The preanalytical (before analysis) or pre-examination phase of the testing process begins for the laboratory when a test is ordered and ends when testing begins. Numerous factors associated with this phase of the testing process, if not properly addressed, can lead to errors that can compromise specimen quality, jeopardize the health and safety of the patient, and ultimately increase the cost of medical care. Since each blood collection situation is unique, a phlebotomist must have—in addition to the technical skills needed to perform a blood draw—the ability to recognize preanalytical factors and address them, if applicable, to avoid or reduce any negative impact. This chapter addresses physiological variables, problem veni-puncture sites, various types of vascular access devices, patient complications and conditions, procedural errors, specimen quality issues, and how to troubleshoot failed venipuncture.

**Reference Ranges/Intervals**

Most tests are performed to confirm health or to screen for, diagnose, or monitor disease. To be properly evaluated, test results typically need to be compared with results expected of healthy individuals. Consequently, result values for most tests are established using specimens from normal, healthy individuals. Because results vary somewhat from person to person, the results used for comparison become a range of values with high and low limits, commonly called a *reference range* or *reference interval*. Most reference ranges are for healthy fasting individuals. Although less common, some tests have reference ranges for specific situations, such as patients who are ill or those being treated for certain disorders, such as diabetes.

**KEY POINT** One way a physician evaluates a patient’s test results is by comparing them to reference ranges and, if applicable, previous results on the same patient. If a specimen has been compromised and the results are not valid, a physician could make a decision based upon incorrect information and thus jeopardize the patient’s care.

**Basal State**

**Basal state** refers to the resting metabolic state of the body early in the morning after fasting for approximately 12 hours. A basal-state specimen is ideal for establishing reference ranges on inpatients because the effects of diet, exercise, and other controllable factors on test results are minimized or eliminated. Basal state is influenced by a number of physiologic patient variables such as age, gender, and conditions of the body that cannot be eliminated.

**Physiological Variables**

**AGE**

Values for some blood components vary considerably depending upon the age of the patient. For example, red blood cell (RBC) and white blood cell (WBC) values are normally higher in newborns than in adults. Some physiological functions such as kidney function decrease with age. For example, creatinine clearance, a measure of kidney function, is directly related to the age of the patient, which must be factored in when test results are being calculated.

**ALTITUDE**

Test results for some blood analytes show significant variation at higher elevations compared with results at sea level. Red blood cell (RBC) counts are a prime example. RBCs carry oxygen. Decreased oxygen levels at higher altitudes cause the body to produce more RBCs to meet the body’s oxygen requirements; the higher the altitude, the greater the increase. Thus RBC counts and related determinations such as hemoglobin (Hgb) and hematocrit (Hct) have higher reference ranges at higher elevations. Other analytes that increase at higher elevations include C-reactive protein and uric acid. Analytes that decrease in value at increased altitude include urinary creatinine (which in turn affects creatinine clearance tests) and plasma renin.

**DEHYDRATION**

Dehydration (decrease in total body fluid), which occurs, for example, with persistent vomiting or diarrhea, causes *hemoconcentration*, a condition in which blood components that cannot easily leave the bloodstream become concentrated in the smaller plasma volume. Blood components affected include RBCs, enzymes, iron (Fe), calcium (Ca), sodium (Na), and coagulation factors. Consequently, results on specimens from dehydrated patients may not accurately reflect the patient’s normal status. In addition, it is often difficult to obtain blood specimens from dehydrated patients.
Blood analyte composition can be altered by the ingestion of food and drink. As a result, blood specimens collected soon after a meal or snack are unsuitable for many laboratory tests. Diet effects on analytes are generally temporary and vary depending upon the amount and type of food or drink and the length of time between ingestion and specimen collection. Requiring a patient to fast or follow a special diet eliminates most dietary influences on testing. Patients are typically asked to fast approximately 8 to 12 hours, depending on the test. Fasting is normally done overnight after the last evening meal, with specimens collected the following morning before the patient has eaten.

**CAUTION:** Fasting beyond 12 hours can cause serious health problems, such as electrolyte imbalance and heart rhythm disturbances. Consequently fasting specimens, especially those requiring a 12-hour fast, should be collected promptly without unreasonable delay.

The following are examples of how some analytes can be significantly affected by the consumption of certain types of food or drink and the excess consumption of some fluids.

- Ammonia, urea, and uric acid levels may be elevated in patients on high-protein diets.
- Cortisol and ACTH levels have been shown to increase with the consumption of beverages containing caffeine.
- Glucose (blood sugar) levels increase dramatically with the ingestion of carbohydrates or sugar-laden substances but return to normal within 2 hours if the patient has normal glucose metabolism. Eating carbohydrates can also increase insulin levels.
- Hgb levels can decrease and electrolyte balance can be altered by drinking excessive amounts of water and other fluids.

