdraw urine from the container into a gray top urinalysis tube using a double-ended ‘straw’ for __________ testing.

   a. culture and sensitivity
   b. drug screening
   c. glucose
   d. reagent strip

8. You notice that the lid is loose on the urine reagent strip container and some of the strips are brown in color. When you compare these pads to the chart on the side of the container, it appears that brown is not the correct color for this pad. What should you do?

   a. Discard the container
   b. Run quality control solutions
   c. Test the urine
   d. Use strips without the brown color

9. A positive urine reagent strip reaction for nitrite can indicate the presence of __________.

   a. bacteria
   b. red blood cells
   c. glucose
   d. protein
10. Which of the following urine volumes represents the recommended volume for
centrifugation for microscopic evaluation?
   a. 4 mL
   b. 12 mL
   c. 15 mL
   d. 20 mL

11. If many squamous epithelial cells are seen in a microscopic exam of urine sediment,
this may indicate __________.
   a. a contaminated sample
   b. a urinary tract infection
   c. serious kidney disease
   d. the presence of bacteria

12. Which of the following should be seen in a microscopic urine sediment exam if the
reagent strip reaction to blood is positive?
   a. bacteria
   b. red blood cells
   c. white blood cells
   d. white blood cell casts

13. You are asked to assist with a paracentesis procedure. Which type of fluid will be
collected?
   a. Cerebral spinal fluid
   b. Pericardial fluid
   c. Peritoneal fluid
   d. Pleural fluid

14. An accumulation of serous fluid is called a/an __________.
   a. effusion
   b. hematoma
   c. paracentesis
   d. traumatic tap

15. A fluid that contains chylous material will appear __________.
   a. bloody
   b. clear
   c. milky
   d. turbid
16. The presence of _________ can indicate a traumatic tap occurred during the collection of a body fluid.

   a. amylase  
   b. blood  
   c. lipids  
   d. white blood cells

17. Why do you centrifuge or cytospin a body fluid specimen?

   a. To measure protein  
   b. To perform a cell count  
   c. To concentrate the specimen  
   d. To culture bacteria

18. A body fluid for culture and sensitivity should be collected in an evacuated tube containing _________.

   a. EDTA  
   b. Sodium heparin  
   c. Sodium fluoride  
   d. No additive

19. Which of the following tubes containing spinal fluid should be used for cellular examination?

   a. Tube #1  
   b. Tube #2  
   c. Tube #3  
   d. Any tube can be used

20. Which of the following is tested for viscosity during collection?

   a. Cerebral spinal fluid  
   b. Pericardial fluid  
   c. Peritoneal fluid  
   d. Synovial fluid

21. Which of the following diagnoses may be made solely from the analysis of pleural, pericardial, or peritoneal fluids?

   a. Diabetes  
   b. Rheumatoid arthritis  
   c. Malignancy  
   d. Myocardial infarction
22. Therapeutic removal of fluid is intended to __________.
   a. alleviate pressure
   b. diminish protein accumulation
   c. diagnose cancer
   d. increase mobility

*end of test*
# P.A.C.E.® Course Evaluation

**Directions:** Please let us know whether this CE Course met your expectations by answering the following questions. Your feedback helps us to make our products better for you!

<table>
<thead>
<tr>
<th>Course Title: Body Fluids - The Ins and Outs</th>
<th>Course Number: 1222118</th>
</tr>
</thead>
</table>

## OBJECTIVES

| ____ Yes  ____ No | 1. Did you meet the objectives while reading this CE course? |
| ____ Yes  ____ No | 2. Did the test measure what you learned? |

## COURSE CONTENT

| ____ Yes  ____ No | 3. Were you satisfied with this course? |
| ____ Yes  ____ No | 4. Was the CE course organized and useful for learning? |
| ____ Yes  ____ No | 5. Was this CE course written at the right level for the practicing professional? |

## VALUE

| ____ Yes  ____ No | 6. Did you learn anything new? |
| ____ Yes  ____ No  ____ Maybe | 7. Did you learn anything you might use at work? |

What can NCCT do to make the CE courses better for you?

What would you like to learn about in the future? Please list *specific* topics!

*Please include this evaluation with your answer sheet.*