This chapter describes special tests and point-of-care testing (POCT). Collecting specimens for special tests requires special preparation, equipment, handling, or timing. POCT specimens are collected using small, portable, and often handheld testing devices that bring laboratory testing to the location of the patient. POCT is convenient for the patient; its short turnaround times (TATs) for results allow healthcare providers to address crucial patient needs, deliver prompt medical attention, and expedite patient recovery. Some of the most commonly encountered special blood test and POCT procedures are described in this chapter.

**Special Procedures**

Most laboratory tests require blood specimens that are collected by routine venipuncture or capillary puncture procedures. Some tests, however, require special or additional collection procedures or are performed on other body substances such as feces or urine. Collecting specimens for these tests may require special preparation, equipment, handling, or timing. The following are some of the most commonly encountered special test procedures.

**BLOOD BANK SPECIMENS**

Blood bank specimens yield information that determines which blood products can be transfused safely into a patient. Faithful attention to protocol in collecting blood bank specimens is crucial to safe transfusions. Follow facility-specific procedures.

**Specimen Requirements**

Blood bank tests require the collection of one or more lavender- or pink-top EDTA tubes. In some cases, a nonadditive glass red-stoppered tube is used.

**Identification and Labeling Requirements**

Blood bank specimens require strict patient identification and specimen labeling procedures. Specimens that have labeling errors of any kind or are unlabeled will not be accepted for testing. An error in specimen identification or labeling requires re-collection of the specimen and causes a delay in patient treatment. An undetected error can result in administration of an incompatible blood product and the possibility of a fatal transfusion reaction. Typical labeling requirements for blood bank specimens are shown in Box 11-1.

**Special Identification Systems**

A variety of special blood bank identification systems are available. One system uses a special ID bracelet such as the PDC Securline Blood Bank (Precision Dynamics Corporation, San Fernando, CA), which is attached to the patient’s wrist.

With this system, the patient’s identity is confirmed and the information written on a self-carbon adhesive label on the special bracelet, which contains a unique ID number. The adhesive label is peeled from the latex-free bracelet, leaving a carbon copy of the information, including the unique ID number, on the bracelet. The adhesive label is then placed on

---

**BOX 11-1**

**LABELING REQUIREMENTS FOR BLOOD BANK SPECIMENS**

- Patient’s full name (including middle initial)
- Patient’s hospital identification number (or social security number for outpatients)
- Patient’s date of birth
- Date and time of collection
- Phlebotomist’s initials
- Room number and bed number (optional)
the patient’s specimen (Fig. 11-1). Additional ID-number labels from the bracelet are sent to
the lab with the specimen to be used in the cross-match process or eventually attached to the
unit of blood or other blood products used for transfusion. Figure 11-2 shows a blood bank
ID bracelet and a patient’s specimen with additional numbered labels attached to it. Prior to
transfusion, the nurse must match the numbers on the patient’s blood bank ID bracelet with
the numbers on the unit of blood. Some facilities require the unique number and patient’s
name to be brought to the blood bank as an additional identification check when the blood
products are being picked up.

In recent years, blood ID-band systems with linear bar-coded BBID numbers have been
introduced for use. Typenex Medical has created two of these systems: their Next Generation
Barcode Blood Bands and their FlexiBlood bar-coded band and form system.

Both of these systems allow for the implementation of electronic blood bank ID systems.
Other features of these systems address two of the major concerns stated by blood bank
personnel. With either of these systems, a person has the ability to add preprinted patient
information labels to the BBID wristband, thus reducing many common transcription errors
at the bedside. Both of these systems also have separate bar-coded specimen tube stickers
containing directions for proper overlabeling on specimen tubes, thereby helping to standard-
ize the process for everyone using this system. Figure 11-3 shows an example of a condensed
Typenex FlexiBlood form, which accompanies the requisition when blood is being collected
for patient cross-matching.
An example of an electronic blood bank ID system is the Siemens Patient Identification Check–Blood Administration workflow. Patient Identification Check provides positive identification safeguards for blood product administration, helping clinicians identify the right patient with the right blood product with bar-code accuracy. The nurse initiates the blood product validation for a patient by gathering four key facts about the blood product in the presence of the patient:

- The clinician’s identity, scanned from the bar code on his or her identification card
- The patient’s identification scanned from the bar code on the patient’s wristband as seen in Figure 11-4.
- The product’s unique bar-coded donor identifier on the blood unit.
- The blood product’s bar code on the blood unit.

Before the healthcare provider physically starts the transfusion, the Patient Identification Check can require a second nurse validation. Once all verification is complete, the unit is ready to be physically transfused by the clinician. Upon completion of the transfusion, the nurse updates the Patient Identification Check system, which in turn updates the blood bank system to reflect that the unit has been administered and logs the date and time of completion. This method helps to increase patient safety and provides accurate records for the blood administration workflow process.

**TYPE, SCREEN, AND CROSS-MATCH**

One of the most common tests performed by the blood bank is a blood type and screen. This test determines a patient’s blood type (ABO) and Rh factor (positive or negative). When required, a cross-match is performed using the patient’s type and screen results to help select a donor unit of blood. During a cross-match, the patient’s plasma or serum and the donor’s RBCs are mixed together to determine compatibility (suitability to be mixed). A transfusion of incompatible blood can be fatal because of agglutination (clumping) and lysis (rupturing) of the RBCs within the patient’s circulatory system.

**BLOOD DONOR COLLECTION**

Blood donor collection involves collecting blood to be used for transfusion purposes rather than for diagnostic testing. Blood is collected from volunteers in amounts referred to as units.
Donor collection requires special training and exceptional venipuncture skills. Facilities that provide blood products for transfusion purposes are called Donor Blood Banks. Blood banks follow guidelines set by the American Association of Blood Banks (AABB) for purposes of quality assurance and standardization. Regulation by the U.S. Food and Drug Administration (FDA) is required, since blood and blood products are considered pharmaceuticals.

**KEY POINT** All potential blood donors must be interviewed to determine their eligibility to donate blood as well as to obtain information for the records that must be kept on all blood donors.

### Donor Eligibility

To donate blood, a person must be between the ages of 17 and 66 years and weigh at least 110 pounds. Minors must have written permission from their parents. Adults over the age of 66 years may be allowed to donate at the discretion of the blood bank physician. A brief physical examination as well as a complete medical history are needed to determine the patient’s health status. This information is collected each time a person donates, no matter how many times a person has donated before. All donor information is strictly confidential. In addition, the donor must give written permission for the blood bank to use his or her blood. The principles of donor unit collection are listed in Box 11-2.

> The anticoagulant and preservative CPD (citrate–phosphate–dextrose) or CPDA1 (CPD plus adenine) is typically used in collecting units of blood for transfusion purposes. The citrate prevents clotting by chelating calcium. A phosphate compound stabilizes the pH, and dextrose provides energy to the cells and helps keep them alive.

### Lookback Program

A unit of blood can be separated into several components: RBCs, plasma, and platelets. All components of the unit must be traceable to the donor for federally required lookback
programs. A lookback program requires notification to all blood recipients when a donor for a blood product they have received has turned positive for a transmissible disease. At that point, it is absolutely necessary that verification for all blood components previously collected and currently in inventory has been retrieved.

**Autologous Donation**

Despite advances in preventing the transmission of infection through transfusions, providing safe blood for blood products remains a challenge. Errors such as drawing blood samples from the wrong patient for blood transfusion present even more of a risk than transmissible diseases.

**Autologous donation** is the process by which a person donates blood for his or her own use. This is done for elective surgeries when it is anticipated that a transfusion will be needed. Using one’s own blood eliminates many risks associated with transfusion, such as disease transmission and blood or plasma incompatibilities. Although blood is normally collected several weeks prior to the scheduled surgery, the minimum time between donation and surgery can be as little as 72 hours. To be eligible to make an autologous donation, a person must have a written order from a physician.

**Cell Salvaging**

Aqueous solutions, plasma, and serum samples or banked erythrocytes often contain lysed RBCs that have released hemoglobin into the solution. For example, during some surgical procedures, the patient’s blood is salvaged, washed, and reinfused. Prior to reinfusion, it is recommended that the salvaged blood be tested for residual free hemoglobin. A high free hemoglobin level indicates that too many red cells were destroyed during the salvage process and renal dysfunction could result if the blood were reinfused. Free hemoglobin can be detected using point-of-care instruments such as the HemoCue Plasma/Low Hemoglobin analyzer (Fig. 11-5).

**BLOOD CULTURES**

It is known that bacteria can enter the body and cause disease. During the disease process, bacteria may also enter the circulatory system, causing **bacteremia** (bacteria in the blood) or **septicemia** (microorganisms or their toxins in the blood). Except when overwhelming infection is present, these organisms are generally cleared from the bloodstream in a short time. Blood cultures help determine the presence and extent of infection as well as indicating the type of organism responsible and the antibiotic to which it is most susceptible. They are also useful in assessing the effectiveness of antibiotic therapy once treatment is initiated.

Blood cultures should be ordered on the basis of whether the patient has a condition in which bloodstream invasion is possible and not only when a patient experiences a **fever of unknown origin**.
origin (FUO). Some elderly patients and others with underlying conditions are often not capable of mounting good fever responses, even though they may be experiencing septicemia.

**KEY POINT** Blood cultures are typically ordered immediately before or after anticipated fever spikes when bacteria are most likely to be present. Timely collection is essential. Recent studies have shown that the best chance for detecting bacteremia exists between 30 minutes to 2½ hours prior to the fever peak, before the body can eliminate some of the microorganisms.

**Specimen Requirements**

The most recent literature of American Society for Microbiology (ASM) states that two to four blood cultures are necessary to optimize the detection of bacteremia and fungemia. For optimum results such specimens should be drawn 30 to 60 minutes apart. However, if the patient is in critical condition or an antibiotic must be given right away, cultures should be drawn consecutively and immediately from different sites. When more than one set is ordered for collection at the same time, the second set should be obtained from a separately prepared site on the opposite arm if possible. In some cases, “second-site” blood cultures are more useful when drawn 30 minutes apart. If timing is not specified on the requisition, the phlebotomist should follow the laboratory protocol.