- Lipid levels increase with ingestion of foods such as butter or margarine, cheese, cream, and some enteral (tube feeding) preparations. *(Lipid* is a term meaning fat-soluble; it is used to describe certain fatty substances of animal or vegetable origin.) Abnormally increased blood lipid content is called **lipemia.** Lipids do not dissolve in water and thus high levels of lipids are visible in serum or plasma, causing it to appear milky (cloudy white) or turbid, and the specimen is described as being **lipemic.**

Lipemia can be present for up to 12 hours, which is why accurate testing of triglycerides (a type of lipid) requires a 12-hour fast. In addition, some chemistry tests cannot be performed on lipemic specimens because the cloudiness interferes with the testing procedure.

**KEY POINT** Lipemia in a fasting specimen is rare. When a test requires a fasting specimen but the serum or plasma sample submitted is lipemic, it is a clue that the patient may not have been fasting.

- Some test methods that detect occult (hidden) blood in stool specimens also detect similar substances in meat and certain vegetables. Consequently, a special diet that eliminates these foods must be followed for several days before the specimen is collected.
- Triglycerides, certain liver enzymes, and other liver function analytes are increased by chronic consumption or recent ingestion of large amounts of alcohol, which can also cause hypoglycemia.
DIURNAL/CIRCADIAN VARIATIONS

The levels of many blood components normally exhibit diurnal (happening daily) or circa-dian (having a 24-hour cycle) variations or fluctuations. Factors that play a role in diurnal variations include posture, activity, eating, daylight and darkness, and being awake or asleep. For example, melatonin levels are affected by light; they increase at night, when it is dark, and decrease during daylight hours. Maximum renin and thyroid-stimulating hormone (TSH) levels normally occur in the predawn hours of the morning during sleep, while peak cortisol levels normally occur later in the morning, around 8:00 A.M. Other blood components that exhibit diurnal variation with highest levels occurring in the morning include aldosterone, bilirubin, cortisol, hemoglobin, insulin, iron, potassium, testosterone, and RBCs. Blood levels of eosinophils, creatinine, glucose, growth hormone (GH), triglycerides, and phosphate are normally lowest in the morning. Diurnal variations can be large. For example the levels of cortisol, TSH, and iron can differ by 50% or more between morning and late afternoon.

KEY POINT Tests influenced by diurnal variation are often ordered as timed tests; it is important to collect them as close to the time ordered as possible.

DRUG THERAPY

Some drugs alter physiological functions, causing changes in the concentrations of certain blood analytes. The effect may be desired or an unwanted side effect or sensitivity. Consequently, it is not uncommon for physicians to monitor levels of specific blood analytes while a patient is receiving drug therapy. The following are just a few examples of drugs that can alter physiologic function and the analytes they affect:

- Chemotherapy drugs can cause a decrease in blood cells, especially WBCs and platelets.
- Many drugs are toxic to the liver, as evidenced by increased levels of liver enzymes such as aspartate aminotransaminase (AST)—also called serum glutamic-oxaloacetic transaminase (SGOT), alkaline phosphatase (ALP), and lactate dehydrogenase (LDH) and decreased production of clotting factors.
- Opiates such as morphine increase levels of liver and pancreatic enzymes.
- Oral contraceptives can affect the results of many tests. For example, they can elevate the erythrocyte sedimentation rate (ESR) and decrease levels of vitamin B₁₂.
- Steroids and diuretics can cause pancreatitis and an increase in amylase and lipase values.
- Thiazide diuretics can elevate calcium and glucose levels and decrease sodium and potassium levels. Other thiazide-type medications that lower blood volume can increase blood levels of nitrogenous waste such as urea, a condition called azotemia.

Drugs can also interfere with the actual test procedure, causing false increases or decreases in test results. A drug may compete with the test reagents for the substance being tested, causing a falsely low or false-negative result, or the drug may enhance the reaction, causing a falsely high or false-positive result.

EXERCISE

Exercise affects a number of blood components, raising levels of some and lowering levels of others. Effects vary, depending on the patient’s physical condition and the duration and intensity of the activity. However, moderate to strenuous exercise appears to have the greatest effect. Levels typically return to normal soon after the activity is stopped. The following are examples of the effects of exercise on a number of blood components:

- Arterial pH and PaCO₂ levels are reduced by exercise.
- Glucose, creatinine, insulin, lactic acid, and total protein can be elevated by moderate muscular activity.
- Potassium (K⁺) is released from the cells during exercise, increasing levels in the plasma. Levels generally return to normal after several minutes of rest.

CAUTION: The simple exercise of pumping the hand (i.e., making and releasing a fist) during venipuncture is enough to erroneously increase potassium levels.
Skeletal muscle enzyme levels are increased by exercise, with levels of creatine kinase (CK) and lactate dehydrogenase (LDH) remaining elevated for 24 hours or more.

Vigorous exercise shortly before blood collection can temporarily increase cholesterol levels by 6% or more. Levels can remain elevated for up to an hour after the exercise has stopped. Vigorous or sustained exercise can also affect hemostasis. For example, an increased number of platelet clumps were seen in a study of runners evaluated immediately after running the Boston marathon.

FEVER
Fever affects the levels of a number of hormones. Fever-induced hypoglycemia increases insulin levels, followed by a rise in glucagon levels. Fever also increases cortisol and may disrupt its normal diurnal variation.

GENDER
A patient’s gender affects the concentration of a number of blood components. Most differences are apparent only after sexual maturity and are reflected in separate normal values for males and females. For example, RBC, Hgb, and Hct normal values are higher for males than for females.

JAUNDICE
Jaundice, also called icterus, is a condition characterized by increased bilirubin (a product of the breakdown of RBCs) in the blood, leading to deposits of yellow bile pigment in the skin, mucous membranes, and sclerae (whites of the eyes), giving the patient a yellow appearance (Fig. 9-2). The term icteric means relating to or marked by jaundice and is used to describe serum, plasma, or urine specimens that have an abnormal deep yellow to yellow-brown color due to high bilirubin levels (Fig. 9-1). The abnormal color can interfere with chemistry tests based on color reactions, including reagent-strip analyses on urine.

KEY POINT Jaundice in a patient may indicate liver inflammation caused by hepatitis B or C virus.

POSITION
Body position before and during blood collection can influence specimen composition. Going from supine (lying down on the back) to an upright sitting or standing position causes blood fluids to filter into the tissues, decreasing plasma volume in an adult up to 10%. Only protein-free fluids can pass through the capillaries; consequently the blood concentration of components that are protein in nature or bound to protein—such as aldosterone, bilirubin, blood cells, calcium, cholesterol, iron, protein, and renin—increases. In most cases the concentration of freely diffusible blood components is not affected by postural changes. Nevertheless, a significant increase in potassium (K⁺) levels occurs within 30 minutes of standing; this has been attributed to the release of intracellular potassium from muscle. Other examples of the effects of posture changes include the following:

- A change in position from lying to standing can cause up to a 15% variation in total and high-density lipoprotein (HDL) cholesterol results.

- Plasma aldosterone and renin change more slowly but can double within an hour. Consequently patients are required to be recumbent (lying down) for at least 30 minutes prior to aldosterone specimen collection, and plasma renin-activity levels require documentation of the patient’s position during collection.

- The RBC count on a patient who has been standing for approximately 15 minutes will be higher than a basal-state RBC count on that patient.

PREGNANCY
Pregnancy causes physiologic changes in many body systems. Consequently results of a number of laboratory tests must be compared with reference ranges established for pregnant populations. For example, increases in body fluid, which are normal during pregnancy, have a diluting effect on the RBCs, leading to lower RBC counts.
SMOKING
A number of blood components are affected by smoking. The extent of these effects depends upon the number of
cigarettes smoked. Patients who smoke prior to specimen collection may have increased cholesterol, cortisol, glucose,
growth hormone, and triglyceride levels as well as WBC counts. Chronic smoking often leads to decreased pulmonary
function and increased RBC counts and hemoglobin levels. Smoking can also affect the body’s immune response,
typically lowering the concentrations of immunoglobulins IgA, IgG, and IgM but increasing levels of IgE.

STRESS
Emotional stress such as anxiety, fear, or trauma can cause transient (short-lived) elevations in WBCs. For example,
studies of crying infants have demonstrated marked increases in WBC counts, which returned to normal within 1 hour
after the crying stopped. Consequently CBC or WBC specimens on an infant are ideally obtained after the infant has been
sleeping or resting quietly for at least 30 minutes. If they are collected while an infant is crying, this should be noted on
the report.

Stress is also known to decrease serum iron levels and increase adrenocorticotropin hormone (ACTH),
catecholamine, and cortisol levels. Other hormones that can be affected include aldosterone and TSH, and GH in
children.

TEMPERATURE AND HUMIDITY
Environmental factors such as temperature and humidity can affect test values by influencing the composition of body fl
uids. Acute heat exposure causes interstitial fluid to move into the blood vessels, increasing plasma volume and influ-
encing its composition. Extensive sweating without fluid replacement, on the other hand, can cause hemoconcentration.
Environmental factors associated with geographic location are accounted for when reference values are es-

tablished.

Problem Sites

BURNS, SCARS, AND TATTOOS
Avoid burned, scarred, or tattooed areas. Veins are difficult to palpate or penetrate in these areas. Healed burn sites and
other areas with extensive scarring may have impaired circulation and can therefore yield erroneous test results. Newly
burned areas are painful and also susceptible to infection. Tattooed areas can have impaired circulation, may be more
susceptible to infection, and contain dyes that can interfere with testing.

KEY POINT If you have no choice but to draw in an area with a tattoo, try to insert the needle in a spot that does not
contain dye.

DAMAGED VEINS
Some patients’ veins feel hard and cord-like and lack resiliency because they are occluded or obstructed. These veins may
be sclerosed (hardened) or thrombosed (clotted) from the effects of inflammation, disease, or chemotherapy drugs.
Scarring caused by numerous venipunctures—as occurs in regular blood donors, persons with chronic illnesses, and illegal
IV drug users—can also harden veins. Damaged veins are difficult to puncture, yield erroneous (invalid) test results
because of impaired blood flow, and should be avoided.