**KEY POINT** According to ASM, the volume of blood drawn for infants and younger children should be from 1% to 4% of the patient’s total blood volume, generally speaking. For adults or people weighing more than 80 pounds, the recommended volumes for blood cultures are 20 to 30 mL per culture with a minimum of 10 mL per draw.

Blood culture specimens are most commonly collected in special bottles (Fig. 11-6) containing nutrient broth (referred to as medium) that encourages the growth of microorganisms. These specimens are typically collected in sets of two: one aerobic (with air) and one anaerobic (without air). When a syringe is used to collect the blood, the anaerobic bottle is filled first. When a butterfly is used, it is preferable to fill the aerobic bottle first because air in the tubing will be drawn into it along with the blood.

**Skin Antisepsis**

The major difficulty in the interpretation of blood cultures is contamination by microbial flora on the skin. **Skin antisepsis**, the destruction of microorganisms on the skin, is a critical part of the blood culture collection procedure. Failure to carefully disinfect the venipuncture site.
can introduce skin-surface bacteria into the blood culture bottles and interfere with interpretation of results. The laboratory must report all microorganisms detected; it is then up to the patient’s physician to determine whether the organism is clinically significant or merely a contaminant. If a contaminating organism is misinterpreted as pathogenic, it could result in inappropriate treatment. This problem is overcome best by meticulous preparation of the skin with a bactericidal agent.

Antiseptic or sterile technique for blood culture collection varies slightly from one laboratory to another. To minimize the risk of contamination by skin flora, the collection sites require a 30- to 60-second friction scrub to get to the bacteria beneath the dead skin cells onto the surface of the arm. Tincture of iodine, chlorhexidine gluconate, and a povidone/70% ethyl alcohol combination have all been shown to be effective.

Traditionally 10% povidone or 1% to 2% tincture of iodine compounds in the form of swab sticks or special cleaning-pad kits such as benzalkonium chloride (Fig. 11-7) have been used to clean the collection site. In using a povidone–iodine or chlorhexidine gluconate ampule swab, the swab should be placed at the site of needle insertion and moved outward in concentric circles without going over any area more than once, as shown in Figure 11-8. The area covered should be 3 to 4 in. in diameter.

Because of the increasing incidence of iodine sensitivities, some healthcare facilities are using chlorhexidine gluconate/isopropyl alcohol antiseptic preparations in blood culture preparation kits that have a one-step application and are effective with a 30-second scrub.
KEY POINT According to the CLSI, chlorhexidine gluconate is the recommended blood culture site disinfectant for infants 2 months and older and patients with iodine sensitivity.

Collection Procedure
The specimen collection procedure for blood culture is described in Procedure 11-1.

View the video Collecting a Blood Culture Specimen at http://thePoint.lww.com/McCall5e.

PROCEDURE 11-1 Blood Culture Specimen Collection

PURPOSE: Collect a blood culture specimen.

EQUIPMENT: Gloves and suitable skin antiseptic; blood culture bottles; butterfly and blood culture tube holder or needle, syringe, and transfer device; alcohol pads; bandage; permanent ink pen.

<table>
<thead>
<tr>
<th>Step</th>
<th>Explanation/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Follow normal identification protocol; explain collection procedure. Patient must be properly identified and consent to the procedure.</td>
</tr>
<tr>
<td>2.</td>
<td>Identify venipuncture site and release tourniquet. Proper disinfection takes time; CLSI Standard H3-A5 states that the tourniquet should not be left on longer than 1 minute.</td>
</tr>
</tbody>
</table>

KEY POINT Blood cultures should not be drawn through an indwelling IV or arterial catheter unless absolutely necessary. Draws from vascular lines are known to have a high contamination rate and may cause a person to receive antibiotic therapy when a septic condition is not truly present.
<table>
<thead>
<tr>
<th>Step</th>
<th>Explanation/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>Aseptically select and assemble equipment. Be very careful when removing the antiseptic sponge applicator from the packaging; keep the sponge sterile by touching only the handle. Aseptic technique in handling equipment aids in accurate diagnosis by reducing the risk of false-positive results due to contamination.</td>
</tr>
<tr>
<td>4.</td>
<td>Perform friction scrub. Bacteria exist on the skin surface; they can be temporarily removed by scrubbing with an effective antiseptic solution for the amount of time designated by the procedure method, generally 30–60 seconds. Maximum area of treatment by one applicator is approximately 2.5 by 2.5 inches. The applicator must be discarded after a single use.</td>
</tr>
<tr>
<td></td>
<td><strong>CAUTION:</strong> Do not scrub the skin of neonates too aggressively, as this may be abrasive and cause the skin to tear.</td>
</tr>
<tr>
<td>5.</td>
<td>Allow the site to dry. Antisepsis does not occur instantly. The 30-second wait allows time for the antiseptic to be effective against skin-surface bacteria. Never blot, fan, or blow on the site.</td>
</tr>
</tbody>
</table>
**PROCEDURE 11-1 Blood Culture Specimen Collection (Continued)**

<table>
<thead>
<tr>
<th>Step</th>
<th>Explanation/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>Remove the flip-off cap and inspect the bottle for visible defects.</td>
</tr>
<tr>
<td></td>
<td>Inspect the bottle for contamination, excessive cloudiness, cracks, and bulging or indented septums. Make certain the bottle is in date and that the vacuum will draw at least 8 cc. Do not use if any defect is noted.</td>
</tr>
<tr>
<td>7.</td>
<td>Cleanse the culture bottle stoppers while the site is drying.</td>
</tr>
<tr>
<td></td>
<td>Tops of the culture bottles must be free of contaminants when inoculated. Typically, culture bottles with plastic caps can be cleaned with 70% isopropyl alcohol after removing the flip-off cap. It is suggested that a clean alcohol prep pad be placed on top of each bottle after cleaning.</td>
</tr>
</tbody>
</table>

(continued)
### PROCEDURE 11-1 Blood Culture Specimen Collection (Continued)

<table>
<thead>
<tr>
<th>Step</th>
<th>Explaination/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Mark the minimum and maximum fill on the culture bottles. A blood culture bottle has a vacuum that usually exceeds 10 mL; consequently the user must carefully monitor how much blood is being added to the bottle. Most bottles have fill lines on the sides that can be marked. Marking the bottles ensures that enough but not too much blood enters the bottle. Typically, adult blood cultures require 10–20 mL per set, while pediatric blood cultures require 1–2 mL per set. Consult manufacturer’s instructions, as volume requirements may vary depending on the system used.</td>
</tr>
<tr>
<td>9.</td>
<td>Reapply the tourniquet and perform the venipuncture without touching or repalpating the site. The tourniquet must be reapplied to aid in venipuncture and care must be taken that the site is not recontaminated in the process. Ensuring antiseptic technique and sterility of the site is critical to accurate diagnosis. However, if the patient has “difficult” veins and a need to relocate the site is anticipated, the gloved palpating finger must be cleaned in the same manner as the site, including the 30-second contact time. Repalpating should only be done above or below the site of needle entry.</td>
</tr>
<tr>
<td>10.</td>
<td>Inoculate the medium as required. Inoculation of the medium can occur directly into the bottle during specimen collection or after collection when a syringe is used. A bottle should never be inserted directly into an ETS holder used for normal specimen collection even though it may fit. There is a possibility that medium in the bottle could flow back into the patient’s vein.</td>
</tr>
<tr>
<td>Step</td>
<td>Explanation/Rationale</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>11.</strong> Invert the bottle several times.</td>
<td>The blood should be mixed with the medium, especially if the bottle contains resin beads to neutralize antibiotics in the patient’s blood, giving any bacteria present a chance to grow.</td>
</tr>
<tr>
<td><strong>12.</strong> Clean the patient’s skin if applicable.</td>
<td>If an iodine preparation was used to clean the arm, the iodine should be removed with alcohol or suitable cleanser. Iodine left on the skin can be irritating and even toxic to those with iodine sensitivity. Iodine contamination of a blood sample can also cause erroneous results for other tests.</td>
</tr>
<tr>
<td><strong>13.</strong> Label the specimen containers with required identification information, including the site of blood collection.</td>
<td>Noting the collection site (e.g., right arm) or source, such as a port-a-cath, is necessary in case there is a localized infection. Some facilities require that labeling information include the amount of blood added to each bottle.</td>
</tr>
<tr>
<td><strong>14.</strong> Dispose of used and contaminated materials.</td>
<td>Materials such as needle caps and wrappers are normally discarded in the regular trash. Some facilities require that contaminated items such as blood-soaked gauze be discarded in biohazard containers.</td>
</tr>
<tr>
<td><strong>15.</strong> Thank the patient, remove gloves, and sanitize hands.</td>
<td>Thanking the patient is courteous and professional. Gloves must be removed in an aseptic manner and hands washed or decontaminated with hand sanitizer as an infection-control precaution.</td>
</tr>
<tr>
<td><strong>16.</strong> Transport specimens to the lab as quickly as possible.</td>
<td>Prompt delivery to the lab protects specimen integrity and is typically achieved by personal delivery, transportation via a pneumatic tube system, or by a courier service.</td>
</tr>
</tbody>
</table>

**Media Inoculation Methods**

Inoculation of media can occur several different ways: directly into the bottle during specimen collection or after collection as when blood has been collected in a syringe. A third way is to use an intermediate collection tube to collect the sample for inoculation in the laboratory and not at the bedside.

**Direct Inoculation**

To collect the specimen directly into the blood culture medium, use a butterfly and specially designed holder (Fig. 11-9). Connect the special holder to the Luer connector of the butterfly collection set. Fill the aerobic vial first, because the butterfly tubing has air in it. Avoid backflow by keeping the culture bottle or tube lower than the collection site and preventing the culture medium from contacting the stopper or needle during blood collection. Mix each container after removing it from the needle holder. After filling both containers and collecting blood for any other tests, remove the needle from the patient’s arm, activate the safety device, and hold pressure over the site.