KEY POINT Choose another site if possible; otherwise draw below (distal to) damaged veins.
**EDEMA**

Edema is swelling caused by the abnormal accumulation of fluid in the tissues. It sometimes results when fluid from an IV infiltrates the surrounding tissues. Specimens collected from edematous areas may yield inaccurate test results owing to contamination with tissue fluid or altered blood composition caused by the swelling. In addition, veins are harder to locate, the tissue is often fragile and easily injured by tourniquet and antiseptic application, and healing may be prolonged in these areas. Another site should be chosen if possible.

**HEMATOMA**

A hematoma (Fig. 9-3) is a swelling or mass of blood (often clotted) that can be caused by blood leaking from a blood vessel during or following venipuncture. A large bruise eventually spreads over the surrounding area. Venipuncture through an existing hematoma is painful and can result in collection of a specimen that is contaminated with hemolyzed blood from outside the vein and unsuitable for testing. Venipuncture in the area surrounding a hematoma may also be painful. In addition, obstruction of blood flow by the hematoma and the effects of the coagulation process may lead to inaccurate test results on the specimen.

**CAUTION:** Never perform venipuncture through a hematoma. If there is no alternative site, perform the venipuncture distal to the hematoma to ensure the collection of free-flowing blood.

**MASTECTOMY**

Blood should never be drawn from an arm on the same side as a mastectomy (surgical breast removal) without first consulting the patient’s physician. Lymph node removal, which is typically part of the procedure, causes lymphostasis (obstruction or stoppage of normal lymph flow). Impaired lymph flow makes the arm susceptible to swelling, called lymphedema, and to infection. Applying a tourniquet to the arm can cause injury. Effects of lymphostasis can also change blood composition in that arm and lead to erroneous test results.

**KEY POINT** When a mastectomy has been performed on both sides, the patient’s physician should be consulted to determine a suitable site. Generally, the side of the most recent mastectomy is the one avoided.

**OBESITY**

Obese (extremely overweight) patients often present a challenge to the phlebotomist. Veins on obese patients may be deep and difficult to find. Proper tourniquet selection and application is the first step to a successful venipuncture. Conventional tourniquets may be too short to fit around the arm without rolling and twisting. A long length of new Penrose drain tubing or a long Velcro closure strap often works better than a latex or vinyl strap. A blood pressure cuff can also be used.

Check the antecubital area first. Obese patients often have a double crease in the antecubital area with an easily palpable median cubital vein between the two creases. If no vein is easily visible or palpable on tourniquet application, ask the patient what sites have been successful for past blood draws. Most patients who are “difficult draws” know what sites work best. If the patient has never had blood drawn before or does not remember, another site to try is the cephalic vein. To locate the cephalic vein, rotate the patient’s arm so that the hand is prone. In this position, the weight of excess tissue often pulls downward, making the cephalic vein easier to feel and penetrate with a needle.
Vascular Access Devices (VADs) And Sites

**ARTERIAL LINE**

An arterial line (A-line or Art-line) is a catheter that is placed in an artery. It is most commonly placed in a radial artery and is typically used to provide accurate and continuous measurement of a patient’s blood pressure. It may also be used to collect blood gas and other blood specimens and for the administration of drugs such as dopamine. Only specially trained personnel should access arterial lines. Never apply a tourniquet or perform venipuncture on an arm with an arterial line.

**ARTERIOVENOUS SHUNT, FISTULA, OR GRAFT**

An arteriovenous (AV) shunt, fistula, or graft is the permanent surgical connection of an artery and vein by direct fusion (fistula), resulting in a bulging vein, or with a piece of vein or tubing (graft) that creates a loop under the skin. It is typically created to be used for dialysis, commonly joins the radial artery and cephalic vein above the wrist on the underside of the arm, and has a distinctive buzzing sensation called a “thrill” when palpated. A temporary shunt with tubing on the surface of the skin can also be created.

**HEPARIN OR SALINE LOCK**

A heparin or saline lock (Fig. 9-6) is a catheter or cannula connected to a stopcock or a cap with a diaphragm (thin rubber-like cover) that provides access for administering medication or drawing blood. It is often placed in a vein in the lower arm above the wrist and can be left in place for up to 48 hours. To keep it from clotting, the device is flushed and filled with heparin or saline. A saline lock is sometimes flushed with heparin also. Heparin readily adheres to surfaces; therefore it is difficult to remove all traces of it. Consequently a 5-mL discard tube should be drawn first when blood specimens are collected from either type of device. Drawing coagulation specimens from either type is not recommended because traces of heparin or dilution with saline can negatively affect test results. Only specially trained personnel should draw blood from heparin and saline locks.

**INTRAVENOUS SITES**

Intravenous (IV) means “of, pertaining to, or within a vein.” An intravenous line, referred to simply as an IV, is a catheter inserted in a vein to administer fluids. It is preferred that blood specimens not be drawn from an arm with an IV (Fig. 9-7), as they can be contaminated or diluted with the IV fluid, causing erroneous test results. This is especially true if the specimen is drawn above the IV. When a patient has an IV in one arm, blood specimens should be collected from the other arm. If a patient has IVs in both arms or the other arm is also unavailable for some reason, it is preferred that the specimen be collected by capillary puncture. Many specimens (e.g., CBCs) can easily be collected this way. A specimen that cannot be collected by capillary puncture (e.g., a coagulation specimen) may be collected below the IV (never above).

**PREVIOUSLY ACTIVE IV SITES**

Previously active IV sites present a potential source of error in testing. Blood specimens should not be collected from a known previous IV site within 24 to 48 hours of the time the IV was discontinued. Follow facility protocol.

**CENTRAL VASCULAR ACCESS DEVICES**

A central vascular access device (CVAD), also called an indwelling line, consists of tubing inserted into a main vein or artery. CVADs are used primarily for administering fluids and medications, monitoring pressures, and drawing blood. Having a CVAD is practical for patients who need IV access for an extended time and is especially beneficial for patients who do not have easily accessible veins.

**CAUTION:** Only specially trained personnel should access CVADs to draw blood. However, the phlebotomist may assist by transferring the specimen to the appropriate tubes.
Patient Complications and Conditions

**ALLERGIES TO EQUIPMENT AND SUPPLIES**

Occasionally patients are encountered who are allergic to one or more of the supplies or equipment used in blood collection. Examples include the following.

**Adhesive Allergy**

Some patients are allergic to the glue used in adhesive bandages. One solution is to place a clean, folded gauze square over the site and wrap it with self adherent bandaging material such as Coban. Care must be taken not to wrap it too tightly, and the patient should be instructed to remove it in 15 minutes. If the patient is alert, mentally competent, and willing, another alternative is to instruct him or her to hold pressure for 5 minutes in lieu of applying a bandage.

**Antiseptic Allergy**

Occasionally, a patient is allergic to the antiseptic used in skin preparation prior to blood collection. (For example, many individuals are allergic to povidone–iodine.) Alternate antiseptics should be readily available for use in such cases.

**Latex Allergy**

Increasing numbers of individuals are allergic to latex. Most latex allergies are seemingly minor and involve irritation or rashes from physical contact with latex products such as gloves. Other allergies are so severe that being in the same room where latex materials are used can set off a life-threatening reaction. There should be a warning sign on the door to the room of any patient known to have a severe latex allergy, and it is vital that no items made of latex be brought into the room. This means that the phlebotomist must wear nonlatex gloves, use a nonlatex tourniquet, and use nonlatex bandages when in the room, whether collecting blood from the patient or a roommate.

**EXCESSIVE BLEEDING**

Normally, a patient will stop bleeding from the venipuncture site within a few minutes. Some patients, particularly those on aspirin or anticoagulant therapy, may take longer to stop bleeding. Pressure must be maintained over the site until the bleeding stops. If the bleeding continues after 5 minutes, the appropriate personnel should be notified.

**FAINTING**

The medical term for fainting is *syncope* (sin’ko-pea), described as a loss of consciousness and postural tone resulting from insufficient blood flow to the brain. It can last for as little as a few seconds or as long as half an hour.

Any patient has the potential to faint before, during, or immediately following venipuncture. Some patients become faint at just the thought or sight of their blood being drawn, especially if they are ill or have been fasting for an extended period. Other contributing factors include anemia, dehydration, emotional problems, fatigue, hypoglycemia, hyperventilation, medications, nausea, needle phobia, and poor compromised breathing. Sudden faintness or loss of consciousness due to a nervous system response to abrupt pain, stress, or trauma is called *vasovagal* (relating to vagus nerve action on blood vessels) syncope.

A patient with a history of fainting should be asked to lie down for the procedure. Patients who feel faint just before or even after venipuncture should be asked to lie down until recovered. Inpatients, who typically are already lying down, rarely faint during blood draws. Outpatients are more likely to faint because they are usually sitting up during venipuncture.

When a patient who has fainted regains consciousness, he or she must remain in the area for at least 15 minutes. The patient should be instructed *not* to operate a vehicle for at least 30 minutes. It is important for the phlebotomist to document the incident (following institutional policy) in case of future litigation.

**NAUSEA AND VOMITING**

It is not unusual to have a patient experience nausea before, during, or after a blood draw. The patient may state that he or she is feeling nauseous or show signs similar to fainting, such as becoming pale or having beads of sweat appear on the forehead. A blood draw should not be attempted until the experience subsides. A blood draw that is in progress should be discontinued.
KEY POINT If the patient vomits during venipuncture, the procedure must be terminated immediately.