---

**KEY POINT** Blood culture specimens are always collected first in the order of draw to prevent contamination from other tubes.
Syringe Inoculation

When the syringe method is used, the blood must be transferred to the bottles after the draw is completed. OSHA regulations require the use of a safety transfer device (see Fig. 7-25A) for this procedure. To transfer blood from the syringe to the culture bottles, activate the needle's safety device as soon as the needle is removed from the vein. Remove the needle and attach a safety transfer device to the syringe. Push the culture bottle into the device until the needle inside it penetrates the bottle stopper. Allow the blood to be drawn from the syringe by the vacuum in the container. The plunger may have to be held back to keep from expelling too much blood into the bottle. Never push the plunger to expel the blood into the vial. This can hemolyze the specimen and cause aerosol formation when the needle is removed.

If a transfer safety device is not available and a needle must be used, use extreme caution upon blood transfer.

![Figure 11-9 BacT/ALERT® blood culture supplies including a specially designed holder for a butterfly needle. (bioMerieux, Durham, NC.)](image)

CAUTION: The practice of changing needles prior to this transfer is no longer recommended. Several recent studies have shown that changing needles has little effect on reducing contamination rates and may actually increase risk of needlestick injury to the phlebotomist.

Never hold the culture bottle in your hand during the inoculation process. Place it on a solid surface or in a rack. When delivering blood to the bottles, direct the flow along the side of the container. As with the transfer device, do not push on the syringe plunger.

Intermediate Collection Tube

Blood is sometimes collected in an intermediate collection tube rather than blood culture bottles. A yellow-top sodium polyanethol sulfonate (SPS) tube (Fig. 11-10) is acceptable for this purpose. Other anticoagulants—such as citrate, heparin, EDTA, and oxalate—may be toxic to bacteria and are not recommended. Use of an intermediate tube is discouraged, however, for the following reasons:

- SPS in the collection tube when added to the blood culture bottle increases the final concentration of SPS.
- Transfer of blood from the intermediate tube to the blood culture bottles presents another opportunity for contamination.
- Transfer of blood to the culture bottles presents an exposure risk to laboratory staff.
ANTIMICROBIAL NEUTRALIZATION PRODUCTS

It is not unusual for patients to be on antimicrobial (antibiotic) therapy at the time blood culture specimens are collected. Presence of the antimicrobial agent in the patient’s blood can inhibit the growth of the microorganisms in the blood culture bottle. In such cases, the physician may order blood cultures to be collected in fastidious antimicrobial neutralization (FAN) (bioMerieux) or antimicrobial removal device (ARD) (Becton Dickinson) bottles, as shown in Figure 11-11. An ARD contains a resin that removes antimicrobials from the blood.

Figure 11-10 A yellow-top tube used for blood culture collection.

Figure 11-11 Left to right: FAN and ARD blood culture bottles.
FAN bottles contain activated charcoal, which neutralizes the antibiotic. The blood can then be processed by conventional technique without the risk of inhibiting the growth of microorganisms. ARDs and FANs should be delivered to the lab for processing as soon as possible.

**COAGULATION SPECIMENS**

There are a number of important things to remember in collecting specimens for coagulation tests.

- At one time it was customary to draw a “clear” or discard tube prior to collection of a blue-top tube. A few milliliters of blood were collected into a plain red-top tube to clear the needle of thromboplastin contamination picked up as it penetrated the skin. The clearing tube was discarded if it was not needed for other tests. New studies have shown that a clear tube is not necessary when collecting for a PT or PTT. A clear tube is required for all other coagulation tests (e.g., factor VIII) because the CLSI still recommends that they be the second or third tube drawn.
- Sodium citrate tubes for coagulation studies must be filled until the vacuum is exhausted to obtain a 9:1 ratio of blood to anticoagulant. Even when the tubes are properly filled, this ratio is altered if the patient’s hemoglobin level is abnormally high or low. In such cases, laboratory personnel may request specimen collection in a special tube that has had the anticoagulant volume adjusted. A blue-top CTAD tube is available for special coagulation testing. In addition to sodium citrate, CTAD tubes contain theophylline, adenosine and dipyridamole to inhibit thrombocyte activation between collection of the blood and performance of the test.

**CAUTION:** All anticoagulant tubes must be gently inverted three or four times immediately after collection to avoid microclots, which can invalidate test results.

- Never pour two partially filled tubes together to create a full tube, as the anticoagulant-to-blood ratio will be greatly increased.
- Cooling on ice during transport may be required for some test specimens to protect the coagulation factors. Some coagulation factors, such as factors V and VIII, are not stable. If the tests cannot be performed in a timely manner, the specimen must be centrifuged and the plasma frozen.
- If a coagulation specimen must be drawn from an indwelling catheter, the CLSI recommends drawing and discarding 5 mL of blood or six times the dead-space volume of the catheter before collecting the specimen. If heparin has been introduced into the line, it should be flushed with 5 mL of saline before drawing the discard blood and collecting the specimen.

**2-HOUR POSTPRANDIAL GLUCOSE**

Postprandial (PP) means after a meal. Glucose levels in blood specimens obtained 2 hours after a meal are rarely elevated in normal persons but may be significantly increased in diabetic patients. Therefore a glucose test on a specimen collected 2 hours after a meal (2-hour PP) is an excellent screening test for diabetes and other metabolic problems. A 2-hour PP test is also used to monitor insulin therapy. Correct timing of specimen collection is very important. Glucose levels in specimens collected too early or late may be falsely elevated or decreased, respectively, leading to misinterpretation of results. The principles of the 2-hour PP procedure are shown in Box 11-3.

**GLUCOSE TOLERANCE TEST**

A glucose tolerance test (GTT) is used to diagnose problems of carbohydrate metabolism. The major carbohydrate in the blood is glucose, the body’s source of energy. The GTT, also called the oral glucose test (OGTT), evaluates the body’s ability to metabolize glucose by monitoring the patient’s tolerance to high levels of glucose without adverse effects. The two
major types of disorders involving glucose metabolism are those in which the blood glucose level is increased (hyperglycemia), as in diabetes mellitus, and those in which the blood glucose levels are decreased (hypoglycemia). Insulin, produced by the pancreas, is primarily responsible for regulating blood glucose levels. The GTT evaluates the insulin response to a measured dose of glucose by recording glucose levels on specimens collected at specific time intervals. Insulin levels are sometimes measured also. GTT length is typically 1 hour for gestational diabetes and 3 hours for other glucose metabolism evaluations. The test rarely exceeds 6 hours. Results are plotted on a graph, creating a so-called GTT curve (Fig. 11-12).

There are a number of variations of the GTT procedure, involving different doses of glucose and timing of collections. The method used to collect the blood, however, should be consistent for all specimens. That is, if the first specimen is collected by venipuncture, all succeeding specimens should be venipuncture specimens. If skin puncture is used to collect the first specimen, all succeeding specimens should also be skin puncture specimens.

**GTT Preparation and Procedure**

Preparation for a GTT is very important. The patient must eat balanced meals containing approximately 150 grams (g) of carbohydrate for 3 days before the test and must fast for at least 12 hours but not more than 16 hours prior to the test. The patient is allowed to drink water during the fast and during the test to avoid dehydration and because urine specimens may be collected as part of the procedure. No other foods or beverages are allowed. The patient is also not allowed to smoke or chew gum, as these activities stimulate the digestive process and may cause erroneous test results. The patient should receive both verbal and written instructions to ensure compliance. The GTT procedure is described in Procedure 11-2.

![Glucose tolerance test (GTT) curves.](Figure 11-12)
### PURPOSE: Perform a glucose tolerance test.

### EQUIPMENT: Gloves, alcohol prep pads, ETS holder, tubes and needle, glucose beverage, urine containers (if applicable), bandage, permanent ink pen.

<table>
<thead>
<tr>
<th>Step</th>
<th>Explanation/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Follow normal identification protocol, explain collection procedure, and advise patient that water is allowed but drinking other beverages, eating food, smoking, or chewing gum is not allowed throughout the test period. Patient must be properly identified and must understand and consent to the procedure. Eating, drinking beverages other than water, smoking, and chewing gum all affect test results.</td>
</tr>
<tr>
<td>2.</td>
<td>Draw fasting specimen and check for glucose. If the fasting glucose result is abnormal, the patient’s physician must be consulted before continuing the test. The test is not normally performed if the patient’s blood glucose is over 200 mg/dL.</td>
</tr>
<tr>
<td>3.</td>
<td>Ask the patient to collect a fasting urine specimen if urine testing has been requested. The GTT can be requested with or without urine testing.</td>
</tr>
<tr>
<td>4.</td>
<td>Give the patient the determined dose of glucose beverage. A typical adult patient dose is 75 g. Children and small adults are given approximately 1 g of glucose per kilogram of weight. The dose for detecting gestational diabetes is normally between 50 and 75 g.</td>
</tr>
<tr>
<td>5.</td>
<td>Remind the patient to finish the beverage within 5 minutes. Results may be inaccurate if the patient takes longer to drink the beverage, as the glucose may start to be metabolized by the body, thus affecting test results.</td>
</tr>
<tr>
<td>6.</td>
<td>Note the time that the patient finishes the beverage, start the timing for the test, and calculate the collection times for the rest of the specimens based on this time. GTT specimens are typically collected 30 minutes, 1 hour, 2 hours, 3 hours, and so forth, after the patient finishes the glucose beverage.</td>
</tr>
<tr>
<td>7.</td>
<td>Give a copy of the collection times to the patient. Patients (especially outpatients) must be aware of the collection times so that they can be available for the draw.</td>
</tr>
<tr>
<td>8.</td>
<td>Collect blood and urine specimens (if applicable) as close to the computed times as possible. Timing of specimen collection is critical for computation of the GTT curve and correct interpretation of results.</td>
</tr>
<tr>
<td>9.</td>
<td>Label all specimens with the exact time collected and the time interval of the test (1/2 hour, 1 hour, etc.) in addition to patient identification information. Each specimen must be correctly identified for accurate computation of the GTT curve and interpretation of results. Actual time of collection must be recorded.</td>
</tr>
<tr>
<td>10.</td>
<td>Deliver or send specimens to the lab as soon as possible. Glucose specimens must be separated from the cells or tested within 2 hours of collection for accurate results. Specimens collected in sodium fluoride are stable for 24 hours and are sometimes held and tested all together. Follow facility protocol.</td>
</tr>
</tbody>
</table>
CAUTION: If the patient vomits during the GTT procedure, his or her physician must be consulted to determine if the test should be continued.