The patient should be reassured and made as comfortable as possible. A feeling of nausea often precedes vomiting, so it is a good idea to give the patient an emesis basin or wastebasket to hold as a precaution. Ask the patient to breathe slowly and deeply. Apply a cold, damp washcloth or other cold compress to the patient’s forehead. If the patient vomits, provide tissues or a washcloth to wipe the face and water to rinse the mouth. If the patient is NPO for surgery, other procedures, or otherwise not allowed to have water, advise him or her to spit the water out after rinsing and not swallow any. Notify the patient’s nurse, physician, or appropriate first-aid personnel of the incident.

PAIN

A small amount of pain is normally associated with routine venipuncture and capillary puncture. Putting patients at ease before blood collection helps them relax and can make the procedure less painful. Warning the patient prior to needle insertion helps avoid a startle reflex. A stinging sensation can be avoided by allowing the alcohol to dry completely prior to needle insertion.

Excessive, deep, blind, or lateral redirection of the needle is considered probing. It can be very painful to the patient; risks injury to arteries, nerves, and other tissues; and should never be attempted.

Marked or extreme pain, numbness of the arm, a burning or electric-shock sensation, or pain that radiates up or down the arm during a venipuncture attempt indicates nerve involvement and requires immediate removal of the needle. If pain persists after needle removal, the patient’s physician or other appropriate personnel should be consulted and the incident documented. Application of an ice pack to the site after needle removal can help prevent or reduce inflammation associated with nerve involvement. Follow your healthcare facility’s protocol.

CAUTION: If marked or extreme pain occurs, or the patient asks you to remove the needle for any reason, the venipuncture should be terminated immediately, even if there are no other signs of nerve injury.

PETECHIAE

Petechiae are tiny, nonraised red spots that appear on the patient’s skin when a tourniquet is applied. The spots are minute drops of blood that escape the capillaries and come to the surface of the skin below the tourniquet, most commonly as a result of capillary wall defects or platelet abnormalities. They are not an indication that the phlebotomist has used incorrect procedure. However, they are an indication that the venipuncture site may bleed excessively.

SEIZURES/CONVULSION

Seizures have been known to occur during venipuncture, although there is no evidence that they can be caused by venipuncture. In the rare event that a patient has a seizure or goes into convulsions during blood specimen collection, it is important to discontinue the draw immediately. Hold pressure over the site without overly restricting the patient’s movement. Do not attempt to put anything into the patient’s mouth. Try to protect the patient from self-injury without completely restricting movement of the extremities. Notify the appropriate first-aid personnel.
HEMATOMA FORMATION

Hematoma formation is the most common complication of venipuncture. It is caused by blood leaking into the tissues during or following venipuncture and is identified by rapid swelling at or near the venipuncture site.

CAUTION: A rapidly forming hematoma may indicate that an artery has been inadvertently hit. Discontinue the draw immediately and apply direct forceful pressure to the puncture site for a minimum of 5 minutes until active bleeding ceases.

A hematoma is painful to the patient and often results in unsightly bruising; it can also cause compression injuries to nerves and lead to lawsuits. Continuing to draw blood while a hematoma is forming risks injury to the patient and collection of a specimen contaminated with hematoma blood that has mixed with tissue fluids from outside the vein. Such a specimen has a high probability of being hemolyzed and of being rejected for testing. Even if it is not hemolyzed, it can still produce inaccurate test results. The presence of a hematoma makes the site unacceptable for subsequent venipunctures. (See “Hematoma” under “Problem Sites”).

If a hematoma forms during blood collection, the phlebotomist should discontinue the draw immediately and hold pressure over the site for a minimum of 2 minutes. A small amount of blood under the skin is relatively harmless and generally resolves on its own. If the hematoma is large and causes swelling and discomfort, the patient should be offered a cold compress or ice pack to relieve pain and reduce swelling. Follow facility protocol.

SITUATIONS THAT CAN TRIGGER HEMATOMA FORMATION

- Excessive or blind probing is used to locate the vein.
- Inadvertent arterial puncture.
- The vein is fragile or too small for the needle size.
- The needle penetrates all the way through the vein.
- The needle is only partly inserted into the vein.
- The needle is removed while the tourniquet is still on.
- Pressure is not adequately applied following venipuncture.

INADVERTENT ARTERIAL PUNCTURE

Inadvertent arterial puncture is rare when proper venipuncture procedures are followed. It is most often associated with deep or blind probing, especially in the area of the basilic vein, which is in close proximity to the brachial artery. If an inadvertent arterial puncture goes undetected, leakage and accumulation of blood in the area can result in compression injury to a nearby nerve. Such injuries are often permanent and can lead to lawsuits.

Signs of inadvertent arterial puncture include a rapidly forming hematoma and blood filling the tube very quickly. In the absence of these clues, arterial blood can be recognized by the fact that it spurts or pulses into the tube or by its bright red color if the patient’s pulmonary function is normal. If arterial puncture is suspected, terminate the venipuncture immediately and apply direct forceful pressure to the site for at least 5 minutes and until bleeding stops.

KEY POINT If you think a specimen might be arterial blood, check with laboratory personnel to determine if a suspected arterial specimen is acceptable for testing, as opposed to redrawing more blood from the patient. If testing is permitted, identify the specimen as possible arterial blood, since some test values are different for arterial specimens.
INFECTION

Although a rare occurrence, infection at the site following venipuncture does happen. The risk of infection can be minimized by the use of proper aseptic technique, which includes the following:

- Do not open adhesive tape or bandages ahead of time or temporarily tape them to your lab coat cuffs or other contaminated objects.
- Do not preload needles onto tube holders to have a supply for many draws ready ahead of time. The sterility of the needle is breached once the seal is broken.
- Before or during needle insertion, do not touch the site with your finger, gauze, or any other nonsterile object after it has been cleaned.
- Try to minimize the time between removing the needle cap and performing the venipuncture.
- Remind the patient to keep the bandage on for at least 15 minutes after specimen collection.

NERVE INJURY

Poor site or improper vein selection, inserting the needle too deeply or quickly, movement by the patient as the needle is inserted, excessive or lateral redirection of the needle, or blind probing while attempting venipuncture can lead to injury of a main nerve (such as the median cutaneous), the risk of permanent damage, and the possibility of a lawsuit. Follow national guidelines for site selection, vein selection, and venipuncture technique to minimize the risk of problems. If initial needle insertion does not result in successful vein entry and slight forward or backward redirection of the needle or use of a new tube does not result in blood flow, the needle should be removed and venipuncture attempted at an alternate site, preferably on the opposite arm.

CAUTION: Extreme pain, a burning or electric-shock sensation, numbness of the arm, and pain that radiates up or down the arm are all signs of nerve involvement, and any one of them requires immediate termination of the venipuncture. Application of an ice pack to the site after needle removal can help prevent or reduce inflammation associated with nerve involvement.

REFLUX OF ADDITIVE

In rare instances, it is possible for blood to reflux (flow back) into the patient’s vein from the collection tube during the venipuncture procedure. Some patients have had adverse reactions to tube additives, particularly EDTA, that were attributed to reflux. Reflux can occur when the contents of the collection tube are in contact with the needle while the specimen is being drawn. To prevent reflux, the patient’s arm must be kept in a downward position so that the collection tube remains below the venipuncture site and fills from the bottom up (Fig. 9-13). This prevents the tube-holder end of the needle from contacting blood in the tube. Back-and-forth movement of blood in the tube should also be avoided until the tube is removed from the evacuated tube holder. An outpatient can be asked to lean forward and extend the arm downward over the arm of the drawing chair to achieve proper positioning. Raising the head of the bed, extending the patient’s arm over the side of the bed, or supporting the arm with a rolled towel can be used to help achieve proper positioning of a bedridden patient.

VEIN DAMAGE

Properly performed, an occasional venipuncture will not impair the patency of a patient’s vein. Numerous venipunctures in the same area over an extended period of time, however, will eventually cause a buildup of scar tissue and increase the difficulty of performing subsequent venipunctures. Blind probing and improper technique when redirecting the needle can also damage veins and impair patency.

Specimen Quality Concerns

The quality of a blood specimen can be compromised by improper collection techniques. A poor-quality specimen will generally yield poor-quality results, which can affect the patient’s care. Because it is not always apparent to the phlebotomist or testing personnel when the quality of a specimen has been compromised, it is very important for the phlebotomist to be aware of the following pitfalls of collection.
HEMOCONCENTRATION

Tourniquet application causes localized venous stasis, or stagnation of the normal venous blood flow. (A similar term for this is venostasis, the trapping of blood in an extremity by compression of veins.) In response, some of the plasma and filterable components of the blood pass through the capillary walls into the tissues. This results in hemoconcentration, a decrease in the fluid content of the blood with a subsequent increase in nonfilterable large molecule or protein-based blood components such as red blood cells. Other abnormally increased analytes include albumin, ammonia, calcium, cholesterol, coagulation factors, enzymes, iron, potassium, and total protein. Changes that occur within 1 minute of tourniquet application are slight; however, prolonged tourniquet application can lead to marked changes.

WAYS TO HELP PREVENT HEMOCONCENTRATION DURING VENIPUNCTURE

Ask the patient to release the fist upon blood flow.
- Choose an appropriate patent vein.
- Do not allow the patient to pump the fist.
- Do not excessively massage the area in locating a vein.
- Do not probe or redirect the needle multiple times in search of a vein.
- Release the tourniquet within 1 minute.

Massaging or squeezing the site, probing for veins, long-term IV therapy, drawing blood from sclerosed or occluded veins, and vigorous hand pumping (making and releasing a fist) can also result in the collection of specimens affected by hemoconcentration.

KEY POINT Hand or fist pumping can increase blood potassium levels up to 20%. It is reported to be responsible for a third of all elevated potasi-ums and may also increase lactate and phosphate levels.

HEMOLYSIS

Hemolysis results when RBCs are damaged or destroyed and the hemoglobin they contain escapes into the fluid portion of the specimen. The red color of the hemoglobin makes the serum or plasma appear pink (slight hemolysis), dark pink to light red (moderate hemolysis), to dark red (gross hemolysis), and the specimen is described as being “hemolyzed”.