In normal patients, blood glucose levels peak within 30 minutes to 1 hour following glucose ingestion. The peak in glucose levels triggers the release of insulin, which brings glucose levels back down to fasting levels within about 2 hours and no glucose spills over into the urine.

Diabetics have an inadequate or absent insulin response; consequently glucose levels peak at higher levels and are slower to return to fasting levels. If blood is not drawn on time, it is important for the phlebotomist to note the discrepancy so that the physician can take this into consideration.

**LACTOSE TOLERANCE TEST**

A lactose tolerance test (Box 11-4) is used to determine if a patient lacks the enzyme (mucosal lactase) that is necessary to convert lactose, or milk sugar, into glucose and galactose. A person lacking the enzyme suffers from gastrointestinal distress and diarrhea following the ingestion of milk and other lactose-containing foods. Symptoms are relieved by eliminating milk from the diet.

A lactose tolerance test is typically performed in the same manner as a 2-hour GTT; however, an equal amount of lactose is substituted for the glucose. Blood samples are drawn at the same times as for a GTT. If the patient has mucosal lactase, the resulting glucose curve will be similar to a GTT curve, and the result is considered negative. If the patient is lactose intolerant (lacking the enzyme lactase), the glucose curve will be flat, rising no more than a few mg/dL from the fasting level. Some individuals normally have a flat GTT curve (resulting in a false-positive result); it is then suggested that they have a 2-hour GTT performed the day before the lactose tolerance test so that results can be evaluated adequately. False-positive results have also been demonstrated in patients with small bowel resections and with disorders such as slow gastric emptying, Crohn’s disease, and cystic fibrosis. A lactose tolerance test can also be performed on breath samples (see Chapter 13).
Drug Screening

Many healthcare organizations, sports associations, and major companies require preemployment drug screening. Random screening (without prior notice) may be performed on employees or athletes. Tests may detect a specific drug or screen for up to 30 different drugs, depending upon the circumstance. Testing is typically performed on urine rather than blood because it is easy to obtain and a wide variety of drugs or their metabolites (products of metabolism) can be detected in urine for a longer period of time. (See Table 11-2 for a list of drugs commonly detectable by drug screening, along with the length of time after use that the drug is detectable in the body.) The Triage TOX Drug Screen device (Biosite Incorporated, San Diego, CA) can rapidly and simultaneously test for seven major classes of drugs of abuse.
Illicit drugs detected include cocaine (crack), opiates (heroin), and amphetamines (ecstasy, speed, crystal), and tetrahydrocannabinol (pot). There are legal implications to drug screening, and a chain-of-custody protocol is required whether or not the test is being performed for legal reasons. The following are urine drug screen patient preparation and collection requirements defined by the National Institute on Drug Abuse (NIDA).

### Patient Preparation Requirements
- Explain the test purpose and procedure.
- Advise the patient of his or her legal rights.
- Obtain a witnessed, signed consent form.

### Specimen Collection Requirements
- A special area must be maintained for urine collection.
- A proctor is required to be present at the time of collection to verify that the specimen came from the correct person.
- A split sample may be required for confirmation or parallel testing.
- The specimen must be labeled appropriately to establish a chain of custody.
- To avoid tampering, a specimen must be sealed and placed in a locked container during transport from the collection site to the testing site. Documentation must be carefully maintained from courier to receiver.

### TRACE ELEMENTS
Trace elements or metals include aluminum, arsenic, copper, lead, iron, and zinc. These elements are measured in such small amounts that traces of them in the glass, plastic, or stopper material of evacuated tubes may leach into the specimen, causing falsely elevated test values. For this reason, specimens for these tests must be collected in special trace element–free
tubes. These tubes are made of materials that have been specially manufactured to be as free of trace elements as possible. An insert with each carton of tubes gives a detailed analysis of residual amounts of metals contained in the tubes. These tubes are typically royal blue and contain EDTA, heparin, or no additive. The type of additive is indicated on the label (e.g., red for no additive, lavender for EDTA, and green for heparin).

In collecting trace elements, it is important to prevent introducing even the smallest amount of the contaminating substance into the tube, since the amounts being tested are in micro- or nanograms. Contaminants in the stoppers accumulate in the needle each time a different tube is pierced in a multiple-tube collection. That accumulation can then carry over to the royal blue–stoppered tube, changing the results. When a trace-element test is ordered, it is best to draw it by itself if using a needle/tube assembly, or a syringe may be used. For best results, change the transfer device before filling the royal-blue tube.

**Point-of-Care Testing**

**Point-of-care testing (POCT)**—also known as alternate site testing (AST) or ancillary, bedside, or near-patient testing—brings laboratory testing to the location of the patient. POCT has been made possible by advances in laboratory instrumentation that have led to the development of small, portable, and often handheld testing devices. Its benefits include convenience to the patient and a short turnaround time (TAT) for results that allow healthcare providers to address crucial patient needs, deliver prompt medical attention, and expedite patient recovery.

In addition to being able to operate the analyzer according to the manufacturer’s instructions and possessing the phlebotomy skills required to collect the specimen, anyone who does POCT should be able to carry out the quality-control (QC) and maintenance procedures necessary to ensure that results obtained are accurate. Everyone who performs POCT in a clinical setting must meet the requirements of the Clinical Laboratory Improvement Amendments (CLIA) for testing and the guidelines of the Occupational Safety and Health Administration (OSHA) for specimen handling.

**QUALITY AND SAFETY IN POINT-OF-CARE TESTING**

It is important to have processes and systems in place to ensure that the testing that is being done at the bedside or at the patient’s side is performed properly and that results correlate with the same test when performed in the main laboratory.

Monitoring the quality of the waived testing being done at bedside is a constant challenge for the laboratory, and each year more tests are classified as waived by the FDA. In addition, the POCT regulations that govern many institutions change periodically with the addition of new regulations and clarification of existing ones.

Waived tests do not require the same level of quality checks as tests classified as nonwaived or sometimes referred to as moderately complex tests. Not too long ago, all POCT required external QC to be performed daily if any patient testing was to be done that day. Today the College of American Pathologists (CAP) requires that external liquid control be performed only as specified by the manufacturer’s instructions on many of the waived tests. In most cases that means performing liquid controls upon receipt of a new shipment of test kits, if the kit is not stored properly, or if patient results are questionable. The POCT regulations from CAP serve as a minimum guide that must be instituted. Some institutions choose to go beyond the minimum requirements because of past experiences and to be reassured that the testing is working properly.

Manufacturers have enhanced instruments to include electronic QC (EQCs), which can detect problems with the specimen (i.e., clotting, short samples, air bubbles) and electronic internal checks that can determine if the instrument is functioning properly. Although EQC has helped ease the regulatory requirements, it cannot check a very important part of the testing process, which is specimen collection and handling.

Some POC tests do not use instruments (often referred to as noninstrumented tests); for that reason the manufacturer or institution may require that daily external liquid QC be performed.
performed as a check on the technique used and the accuracy of the results. An example of such a test could be urine dipsticks that are read visually. At the bedside, this test does not use an instrument; instead, an individual compares the color pads on the dipstick (which has been dipped in urine) to a color chart on the strip vial. All control results must be recorded on a QC log and reviewed for consistency and acceptibility. An example of a log listing high UA control results for urine specimens is shown in Figure 11-15. This log is usually composed of two pages: one page for recording low QC values and the other for the high QC.

In addition to the many quality assurance issues with the POC instruments in use in today’s healthcare facilities, it has become evident that handheld POC analyzers carried between patients in a healthcare institution can be fomites for disease. One relevant publication from the Center for Disease Control (CDC) is entitled Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). The following quote

Figure 11-15 Urinalysis QC log showing daily recorded results for the positive control.
from that document illustrates the important role medical equipment can play in the spread of infections.

Although microbiologically contaminated surfaces can serve as reservoirs of potential pathogens, these surfaces generally are not directly associated with transmission of infections to either staff or patients. The transfer of microorganisms from environmental surfaces to patients is largely via hand contact with the surface. Although hand hygiene is important to minimize the impact of this transfer, cleaning and disinfecting environmental surfaces routinely is fundamental in reducing their potential contribution to the incidence of healthcare-associated infections.

In an effort to reduce the possible transmission of microorganisms to patients, glucose meter manufacturers have developed recommendations to disinfect their instruments. These vary by manufacturer; therefore, the specific recommendations for a particular glucose meter should be followed. Several manufacturers recommend cleaning the glucose meter with 10% bleach. It has been proven that a 1:10 bleach solution can effectively clean and disinfect POC instruments, but to be effective, such a solution must be mixed daily. A similar product available commercially is made up of individually wrapped EPA-registered bleach wipes designed to be used once and then thrown in the trash.

These wipes, shown in Figure 11-16, meet all OSHA and CDC regulations pertaining to devices that can be exposed to blood-borne pathogens. Because of their convenience, they have been found to encourage cleaning, thus reducing cross-contamination between patients of various bacteria including Clostridium difficile, methicillin-resistant Staphylococcus aureus (MRSA), and vancomycin-resistant Enterococcus (VRE).