PROCEDURAL ERRORS THAT CAN CAUSE SPECIMEN HEMOLYSIS

Drawing blood through a hematoma or from a vein with a hematoma
- Failure to wipe away the first drop of capillary blood, which can contain alcohol residue
- Forceful aspiration of blood during a syringe draw
- Forcing the blood from a syringe into an evacuated tube
- Frothing of blood caused by improper fit of the needle on a syringe
- Horizontal transport of tubes, which lets the blood slosh back and forth
- Mixing additive tubes vigorously, shaking them, or inverting them too quickly or forcefully
- Partially filling a normal-draw sodium fluoride tube
- Pulling back the plunger too quickly during a syringe draw
- Rough handling during transport
- Squeezing the site during capillary specimen collection
- Syringe transfer delay in which partially clotted blood is forced into a tube
- Using a large-volume tube with a small-diameter butterfly needle
- Using a needle with a diameter that is too small for venipuncture
PARTIALLY FILLED TUBES

ETS tubes should be filled until the normal amount of vacuum is exhausted. Failing to do so results in a partially filled tube, referred to as a short draw. Short-draw serum tubes such as red tops and SSTs are generally acceptable for testing as long as the specimen is not hemolyzed and there is sufficient specimen to perform the test. Underfilled anticoagulant tubes and most other additive tubes, however, may not contain the blood-to-additive ratio for which the tube was designed.

CAUTION: Never pour two partially filled additive tubes together to fill one tube, as this will also affect the blood-to-additive ratio.

Although in some cases underfilled additive tubes may be accepted for testing, the specimens can be compromised. For example:

- Excess EDTA in underfilled lavender-top tubes can shrink RBCs, causing erroneously low blood cell counts and hematocrits and negatively affecting the morphological examination of the RBCs on a blood smear. It can also alter the staining characteristics of the cells on a blood smear.

- Excess heparin in plasma from underfilled green-top tubes may interfere with the testing of some chemistry analytes.

- Excess sodium fluoride in underfilled gray-top tubes can result in hemolysis of the specimen.

- Underfilled coagulation tubes do not have the correct blood-to-additive ratio and will produce erroneous results.

Inadvertent (unintentional) short draws are usually the result of difficult draw situations in which blood flow stops or vacuum is lost during needle manipulation. Phlebotomists sometimes underfill tubes on purpose when it is advisable to obtain larger quantities of blood, as when drawing from infants, children, or severely anemic individuals.

CAUTION: Some phlebotomists underfill tubes to save time. This practice is never recommended.

SPECIMEN CONTAMINATION

Specimen contamination is typically inadvertent and generally the result of improper technique or carelessness, such as:

- Allowing, alcohol, fingerprints, glove powder, baby powder, or urine from wet diapers to contaminate newborn screening forms or specimens, leading to specimen rejection.

- Getting glove powder on blood film (slides) or in capillary specimens, resulting in misinterpretation of results. Calcium-containing powders can affect calcium results.

- Unwittingly dripping perspiration into capillary specimens during collection or any specimen during processing or testing. The salt in sweat, for example, can affect sodium and chloride levels.

- Using the correct antiseptic but not following proper procedure. For example, improperly cleaning blood-culture bottle tops or the collection site, touching the site after it has been prepped (cleaned), or inserting the needle before the antiseptic on the arm or bottle tops is dry. (Traces of the antiseptic in the culture medium can inhibit the growth of bacteria and cause false-negative results.) Performing capillary puncture before the alcohol is dry can cause hemolysis of the specimen and lead to inaccurate results or rejection of the specimen by the lab.

- Using the wrong antiseptic to clean the site prior to specimen collection. For example, using alcohol to clean the site can contaminate an ethanol (blood alcohol) specimen. Using povidone–iodine (e.g., Betadine) to clean a skin puncture site can contaminate the specimen and cause erroneously high levels of uric acid, phosphate, and potassium.
Troubleshooting Failed Venipuncture

Failure to initially draw blood during a venipuncture attempt can be caused by a number of procedural errors. Being aware of these errors and knowing how to correct them may determine whether you obtain blood on the first try or have to repeat the procedure. If you fail to obtain blood, remain calm so that you can clearly analyze the situation and check the following:

**TUBE POSITION**

Tube position is important. Check the tube to see that it is properly seated and the needle in the tube holder has penetrated the tube stopper. Reseat the tube to make certain that the needle sleeve is not pushing the tube off the needle.

**NEEDLE POSITION**

Insertion of the venipuncture needle so that the bevel is correctly positioned within the vein is critical to the success of venipuncture. If the needle or bevel is incorrectly positioned, blood may not flow into the tube or syringe properly or at all. If blood flow is not established or the rate of flow is not normal, use visual cues to help determine if the needle is correctly positioned in the vein. Some problems are harder to discern than others. Eliminate any that you can and try the remedy for the others to see if one works. All needle adjustments must be made slowly and precisely to avoid injuring the patient.