**COAGULATION MONITORING BY POCT**

Several different types of coagulation POCT analyzers can be used to measure and evaluate patient warfarin and heparin therapy. Some of the more common POCT coagulation tests monitored are:

- Prothrombin time (PT) and international normalized ratio (INR)
- Activated partial thromboplastin time (APTT or PTT)
- **Activated clotting time (ACT)**
- Platelet function
The numerous POCT instruments available to perform various coagulation tests include:

- Cascade POC—ACT, APTT, PT/INR
- CoaguChek XS Plus—PT/INR
- GEM Premier 4000—ACT, APTT, PT/INR
- i-STAT—ACT, PT/INR
- Verify Now—Platelet function

**ACT**

The ACT test analyzes activity of the intrinsic coagulation factors and is used to monitor heparin therapy. Heparin is given intravenously to patients who have blood clots or whose blood is apt to clot too easily; it is also given as a precaution following certain surgeries. Effects on intravenous heparin administration are immediate but difficult to control. Too much heparin can cause the patient to bleed; therefore heparin therapy is closely monitored. Once a patient’s condition is stabilized, the patient is placed on oral anticoagulant therapy (such as warfarin) and monitored by PT testing.

The ACT test has traditionally been a bedside test; however, timing and mixing was done manually and prone to error. With automated ACT analyzers, the mixing and timing are done automatically. An example of an analyzer used to perform this test is the Cascade POC (Helena, Beaumont, TX). To begin the testing process with the Cascade POC, the bar-coded assay card is scanned by a reader on the instrument. This lets the instrument know which assay is requested and also the calibration details. The card is then placed into the instrument and, as shown in Figure 11-17, a whole-blood sample is added to the card for analysis. The data management system allows for the results to be sent directly to the laboratory information system (LIS) if desired.

**PT/INR**

The PT test is used to monitor warfarin (e.g., Coumadin) therapy. Many warfarin or anticoagulation clinics use POCT coagulation analyzers that perform protime (PT) and international normalized ratio (INR) tests on whole blood from a fingerstick to provide timely laboratory results. An example of a prothrombin time (PT/INR) meter that is frequently used is the CoaguChek XS (Roche Diagnostics, Indianapolis, IN) (Fig. 11-18).

The INR is derived from the mathematical formula below, which was developed to standardize the differences found between the various manufacturer’s reagents.

\[
\text{INR} = \left(\frac{\text{PT}_{\text{patient}}}{\text{PT}_{\text{normal}}}\right)^{\text{ISI}}
\]

\(\text{PT}_{\text{patient}}\) = the patient’s PT result expressed in seconds
PT_normal = the laboratory’s geometric mean value for normal patients in seconds
ISI = international sensitivity index for the tissue factor in the manufacturer’s reagent

Some POCT analyzers, such as CoaguChek, allow patients to perform protimes at home and transmit their results to the physician’s office. The physician can then adjust medication over the phone and the patient does not have to make an office visit.

PTT
The APTT/PTT test is used to screen for bleeding disorders prior to surgery, investigate bleeding or clotting disorders, detect clotting factor deficiencies, and monitor low-dose heparin therapy. Cascade POC and GEM Premier (Instrumentation Laboratories, Bedford, MA) are two POC analyzers that have test functions for APTT.

Platelet Function
Platelet function testing allows the clinician to determine a patient’s response to medication before open heart surgery or cardiac catheterization. This can help prevent excessive bleeding or blood clots. This testing can be done utilizing an automated analyzer with single-use, disposable assays called the VerifyNow® System (Accumetrics, San Diego, CA; Fig. 11-19). It uses whole-blood samples and gives measurements that correlate with laboratory testing.

Platelet function tests can measure the ability of an individual to respond to various antiplatelet medications. Patients respond differently to this type of medication; some are even very resistant. The VerifyNow System Aspirin Assay, which is CLIA-waived, provides a measurement to determine whether or not a patient is responding to aspirin therapy.

Bleeding Time
Bleeding time is the time required for blood to stop flowing from a standardized puncture on the inner surface of the forearm. The bleeding-time (BT) test, which evaluates platelet
plug formation in the capillaries to detect platelet function disorders and capillary integrity problems, has always been a POCT and does not require special POCT instrumentation. It is used in diagnosing problems with hemostasis and as a presurgical screening test. Although it has largely been replaced by other coagulation tests, such as platelet function assays, it is still occasionally ordered. Since accuracy of results depends on technique, the test must be performed correctly.

The BT test is performed on the volar (inner) lateral surface of the forearm, using a blood pressure cuff to standardize and maintain a constant pressure. The incision is made with a sterile automated incision device, such as the Surgicutt (ITC, Edison, NJ) (Fig. 11-20), that controls the width (5.0 mm) and depth (1.0 mm) of the incision. The steps of BT testing are shown in Procedure 11-3.
**PROCEDURE 11-3 Bleeding-Time Test**

**PURPOSE:** To perform a bleeding-time test.

**EQUIPMENT:** Gloves, suitable skin antiseptic, automated bleeding time incision device, blood pressure cuff, timing device, filter paper (#1 Whatman or equivalent), alcohol pads, butterfly bandage or Steri-Strips, waterproof bandage, permanent ink pen.

<table>
<thead>
<tr>
<th>Step</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify patient and sanitize hands.</td>
<td>Correct ID is vital to patient safety and meaningful test results. Proper hand hygiene plays a major role in infection control by protecting the phlebotomist, patient, and others from contamination. Gloves are sometimes put on at this point. Follow facility protocol.</td>
</tr>
<tr>
<td>2. Determine whether the patient has taken aspirin or any other salicylate-containing drug within the previous 2 weeks. Advise the patient of the potential for scarring.</td>
<td>Salicylates interfere with interpretation of the test by prolonging bleeding time. Although the incision is minor, there is a possibility of scarring.</td>
</tr>
<tr>
<td>3. Support the patient’s arm on a steady surface.</td>
<td>Support is required so the patient is comfortable for the duration of the test and doesn’t move the arm when the incision is made.</td>
</tr>
<tr>
<td>4. Select an area on the inner (volar) lateral surface of the forearm, approximately 5 cm distal to the antecubital area and devoid of surface veins, scars, bruises, or edema. It may be necessary to shave the test area lightly if it is covered with a large amount of hair.</td>
<td>The lateral aspect is preferred because the medial aspect tends to cause more pain and has a higher incidence of scarring. Scars, veins, bruises, and edema are avoided for accuracy of test results. The area must be devoid of hair for the incision device to make proper contact with the skin before activation.</td>
</tr>
<tr>
<td>5. Place the blood pressure cuff around the arm.</td>
<td>The blood pressure cuff must be in place and ready to be inflated before the incision is made. Applying it before cleaning the site minimizes chance of contaminating the site during application and adjustment.</td>
</tr>
<tr>
<td>6. Clean the selected area with alcohol and allow to air-dry.</td>
<td>Cleaning the site with an antiseptic helps avoid contaminating the patient with skin-surface bacteria when the incision is made. Letting the site dry naturally permits maximum antiseptic action, prevents contamination caused by wiping, and avoids stinging when the incision is made.</td>
</tr>
<tr>
<td>7. Put on gloves and prepare equipment.</td>
<td>According to the OSHA BBP standard, gloves must be worn during phlebotomy procedures. Preparing equipment while the site is drying saves time.</td>
</tr>
</tbody>
</table>

View the Bleeding Time Test video at [http://thepoint.lww.com/McCall5e](http://thepoint.lww.com/McCall5e).
<table>
<thead>
<tr>
<th>Step</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Remove the puncture device from its package, being careful not to touch or rest the blade slot on any nonsterile surface.</td>
<td>Sterility of the incision device must be maintained for the safety of the patient.</td>
</tr>
<tr>
<td>9. Inflate the blood pressure cuff to 40 mm Hg.</td>
<td>This pressure must be maintained throughout the entire procedure for standardization purposes.</td>
</tr>
<tr>
<td>10. Quickly remove the safety clip and place the puncture device firmly on the lateral aspect of the forearm (without pressing hard) approximately 5 cm below to the antecubital crease.</td>
<td>Time between inflation of the blood pressure cuff and making the incision should be between 30 and 60 seconds for accuracy of results. A horizontal incision parallel to the antecubital crease is recommended.</td>
</tr>
<tr>
<td>11. Depress the trigger while simultaneously starting the timer. Remove the device from the arm as soon as the blade has retracted and discard it in the sharps container.</td>
<td>Timing is critical and must start when the incision is made. Removing the device before the blade retracts can result in injury to the patient or phlebotomist. All sharp objects must be discarded in a sharps container.</td>
</tr>
<tr>
<td>12. Blot the blood flow at 30 seconds by bringing the filter paper close to the incision and absorbing or “wicking” the blood onto the filter paper without touching the wound.</td>
<td>Standardization of timing is necessary for accuracy of results. Touching the wound disturbs platelet plug formation.</td>
</tr>
<tr>
<td>13. Stop the timer when blood no longer stains the filter paper. (If bleeding persists beyond 15 minutes, the test is normally stopped and the result is reported as 15 minutes or greater.)</td>
<td>The end point is determined by stoppage of blood flow indicated when no more blood soaks into the paper. Follow facility protocol for stopping the test if the bleeding time is excessive.</td>
</tr>
</tbody>
</table>
Sources of Error

- Ingestion of aspirin or other salicylate-containing drugs or drugs such as ethanol, dextran, and streptokinase within 2 weeks of the test can abnormally prolong bleeding time.
- Any disturbance of platelet plug formation will increase the bleeding time.
- BP below or above 40 mm Hg will decrease or increase the bleeding time, respectively.
- Failure to start the timing as soon as the incision is made will decrease the bleeding time.
- Too little pressure on the incision device will decrease, and too much pressure will increase the bleeding time.

ARTERIAL BLOOD GASES AND ELECTROLYTES

Arterial blood gases (ABGs) and electrolytes are panels of tests that are often ordered in an emergency situation because of the critical balance in which these analytes must be maintained. ABG readings are used to determine the pH of blood which if outside the very narrow normal range threatens the patient’s survival. Balance of the electrolytes is essential for normal function of cells and organs. POCT has proven to be invaluable in critical care challenges.

Arterial Blood Gases

Arterial blood gases (ABGs) measured by POCT methods include pH, partial pressure of carbon dioxide (Pco₂), oxygen saturation (So₂), and partial pressure of oxygen (Po₂).

- pH is an abbreviation for potential hydrogen, a scale representing the relative acidity or alkalinity of a solution. The arterial blood pH test is a measure of the body’s acid–base balance and indicates his or her metabolic and respiratory status. The normal range for arterial blood pH is 7.35 to 7.45. Below-normal pH is referred to as acidosis and above-normal pH is referred to as alkalosis.
- The Pco₂ is a measure of the pressure exerted by dissolved CO₂ in the blood plasma and is proportional to the Pco₂ in the alveoli; therefore it is an indicator of how well air is being exchanged between the blood and the lungs. CO₂ levels are maintained within normal limits by the rate and depth of respiration. An abnormal increase in Pco₂ is associated with hypoventilation and a decrease with hyperventilation.
- The Po₂ is a measure of the pressure exerted by dissolved O₂ in the blood plasma and indicates the ability of the lungs to diffuse O₂ through the alveoli into the blood. It is used to evaluate the effectiveness of oxygen therapy.
So$_2$ is a measure of the percentage of hemoglobin binding sites occupied by oxygen in the bloodstream. It is used by physicians to determine a patient’s oxygenation status. A normal, healthy individual will usually exhibit oxygen saturation around 98%. A person with an arterial So$_2$ below 90% is said to have hypoxemia (a low oxygen level in the blood) and may be cyanotic.

Electrolytes

The most common electrolytes measured by POCT are sodium (Na$^+$), potassium (K$^+$), chloride (Cl$^-$), bicarbonate ion (HCO$_3^-$), and ionized calcium (iCa$^{2+}$).

- Sodium is the most plentiful electrolyte in the blood. It plays a major role in maintaining osmotic pressure and acid–base balance and in transmitting nerve impulses. Reduced sodium levels are referred to as hyponatremia. Elevated levels are referred to as hypernatremia.

- Potassium is primarily concentrated within the cells, with very little found in the bones and blood. It is released into the blood when cells are damaged. Potassium plays a major role in nerve conduction, muscle function, acid–base balance, and osmotic pressure. It influences cardiac output by helping to control the rate and force of heart contraction. The presence of a U wave on an electrocardiogram indicates potassium deficiency. Decreased blood potassium is called hypokalemia. Increased blood potassium is called hyperkalemia.

- Chloride exists mainly in the extracellular spaces in the form of sodium chloride (NaCl) or hydrochloric acid. Chloride is responsible for maintaining cellular integrity by influencing osmotic pressure and both acid–base and water balance. Chloride must be supplied along with potassium when hypokalemia is being corrected.

- Bicarbonate ion plays a role in transporting carbon dioxide (CO$_2$) to the lungs and in regulating blood pH. It is formed when carbonic acid is dissociated into H$^+$ and HCO$_3^-$ ions. Hydrogen ions (H$^+$) released in the process cause a decrease in pH, which means that the blood becomes more acid. The released HCO$_3^-$ moves from the cells to the plasma and is carried to the lungs, where it re-enters the cells and releases CO$_2$ for removal through the walls of the alveoli. Removal of CO$_2$ by the lungs results in a decrease of H$^+$ ions and an increase in blood pH. Decreased ventilation (hypoventilation) results in higher CO$_2$ levels and the production of more H$^+$ ions and can lead to acidosis. Hyperventilation decreases CO$_2$ levels and can lead to alkalosis.

- Ionized calcium (iCa$^{2+}$) accounts for approximately 45% of the calcium in the blood; the rest is bound to protein and other substances. Only ionized calcium can be used by the body for such critical functions as muscular contraction, cardiac function, transmission of nerve impulses, and blood clotting.

MULTIPLE-TEST-PANEL MONITORING BY POCT

Several small, portable, and in some cases handheld instruments are available that measure multiple test panels of commonly ordered stat tests such as BUN, glucose, lactate, hemoglobin and potassium. The body normally maintains these analytes in specific proportions within a narrow range; any uncorrected imbalance can quickly turn life threatening. POCT instruments in the ER or ICU play an important role at these times because of the immediate test result availability.

Examples of instruments that have a menu of several different tests are:

- GEM Premier
- i-STAT
- NOVA Stat Profile Analyzer
- ABL80 Flex

All the testing devices listed measure a multitude of analytes. Although they all have slightly different test menus, some of the more common analytes are Na$^+$, K$^+$, Cl, and HCO$_3^-$ as well as blood gas values for pH, PCO$_2$, PO$_2$, and SO$_2$, BUN, glucose, Hgb and Hct, ACT, lactate, and troponin.
The handheld i-STAT (Fig. 11-21) (Abbott Diagnostics, Abbott Park, IL) is a versatile, portable system that can measure a variety of tests. This system utilizes small test cartridges. Some cartridges are for single tests, but most can perform multiple tests on one cartridge. It can measure blood gas values and the electrolytes as well as BUN, glucose, Hgb and Hct, and ACT values.

Another POCT analyzer that measures blood gases and electrolytes is the GEM Premier 4000 (Instrumentation Laboratories, Lexington, MA) (Fig. 11-22). Test cartridges for this instrument also measure critical chemistry analytes, such as lactate, potassium, BUN, and creatinine, allowing for rapid “near-patient” screening for renal disease.

The AVOXimeter (ITC, Edison, NJ) (Fig. 11-23) provides physicians with quick results to aid in diagnosing carbon monoxide toxicity and methemoglobin status of patients in neonatal intensive care. This instrument aids physicians in diagnosing and detecting intracardiac (within the heart) and great-vessel shunts. Because of its point-of-care availability, it can offer...
an evaluation of blood gases in approximately 10 seconds, enabling the physician to make critical decisions concerning care and treatment without delay.

The portable blood gas analyzer ABL80 Flex (Fig. 11-24) is used in primary clinics and full-service hospitals. The ABL80 series offers the ability to personalize diagnostic and test capabilities to suit the needs of a facility’s acute care requirements.

**OTHER TESTS PERFORMED BY POCT**

**Cardiac Troponin T and I**

Cardiac troponin T (TnT) and troponin I (TnI) are proteins specific to heart muscle. Blood levels of cardiac TnT begin to rise within 4 hours of the onset of myocardial damage and may stay elevated for up to 14 days. Cardiac TnI levels rise within 3 to 6 hours and return to normal in 5 to 10 days. Measurement of these proteins is a valuable tool in the diagnosis of acute myocardial infarction (AMI) or heart attack. TnT is also measured to monitor
the effectiveness of thrombolytic therapy in heart attack patients. Cardiac troponin POCT analyzers include

- The CARDIAC T Rapid Assay (Roche Corporation, Indianapolis, IN), a one-step, whole-blood test for cardiac TnT that uses disposable test kits to provide results in minutes
- The Triage® Cardiac Panel (Alere, San Diego, CA), which provides results for three cardiac markers, TnI, CK-MB, and myoglobin

Lipid Testing

The Cholestech LDX analyzer (Alere, San Diego, CA) (Fig. 11-25A) can perform cholesterol, triglyceride, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) tests. Blood can be obtained by venipuncture or fingerstick and collected in a lithium heparin capillary tube for transfer into the testing cartridge (Fig. 11-25B). A quantitative result is obtained by the instrument’s evaluation of the intensity of a colored bar. A separate cartridge measures alanine transferase (ALT), a liver enzyme that is monitored when patients are on certain lipid-lowering medications.

B-Type Natriuretic Peptide

B-type natriuretic peptide (BNP) is a cardiac hormone produced by the heart in response to ventricular volume expansion and pressure overload. It is the first objective measurement for congestive heart failure (CHF). BNP levels help physicians differentiate chronic obstructive pulmonary disease (COPD) and CHF. This facilitates early patient diagnosis and placement into the appropriate care plan. BNP blood concentrations increase with the increasing severity of CHF and have been shown to more accurately reflect final diagnosis than echocardiographic ejection fractions. BNP can be determined by the Triage® MeterPro (Fig. 11-26) using a whole-blood EDTA specimen and a special cartridge.

C-Reactive Protein (CRP)

C-reactive protein (CRP) is a β-globulin found in the blood that responds to inflammation and can therefore be used as a sensitive though nonspecific marker of systemic inflammation. The test from Cholestech called hs-CRP (high sensitivity CRP) can be used as an aid in the detection and evaluation of infection, tissue injury, and inflammatory disorders. Owing to its high sensitivity, this test can detect low-grade inflammation and even CRP in asymptomatic individuals. Healthcare providers can use the POC Cholestech LDX® instrument (Fig. 11-25A) to measure this reactive protein within 7 minutes, using capillary blood.
Glucose testing is one of the most common POCT procedures and is most often performed to monitor glucose levels of patients with diabetes mellitus. POCT glucose analyzers/meters are small, portable, and relatively inexpensive. Two different types of meters are made: one type for an individual’s personal use and the other for use in healthcare settings. Hospital-approved glucose analyzers are equipped with data management systems and require various QC checks to monitor the performance of the meter and the operator. Glucose meters manufactured for home use do not have the same level of QC checks. It is common practice in hospitals not to use a patient’s personal glucose meter for treatment decisions.

**KEY POINT** Regulatory guidelines and the CLSI recommend that a person receive institutional authorization to perform POCT glucose testing only after completing formal training in facility-established procedures, including maintenance and QC.

An example of some of the glucose meters that are available include:

- ACCU-CHEK Inform
- HemoCue Glucose 201 DM
- Precision Xceed Pro
- SureStep Flex30

These analyzers require the use of special reagent test strips or microcuvettes that are unique to their meters. To prevent deterioration of the strips/microcuvettes, the containers they are stored in must be protected from excessive heat and moisture. Some strips/microcuvettes are stored in vials, which should be tightly recapped after obtaining the necessary strip/microcuvette, while other strips are individually wrapped, like those used in Precision XceedPro. The Accu-Chek Inform (Roche Diagnostics, Indianapolis, IN) (Fig. 11-27) has a code chip in the analyzer that must match the strip code number.

Glucose analyzers predominantly use whole-blood specimens obtained by routine skin puncture. Some will also accept heparinized venous specimens. To perform the test, a drop of blood is applied to the test strip/microcuvette. The analyzer determines the level of glucose in the blood, and the result appears on a display screen.

All of the analyzers approved for hospital use have the following in common:

- Sample types used may be venous, arterial, or capillary.
- They allow data for the glucose meter to be downloaded to a data management program.
- They require the use of a patient and/or authorized operator identification number.
- They require QC.
To download POCT test results from a remote location, an analyzer must be linked to a serial downloader. The SureStep Flexx (Lifescan, Inc., Milpitas, CA) (Fig. 11-28) is shown with a network downloader which, when connected to the instrument, allows transfer of patient glucose results to the patient’s chart through various interface options. The SureStep Flexx procedure involves “off-meter dosing,” which means that the test strip is touched to the blood before the strip is placed in the meter/instrument to be measured. This can help protect the patient from possible contamination by infectious agents, as may be associated with instruments where blood is added to a strip that is already in the instrument.

**KEY POINT** QC should be repeated if the analyzer is dropped, the battery is replaced, or patient results or analyzer functioning are questioned.

*Figure 11-27* AccuChek® Inform glucose meter. (Courtesy Roche Diagnostics, Indianapolis, IN.)

*Figure 11-28* SureStep® Flexx glucose meter with the connection module to the network. (Courtesy Lifescan, Inc., Milpitas, CA.)
The HemoCue Glucose 201 DM (HemoCue, Inc., Lake Forest, CA) Analyzer accepts arterial specimens as well as skin puncture and venous specimens. The test is performed using a microcuvette instead of a test strip. This unit is also a data management system that prompts the operator for identification, lot numbers, and other required QC information during analysis. The data are then transferred to the computer information system in the laboratory.

The Abbott Precision XceedPro (PXP) is designed to monitor patients at risk for diabetic ketoacidosis and is presently the only POC system that can test both blood glucose and β-ketones on the same instrument. The system incorporates the latest technology to minimize the chance of error and to ensure patient safety in performing POCT. For example, the PXP is capable of scanning the patient’s wrist band, the operator’s badge and the test strip’s bar code (Fig. 11-29). The scan identifies the lot number and expiration date found on the strip and automatically calibrates the system. Each strip is individually wrapped so as to protect it from moisture and light until used. The patient name, date of birth and gender is clearly displayed on the monitor to aid in patient identification.

**Glycemic Index Control**

Most institutions use a practice of intensive insulin therapy commonly referred to as **tight glycemic control (TGC)**. This may involve monitoring a patient’s glucose level every half hour and the administration of insulin as required to keep glucose levels in a predetermined range and avoid hyperglycemia. TGC requires frequent and fast glucose results. Blood glucose monitors on a nursing unit are an integral part of this testing. It has been well documented that managing a patient’s glucose level reduces infections, speeds healing, decreases length of stay, and lowers the costs of caring for a patient.

**Glycosylated Hemoglobin**

Glycosylated hemoglobin is a diagnostic tool for monitoring diabetes therapy and was recently accepted as a more accurate predictor than current techniques of a diabetic patient’s likelihood of developing complications of the disease; it is being considered as the primary diagnostic test for type 2 diabetes. Three hemoglobins—$A_{1a}$, $A_{1b}$, and $A_{1c}$—are types of Hgb A formed by glycosylation. Because glycosylation occurs at a constant rate during the 120-day life cycle of a red cell, glycosylated (sugar chemically linked to protein) Hgb levels reflect the average blood glucose level during the preceding 4 to 6 weeks and thus can be used to evaluate the long-term effectiveness of diabetes therapy. Since this test measures glucose within a RBC, levels are more stable than tests involving plasma or whole-blood glucose. Glycosylated hemoglobin values are reported as a percentage of the total hemoglobin within an erythrocyte. Since $A_{1c}$ is present in larger quantity than the others, it is the one measured.
One analyzer that measures glycosylated hemoglobin is the DCA Vantage A1c Analyzer (Siemens Healthcare Diagnostics, Inc., Tarrytown, NY) (Fig. 11-30). The device has a data management system and an “on-board” printer that allows the clinician to see a patient’s trend graph for an immediate review of previous results; this also facilitates a discussion of compliance issues with the patient.

Hematocrit

Hematocrit (Hct), also called packed cell volume (PCV), is a measure of the volume of RBCs in a patient’s blood. It is calculated by centrifuging a specific volume of anticoagulated blood and determining the proportion of RBCs to plasma. Blood is collected in special microhematocrit capillary tubes. The tubes are sealed at one end with clay or a special stopper and placed in a special hematocrit centrifuge (Fig. 11-31). The StatSpin® CritSpin microhematocrit centrifuge provides complete cell packing in 2 minutes. The result is expressed as a percentage of cells to liquid.

Hematocrits are often performed in physician office labs (POLs), clinics, and blood donor stations to screen for anemia or as an aid in the diagnosis and monitoring of patients with polycythemia.
Hemoglobin

The measurement of hemoglobin (hgb) levels is an important part of managing patients with anemia. A number of POCT analyzers measure hemoglobin. One example is the Hemocue HB 201+ Analyzer (Fig. 11-32) (HemoCue, Inc. Lake Forest, CA). It can determine hemoglobin levels in arterial, venous, or capillary blood specimens. A small amount of blood sample is placed in a special microcuvette and inserted into the machine for a reading. As part of the analyzer’s electronic QC, the analyzer automatically verifies the performance of the optics every time it is turned on and every 2 hours while the analyzer is left on.

Lactate

It has long been known that patients who are critically ill can exhibit metabolic acidosis. The accumulation of lactic acid in blood has been identified as the cause of acid–base disorder. Lactic acidosis is associated with major metabolic issues and is due to hyperlactatemia (increased lactate in the blood). Hyperlactatemia is usually present in patients with severe sepsis or septic shock.

The lactate level can be used as a marker of the severity of the condition and the patient’s stress response. Patients who have an arterial lactate level of more than 5 mmol/L have a very poor prognosis; consequently it is important to be able to obtain lactate results within minutes to effectively treat severe sepsis. If the test is to be performed in the laboratory, the sample must be transported on ice without delay and analyzed as soon as it arrives in the lab. Today the test can be performed at the bedside within a few seconds using the i-STAT or Nova Biomedical’s StatStrip Lactate analyzer (Waltham, MA) (Fig. 11-33).

Occult Blood (Guaiac)

Detection of occult (hidden) blood in stool (feces) is an important tool in diagnosing and determining the location of a number of diseases of the digestive tract, including gastric ulcer disease and colon cancer. Most tests that detect fecal blood make use of the peroxidase activity of the hemoglobin molecule to bring about a color change in the specimen being tested. For this reason, a patient’s diet should be free of meat and vegetable sources of peroxidase, which may lead to false-positive results. Other sources of false-positive results may be certain drugs, vitamin C, alcohol, and aspirin.
Testing for occult blood in POCT settings typically involves the use of special kits containing cards on which small amounts of feces are placed. Hemoccult® II Sensa® (Beckman Coulter Inc., Brea, CA) offers easily used and safely transported cards for collection of the sample (Fig. 11-34). The specimen can be collected and tested on site or the cards can be sent home with the patient to collect the samples and mail back to the lab.

**Pregnancy Testing**

Most rapid pregnancy tests detect the presence of *human chorionic gonadotropin* (hCG), a hormone produced by the placenta that appears in both urine and serum beginning approximately 10 days after conception. Most rapid pregnancy testing is performed on urine. Peak urine levels of hCG occur at approximately 10 weeks of gestation.

A number of manufacturers supply pregnancy testing kits. Two examples are the Beckman Coulter Icon hCG (Beckman Coulter, Inc., Brea, CA) (Fig. 11-35) and Quidel’s (San Diego, CA)
QuickVue+ One Step hCG Combo, both of which can use urine or serum to perform testing. Each manufacturer’s kit has unique reagents, timing, and testing methods, and most test kits have a built-in control system. It is important to follow directions exactly. The steps in testing for hCG are outlined in Procedure 11-4.

**PROCEDURE 11-4 Pregnancy Testing**

**hCG Pregnancy Test Procedure**

**PURPOSE:** To determine pregnancy status using a qualitative hCG urine test. The test checks to see if there is a hormone called human chorionic gonadotropin in the urine. HCG is a hormone normally present in serum and urine during pregnancy.

**EQUIPMENT:** Gloves, hCG test kit test device, disposable dropper or other transfer device (usually supplied with test device), specimen collection cup, patient label, certified timer.
**PROCEDURE 11-4 Pregnancy Testing** (Continued)

**SPECIMEN REQUIREMENTS:** No special patient preparation is necessary. Use a clean container to collect sample and keep at room temperature. First morning specimen is suggested because it generally contains the highest concentration of hCG, but any urine sample is suitable for testing.

**NOTE:** The pouch containing the hCG test kit must be at room temperature before it is opened.

<table>
<thead>
<tr>
<th>Step</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify the patient according to facility policy.</td>
<td>Correct ID is vital to patient safety and meaningful test results.</td>
</tr>
<tr>
<td>2. Label the specimen cup with the patient’s label.</td>
<td>To avoid errors, the specimen cup should be labeled even if the specimen is the only one being tested at that time.</td>
</tr>
<tr>
<td>3. Obtain the patient’s urine specimen.</td>
<td>If the patient will be collecting a urine specimen for the test, explain how to do so.</td>
</tr>
<tr>
<td>4. Remove the test device from the protective pouch and place it on a flat surface.</td>
<td>For correct results, the device should be absolutely flat so the urine will flow evenly onto the testing surface of the device. Note: If the specimen appears to look watery, a specific gravity test should be performed.</td>
</tr>
<tr>
<td>5. Using the disposable dropper, add the required amount (3 drops) of sample to the sample well (S) on the cassette.</td>
<td>Use the dropper supplied in the protective pouch for adding the sample. The size of the drops must be exactly as specified and consistent for results to be accurate.</td>
</tr>
<tr>
<td>6. Set a timer for the time the hCG kit’s manufacturer states a negative test must be read.</td>
<td>The reaction must be carefully timed with a certified timer. The test cassette should not be handled or moved until the test is ready to be read, and the results must be read at the specified time. Most manufacturers suggest reading their test after 3 minutes and to not read it after 10 minutes.</td>
</tr>
<tr>
<td>7. Read the cassette window’s results when the timer goes off.</td>
<td>A positive result can be read as soon as lines at both the T and C areas of the test cassette window appear. A negative result is indicated by a line at the C area of the test cassette window only.</td>
</tr>
</tbody>
</table>
### Negative Results

The test is negative if a colored line appears only in the control (C) position.

A negative result means, in most cases, that the person is not pregnant.

- Once you have a negative test after 3–5 minutes, **throw out the test**. Any positive test appearing after that time is inaccurate and cannot be considered positive.
- False negatives may occur when levels of hCG in the sample are below the sensitivity level of the test. If pregnancy is still suspected, the test can be repeated on a fresh sample collected 48 hours later. If results are questionable, a blood sample should be drawn and sent to the laboratory for testing. Most laboratories have hCG tests that are more sensitive than urine hCG tests.
- False-negative results may occur when the sample is diluted due to a large amount of fluid consumption and a low specific gravity. A fresh morning sample will usually have the highest concentration of hCG.
- If the results do not agree with other patient findings, a specimen should be sent to the laboratory for confirmation.

### Positive Results

The test is positive if two colored lines appear, one at the test (T) position and one at the control (C) position. These lines may not be equally light or dark.

A positive result means, in most cases, that the person is pregnant.

- Some tests will produce a faint positive test result if read after the instructed time due to the formation of something called an “evaporation line.”
- Expired tests can also lead to false positive results. Always check the expiration date before testing.
- Certain rare medical conditions, such as ectopic pregnancy, and some drugs can give a false-positive pregnancy test.

**Note:** If a female receives shots of hCG for ovulation it is possible to have a positive urine for two to three weeks after the shot and not be pregnant. After delivery or an abortion, hCG may remain detectable for a few days to several weeks.
PROCEDURE 11-4 Pregnancy Testing (Continued)

Step Rationale

Invalid Results
The test is considered invalid if there is no distinct visible line at the control (C) position, even if a colored line appears in the test (T) position.

An invalid result means that the test should be repeated.

Skin Tests
Some laboratories offer skin testing services, especially for outpatients. Skin tests most often involve the intradermal (within the skin) injection of an allergenic substance (a substance that causes an immune response). Such tests are performed to determine whether an individual has come in contact with a specific allergen (antigen) and developed antibodies against it. Many disease-producing microorganisms function as allergens, stimulating an antibody response in susceptible individuals. Skin testing can determine an individual’s immune status associated with such microorganisms.

Examples of Skin Tests
- **Tuberculin (TB) test:** Also called the PPD test after the purified protein derivative used in it.
- **Aspergillus test:** Detects hypersensitivity to *Aspergillus*, a type of mold.
- **Coccidioidomycosis (cocc) test:** Tests for an infectious fungal disease caused by *Coccidioides immitis*.
- **Histoplasmosis (histo) test:** Tests for past or present infection by the fungus *Histoplasma capsulatum*.

**Tuberculin Test**
The tuberculin (TB) test is a skin test that determines whether an individual has developed an immune response to *Mycobacterium tuberculosis*, the microbe that causes
An immune response or reaction to the test can occur if someone currently has TB or has been exposed to it in the past. The procedure for administering a TB test is given in Procedure 11-5.

**PROCEDURE 11-5 TB Test Administration**

**PURPOSE:** Administer a TB skin test.

**EQUIPMENT:** Gloves, alcohol pad, tuberculin syringe, 1/2 inch 27-gauge safety needle, TB antigen, permanent ink pen.

<table>
<thead>
<tr>
<th>Step</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify the patient, explain the procedure, and sanitize hands.</td>
<td>Correct ID is vital to patient safety and meaningful test results. Proper hand hygiene plays a major role in infection control by protecting the phlebotomist, patient, and others from contamination. Gloves are sometimes put on at this point. Follow facility protocol.</td>
</tr>
<tr>
<td>2. Support the patient’s arm on a firm surface and select a suitable site on the volar surface of the forearm, below the antecubital crease.</td>
<td>The arm must be supported to minimize movement during test administration. Areas with scars, bruises, burns, rashes, excessive hair, or superficial veins must be avoided as they can interfere with interpretation of the test.</td>
</tr>
<tr>
<td>3. Clean the site with an alcohol pad and allow it to air dry.</td>
<td>Cleaning with antiseptic and allowing it to air dry permits maximum antiseptic action.</td>
</tr>
<tr>
<td>4. Put on gloves at this point if you have not already done so</td>
<td>Gloves are necessary for safety and infection control.</td>
</tr>
<tr>
<td>5. Clean the top of the antigen bottle and draw 0.1 mL of diluted antigen into the syringe.</td>
<td>The top of the bottle must be clean to prevent contamination of the antigen.</td>
</tr>
<tr>
<td>6. Stretch the skin taut with the thumb in a manner similar to venipuncture and slip the needle just under the skin at a very shallow angle (approximately 10–15 degrees).</td>
<td>The skin must be taut so the needle will slip into it easily. The antigen must be injected just beneath the skin for accurate interpretation of results.</td>
</tr>
<tr>
<td>7. Pull back on the syringe plunger slightly to make certain a vein has not been entered.</td>
<td>The antigen must not be injected into a vein.</td>
</tr>
<tr>
<td>8. Slowly expel the contents of the syringe to create a distinct, pale elevation commonly called a bleb or wheal.</td>
<td>Appearance of the bleb or wheal is a sign that the antigen has been injected properly.</td>
</tr>
</tbody>
</table>
### PROCEDURE 11-5 TB Test Administration (Continued)

<table>
<thead>
<tr>
<th>Step</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9.</strong> Without applying pressure or gauze to the site, withdraw the needle, activate the safety feature, and discard the needle.</td>
<td>Applying pressure could force the antigen out of the site. Gauze might absorb the antigen. Both actions could invalidate test results. Activation of safety features and prompt needle disposal minimize the chance of an accidental needlestick.</td>
</tr>
<tr>
<td><strong>10.</strong> Ensure that the arm remains extended until the site has time to close. Do not apply a bandage.</td>
<td>A bandage can absorb the fluid or cause irritation, resulting in misinterpretation of test results.</td>
</tr>
<tr>
<td><strong>11.</strong> Check the site for a reaction in 48 to 72 hours. This is called “reading” the reaction.</td>
<td>Maximum reaction is achieved in 48–72 hours. A reaction can be underestimated if read after this time.</td>
</tr>
<tr>
<td><strong>12.</strong> Measure induration (hardness) and interpret the result. Do not measure erythema (redness).</td>
<td>A TB reaction is interpreted according to the amount of induration or firm raised area due to localized swelling. The health status and age of the individual are important considerations when interpreting results. 5 mm of induration can be considered a positive test result in patients who are immunosuppressed due to chronic medical conditions.</td>
</tr>
</tbody>
</table>

**Negative:** induration absent or less than 5 mm in diameter.  
**Doubtful:** induration between 5 and 9 mm in diameter.  
**Positive:** induration 10 mm or greater in diameter.

---

**KEY POINT** A TB test is also called a PPD test after the purified protein derivative used in the test.

**View the video Rapid Detection of Strep at [http://thepoint.lww.com/McCall5e](http://thepoint.lww.com/McCall5e).**

**Strep Testing**

Numerous kits are available for the direct detection of group A streptococci on throat swab specimens; for example, the Genzyme OSOM Ultra A test kit or the Strep A Dipstick test kit (ACON Laboratories, San Diego, CA), as shown in Figure 11-36. Performance of the test normally
requires two steps. The first involves nitrous acid or enzymatic extraction of the swab; the second involves a latex agglutination or enzyme immunoassay method of antigen detection. Results are available in minutes.

**Urinalysis**

A routine urinalysis (UA) consists of a physical and chemical analysis of the specimen as well as microscopic analysis if indicated. A medical laboratory technician or technologist must perform a microscopic analysis.

Chemical composition is most commonly determined by use of an inert plastic reagent strip containing pads impregnated with reagents that test for the presence of bacteria, blood, bilirubin, glucose, leukocytes, protein, and urobilinogen; they measure pH and specific gravity as well. (Specific gravity can also be measured separately using an instrument called a refractometer.) A chemical reaction resulting in color changes to the strip takes place when the strip is dipped in urine. The results can be determined by comparing the strip visually against a code on the container, as shown in Figure 11-37, or by inserting the strip into a machine called a reflectance photometer, which reads the strip and prints out the results. Reflectance photometers include the Clinitek Advantus (Siemen’s Diagnostic, Deerfield, IL) and the CLIA-waived analyzers Clinitek Status Connect and Roche Urisys 1100 Urine Analyzers (Roche, Indianapolis, IN). The Clinitek Status Connect and Advantus both have lockouts that require the use of an authorized operator identification and can prevent patient testing until the QC has been accepted. These features are welcome additions to POCT urine instruments.

To ensure the integrity of the strips, they should remain tightly capped in their original containers when not in use so as to protect them from the deteriorating effects of light, moisture, and chemical contamination. The containers should also be protected from heat.